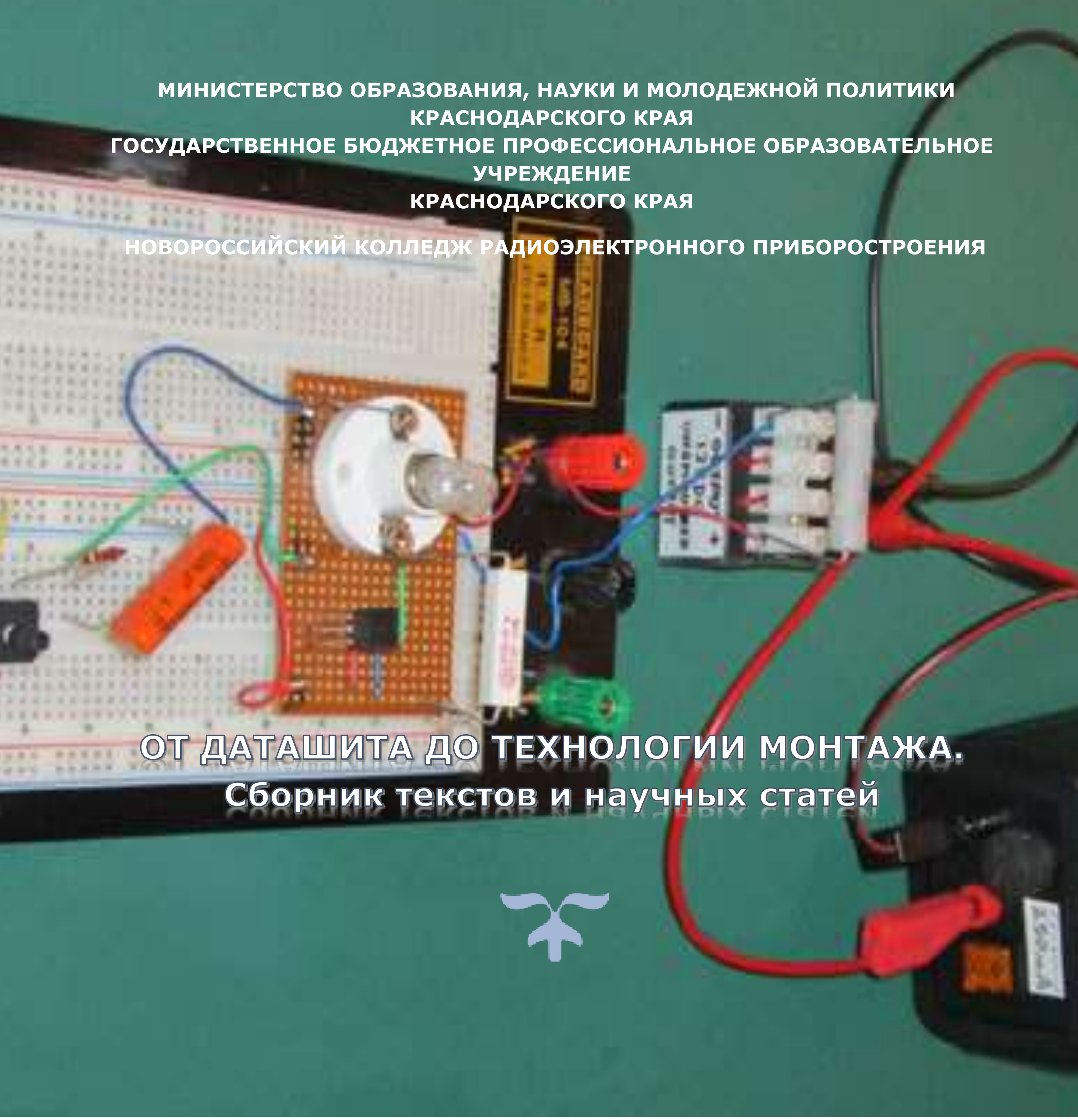
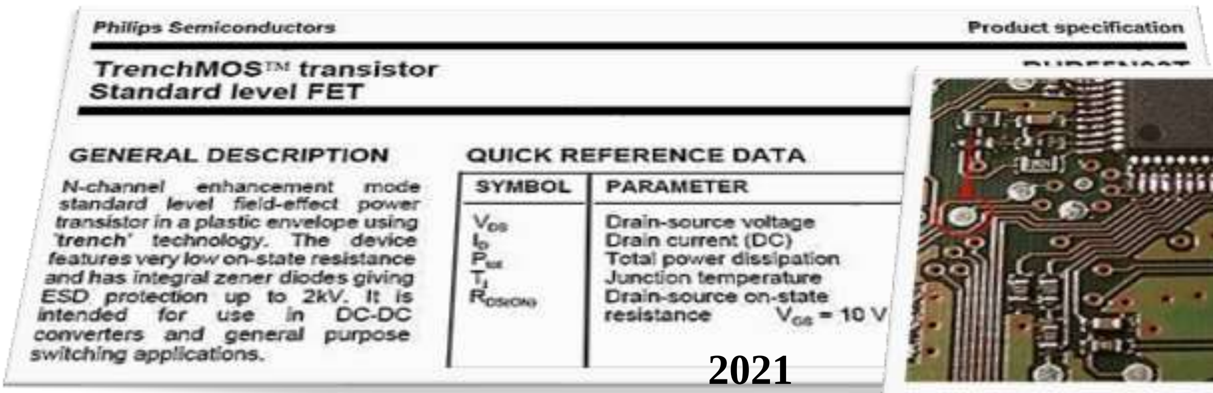
МИНИСТЕРСТВО ОБРАЗОВАНИЯ, НАУКИ И МОЛОДЕЖНОЙ ПОЛИТИКИ
КРАСНОДАРСКОГО КРАЯ
ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ПРОФЕССИОНАЛЬНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ
КРАСНОДАРСКОГО КРАЯ

НОВОРОССИЙСКИЙ КОЛЛЕДЖ РАДИОЭЛЕКТРОННОГО ПРИБОРОСТРОЕНИЯ



ОТ ДАТАШИТА ДО ТЕХНОЛОГИИ МОНТАЖА.

Сборник текстов и научных статей


Philips Semiconductors — Product specification

TrenchMOS™ transistor
Standard level FET

GENERAL DESCRIPTION

N-channel enhancement mode standard level field-effect power transistor in a plastic envelope using 'trench' technology. The device features very low on-state resistance and has integral zener diodes giving ESD protection up to 2kV. It is intended for use in DC-DC converters and general purpose switching applications.

QUICK REFERENCE DATA

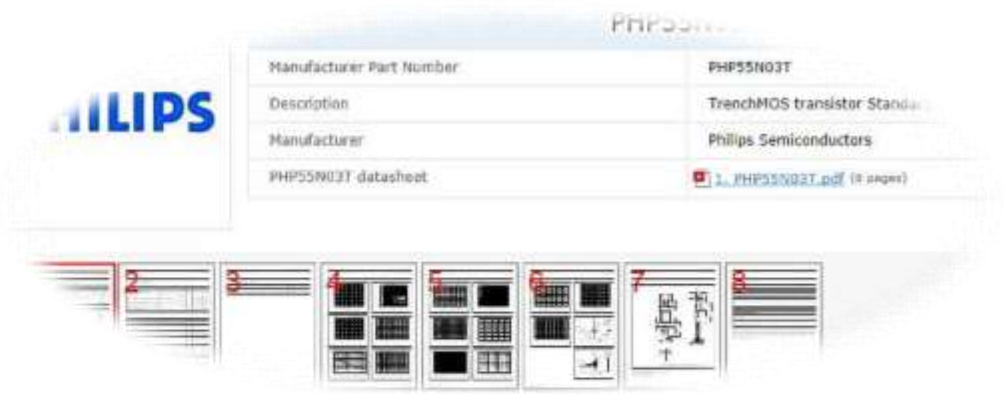
SYMBOL	PARAMETER
V_{DS}	Drain-source voltage
I_D	Drain current (DC)
P_{tot}	Total power dissipation
T_j	Junction temperature
$R_{DS(ON)}$	Drain-source on-state resistance V_{GS} = 10 V

2021

МИНИСТЕРСТВО ОБРАЗОВАНИЯ, НАУКИ И МОЛОДЕЖНОЙ ПОЛИТИКИ КРАСНОДАРСКОГО КРАЯ

ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ПРОФЕССИОНАЛЬНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ КРАСНОДАРСКОГО КРАЯ

«НОВОРОССИЙСКИЙ КОЛЛЕДЖ РАДИОЭЛЕКТРОННОГО ПРИБОРОСТРОЕНИЯ»



УЧЕБНОЕ ПОСОБИЕ

на тему «От Даташита до Технологии Монтажа. Сборник текстов и научных статей»

по учебной дисциплине «**Иностранный язык»**
(английский)

для специальности 11.02.02

Техническое обслуживание и ремонт радиоэлектронной

техники

2 курс

2 0 2 1

СОГЛАСОВАНО На заседании Совета по методическим вопросам от 19 06 2021 г. протокол № 7 Председатель Совета по методическим вопросам _________ Е. В. Кужилева	УТВЕРЖДАЮ Зам. директора по УР _________ Т.В. Трусова 19 06 2021 г.

Одобрено на заседании УМО филологических дисциплин
от 03 марта 2021 г.
протокол № 7
Председатель УМО _________ Е. Н. Ткалина

Организация – разработчик: государственное бюджетное профессиональное образовательное учреждение Краснодарского края «Новороссийский колледж радиоэлектронного приборостроения» (ГБПОУ КК НКРП)

Разработчик:
Преподаватель ГБПОУ КК НКРП _________ М.А. Марарь

Рецензенты:

Парфенова Е. В., (Ф.И.О)	преподаватель ГАПОУ КК НКСЭ (должность, место работы) филолог, преподаватель по предмету «Иностранный язык» (английский) (квалификация по диплому)
Ткалина Е. Н., (Ф.И.О.)	преподаватель высшей квалификационной категории ГБПОУ КК НКРП (должность, место работы) лингвист, преподаватель английского языка (квалификация по диплому)

Рецензия

на учебное пособие по иностранному языку (английский)

«От Даташита до Технологии Монтажа. Сборник текстов и научных статей»

преподавателя Марарь Марины Александровны

ГБПОУ КК НКРП

Учебное пособие «От Даташита до Технологии Монтажа. Сборник текстов и научных статей» преподавателя М.А. Марарь рассчитано для студентов 2 курса специальности 11.02.02 «Техническое обслуживание и ремонт радиоэлектронной техники». Количество страниц – 79.

Автор акцентирует внимание на том, что учебное пособие направлено на развитие индивидуальной траектории образования каждого обучающегося. Пособие аккумулирует важные процессы радиоэлектроники, начиная со схемы описания прибора – даташита – и заканчивая технологией работы этого прибора по учебной дисциплине «иностранный язык (английский)».

Актуальность и педагогическая целесообразность данного учебного пособия заключается в развитии умений и навыков у обучающихся по дисциплине «Иностранный язык». В системе образования данное учебное пособие связано с другими дисциплинами, изучаемыми в СПО: инженерная графика, электротехника, метрология, стандартизация и сертификация, электронная техника, материаловедение, электрорадиоматериалы и радиокомпоненты, электрорадиоизмерения.

Основная идея разработанного учебного пособия заключается в привитии обучающимся навыков профессии посредством иностранного языка, что позволит студентам в будущем ориентироваться в документах, схемах, таблицах не только на родном языке, но и на изучаемом языке, на который ориентируется большинство производителей. Грамматические и лексические упражнения, которые предоставляются автором в пособии, делают этот материал интересным и оптимальным для восприятия студентов старших курсов.

Учебное пособие обладает практической значимостью: ряд заданий после рассматриваемой определенной темы стимулирует интеллектуальную, поисковую и коммуникативную активность и, как следствие, формирует новые навыки студентов, которых, возможно, ранее у них не было (накопление запаса слов, логически правильное построение перевода, т.д.)

Рецензируемое учебное пособие актуально для системы образования, интересно по содержанию, будет доступно и понятно как преподавателю, так и студентам-старшекурсникам, которые осваивают специальность в теории и на практике.

Таким образом, данное пособие учебной дисциплины «Иностранный язык (английский)» может быть рекомендовано для использования в образовательном учреждении ГБПОУ КК «Новороссийский колледж радиоэлектронного приборостроения».

Рецензент:

Е. Н. Ткалина

(Ф.И.О. рецензента)

Преподаватель высшей квалификационной категории

ГБПОУ КК НКРП

(должность, место работы)

Лингвист, преподаватель английского языка

(квалификация по диплому)

17 июня 2021 г.

Рецензия

Настоящее учебное пособие «От Даташита до Технологии Монтажа. Сборник текстов и научных статей» предназначена для работы обучающихся 2 курса специальности 11.02.02 «техническое обслуживание и ремонт радиоэлектронной техники».

Основа для учебного пособия была заимствована из научно-публицистической литературы, которая является учебным материалом, изучаемым студентами по данной теме, рассчитанной на 66 (32+34) часов (или на два учебных семестра).

Все тексты данного учебного пособия профессионально направлены. Во избежание языковых трудностей и трудностей перевода предусмотрена поэтапная работа с текстами, ряд упражнений и заданий для их последовательного разбора по частям, а также выявления сути и краткого изложения на изучаемом языке. Учебное пособие включает в себя:

- Тексты - Datasheet. Types of Datasheets. Creating and Formatting Datasheets; Main Components of a Circuit (Resistors); Capacitance and Capacitors; Inductance and Inductors; Klystrons. Klystron Amplifiers; Cathode Ray Tubes (CRT). Photosensitive Tubes; Gas Discharge Lamps; Plasma Panel Displays (PDP); Thyristors; Solid State Relays; Opto Coupled Devices; a Signal; Trigger and Synchronization Spectrum; Encoders and Decoders. More Combinational circuits – Multiplexers, Demultiplexers, Encoders and Decoders; Electrical Installation Work. Soldering in Electronics. Soldering Tools. Solder Pastes for SMDS; Printed Circuit Board – Diagram and Assembly, Materials, Design; Types of Electrical Cable. The Basics of Wiring Harnesses for Industrial Engines.

- Новую лексику;
- Лексические упражнения;
- Грамматические упражнения.

Применение данного пособия на практике способствует решению следующих задач:

- развитие навыков чтения текста и его понимание;
- использование навыков чтения изучающего и поискового характера;
- развитие диалогической и монологической речи;
- развитие логического мышления обучаемых;
- закрепление грамматических навыков, полученных в процессе обучения.

Требования к результатам освоения материала учебного пособия конкретизированы и Практические задачи обучения направлены на развитие составляющих коммуникативной компетентности студентов (речевой, языковой, социокультурной, компенсаторной и учебно-познавательной).

Предлагаемое учебным пособием содержание практических заданий носит профессионально ориентированный характер, обеспечивает приобретение обучаемыми требуемых умений и навыков.

соответствуют требованиям к знаниям и умениям базовой подготовки по специальности.

Рецензент:

Е. В. Парфенова

(Ф.И.О. рецензента)

преподаватель ГАПОУ КК НКСЭ

(должность, место работы)

филолог, преподаватель по предмету «Иностранный язык» (английский)

(квалификация по диплому)

17 июня 2021 г.

ОГЛАВЛЕНИЕ

ВВЕДЕНИЕ

Данное учебное пособие «От Даташита до Технологии Монтажа. Сборник текстов и научных статей» предназначено для студентов образовательных организаций, в программу которых входит изучение радиоэлектронной техники и приборостроения. Пособие соответствует базовому этапу подготовки иностранного языка и обеспечивает коммуникативную и профессиональную направленность в обучении языку в неязыковой образовательной организации.

Все компоненты учебного пособия построены на единых методических принципах, развивают все виды иноязычной речевой деятельности, позволяют организовать аудиторную и самостоятельную работу по овладению английским языком и формирование межкультурной компетенции будущих специалистов.

Целью учебного пособия является формирование умения беседовать на профессиональные темы, развитие умения читать специальную литературу средней и повышенной степени трудности и извлекать из нее информацию. Для достижения этого в пособии предусмотрена регулярная, от текста к тексту, учебная деятельность по созданию словаря активной лексики, включающего употребительные в данной специальности термины и слова общего значения.

Материалы, входящие в пособие, отобраны из оригинальной литературы. Последовательность текстов имеет логическую направленность, соответствующую логике развития данной отрасли. Учебное пособие включает в себя 24 текста. Тематика текстов соответствует реально существующим направлениям подготовки специалистов профиля техническое обслуживание и ремонт радиоэлектронной техники на основе знаний по электронной технике, электротехнике, материаловедения, электрорадиоматериалов и радиокомпонентов, а также электрорадиоизмерений.

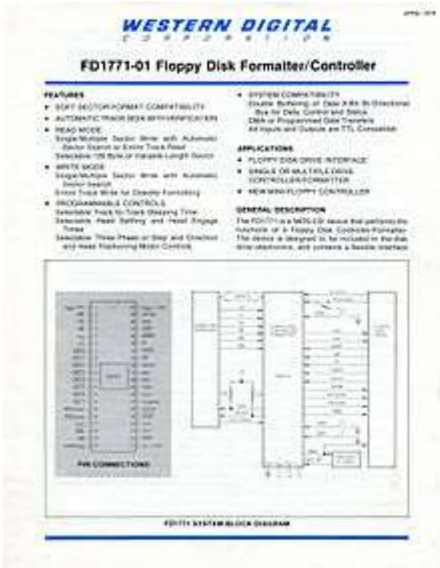
При разработке практических заданий использованы элементы функционально-коммуникативного обучения иностранному языку, при котором явления языка (лексика и грамматика) рассматриваются не только как система языковых правил, но и как система коммуникативных функций. Такие функции типичны для текстов профиля техническое обслуживание и ремонт радиоэлектронной техники и находят свое отражение в типичных грамматических моделях и типичном наборе лексических единиц и словосочетаний. В конце пособия даны контрольные вопросы на усвоение учебного материала, рассчитанного на закрепление понятой обучающимися информации. Также данное пособие включает дополнительные теоретические сведения по тематике на английском и русском языках (дополнительные данные о даташитах).

UNIT 1

Раздел 2 Даташиты. Перечни данных от производителя. Тема 2.1 Спецификации

PREAMBLE

TEXT 1 DATASHEET



A floppy disk controller datasheet

A **datasheet**, **data sheet**, or **spec sheet** is a document that summarizes the performance and other technical characteristics of a product, machine, component (e.g., an electronic component), material, a subsystem (e.g., a power supply) or software in sufficient detail that allows design engineer to understand the role of the component in the overall system. Typically, a datasheet is created by the manufacturer and begins with an introductory page describing the rest of the document, followed by listings of specific characteristics, with further information on the connectivity of the devices. In cases where there is relevant source code to include, it is usually attached near the end of the document or separated into another file. Depending on the specific purpose, a datasheet may offer an average value, a typical value, a typical range, engineering tolerances, or a nominal value. The type and source of data are usually stated on the datasheet.

A **datasheet** is usually used for technical communication to describe technical characteristics of an item or product. It can be published by the manufacturer to help people choose products or to help use the products. By contrast, a technical specification is an explicit set of requirements to be satisfied by a material, product, or service. An electronic datasheet specifies characteristics in a formal structure that allows the information to be processed by a machine. Such machine readable descriptions can facilitate information retrieval, display, design, testing, interfacing, verification, and system discovery. Examples include transducer electronic data sheets for describing sensor characteristics, and Electronic device descriptions in CANopen or descriptions in markup languages, such as SensorML.

Typical electronics datasheet information

Electronic component

A typical datasheet for an electronic component contains most of the following information:

- Manufacturer's name
- Product number and name
- List of available package formats (with images) and ordering codes
- Notable device properties
- Short functional description
- Pin connection diagram
- Absolute minimum and maximum ratings (supply voltage, power consumption, input currents, temperatures for storage, operating, soldering, etc.)
- Recommended operating conditions (as absolute minimum and maximum ratings)
- DC specifications (various temperatures, supply voltages, input currents, etc.)
- Maximum power consumption over the whole operating temperature range
- AC specifications (various temperatures, supply voltages, frequencies, etc.)
- Input/output wave shape diagram

- timing diagram
- Some characteristics are only given at a specific temperature, typically 25 °C (77 °F)
- Physical details showing minimum/typical/maximum dimensions, contact locations and sizes
- Ordering codes for differing packages and performance criteria
- Liability disclaimer regarding device use in certain environments such as nuclear power plants and life support systems
- Application recommendations, such as required filter capacitors, circuit board layout, etc.
- Errata, often published prior to subsequent correction and relevant datasheet revision

Personal computer

- Number of ports
  - USB, Ethernet, FireWire, S/PDIF, PS/2, Serial, Parallel
- Expansion bays
  - 5.25 inch bays
  - 3.5 inch bays
- Motherboard
  - CPU socket
    - Front-side bus (FSB)
    - Back-side bus (BSB)
  - Chipset
    - North bridge
    - South bridge
  - Random-access memory (RAM) slots
  - Peripheral Component Interconnect (PCI) and PCI Express (PCIe) buses and slots
  - Floppy, ATA (IDE) and SATA interfaces
  - Fans and temperature monitoring
  - Integrated graphics controllers
  - Integrated LAN interfaces
  - Firmware (BIOS)
  - Form factor
- Graphics card
  - AGP type
  - Memory
- Audio card
- Hardware compatibility requirements and basic setup details for computer device drivers
- Operating system and other installed software (if included)

Although a datasheet may include a "typical use" circuit diagram, as well as programming examples in the case of programmable devices, this sort of information is often published in a separate **application note**, with a high level of detail.

Historically, datasheets were typically available in a **databook** that contained many datasheets, usually grouped by manufacturer or general type. Today, they are also available through the Internet in table form or via downloadable (usually PDF) documents.

Chemical data sheets

Material Safety Data Sheets

A Material Safety Data Sheet (MSDS), Safety Data Sheet (SDS), or Product Safety Data Sheet (PSDS) is an important component of product stewardship and occupational safety and health. These are required by agencies such as OSHA in its Hazard Communication Standard, 29 C.F.R. 1910.1200. It provides workers with ways to allow them to work in a safe manner and gives them physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill-handling procedures. The MSDSs differ from country to country, as different countries have different regulations. In some jurisdictions, it is compulsory for the SDS to state the chemical's risks, safety, and effect on the environment. The SDSs are a commonly used classification for logging information on chemicals, chemical compounds, and chemical mixtures. The SDSs often include the safe use of the chemical and the hazardous nature of the chemical. Anytime chemicals are used these data sheets will be found. There is a need to have an internationally recognized symbol when describing hazardous substances. Labels can include hazard symbols such as the European Union standard black diagonal cross on an orange background, used to denote a harmful substance.

The purpose of an SDS is not so that the general public will have a knowledge of how to read and understand it, but more so that it can be used in an occupational setting to allow workers to be able to work with it.

Chemical data
Data sheets and pages are available for specific properties of chemicals in Chemical elements data references: example, Melting points of the elements (data page). Specific materials have technical data in individual sheets such as Ethanol (data page): this includes subjects such as structure and properties, thermodynamic properties, spectral data, vapor pressure, etc. Other chemical data sheets are available from individual producers of chemicals, often on their web pages.

Data sheets for automobiles

Data sheets for automobiles may be described under several names such as features, specs, engineering data, technical summary, etc. They help communicate the technical information about a car to potential buyers and are useful for comparisons with similar cars. They might include: critical inside and outside dimensions, weight, fuel efficiency, engine and drive train, towing capability, safety features and options, warranty, etc.

Similar Documents

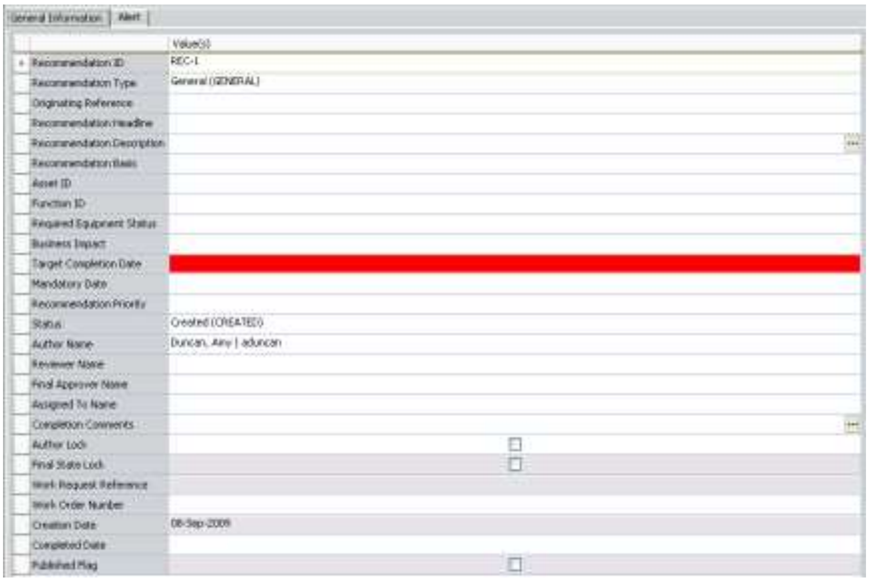
- **Brochure** focuses more on the benefits and advantages of a products, and states less details, especially less quantitative parameters to describe the product. The beginning parts of a brochure and a datasheet for the same product may look the same and include the name of the product, manufacturer's name, logo and contact details, brief description, photo of scheme of the product.
- **Catalog** presents a variety of products and in comparison to datasheets, that presents one product or a relatively small group of similar products. Catalog may present many of the parameters that are stated in the datasheets of the products, but usually catalogs are not as comprehensive as datasheets.
- **User guide** deals more with the step-by-step usage of a products, and may include a brief or complete list of parameters that describe the product, usually as an appendix for the actual user guide document.
- **Application notes** is a document that gives more specific details on using a component in a specific application, or relating to a particular process (e.g., the physical assembly of a product containing the component). Application notes are especially useful for giving guidance on more unusual uses of a particular component, which would be irrelevant to many readers of the more widely read datasheet. application notes may either be appended to a datasheet, or presented as a separate document.
- A **technical specification** is an explicit set of requirements to be satisfied by a material, product, or service

TYPES OF DATASHEETS

Meridium APM offers the following types of datasheets

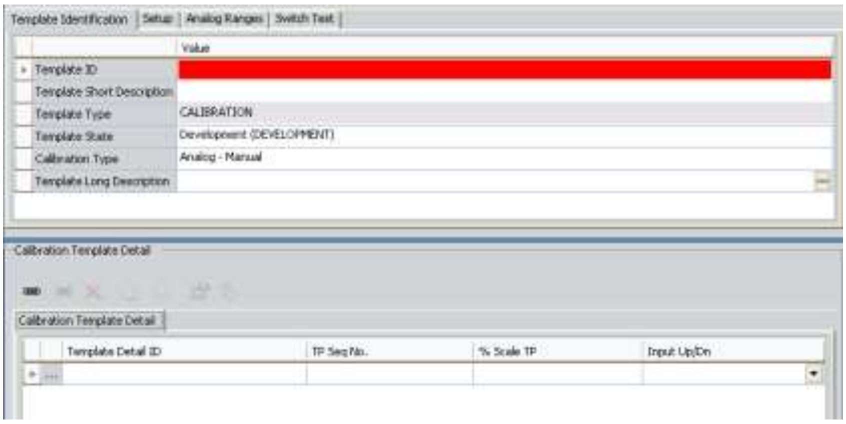
Standard datasheets: Datasheets that display fields in a grid. The following image shows a standard datasheet that is configured by default for the Recommendation family.

Note: The Meridium APM Web Framework supports only standard datasheets. If you want to view the datasheet in the Meridium APM Web Framework, you will need to create a standard datasheet for the desired family.



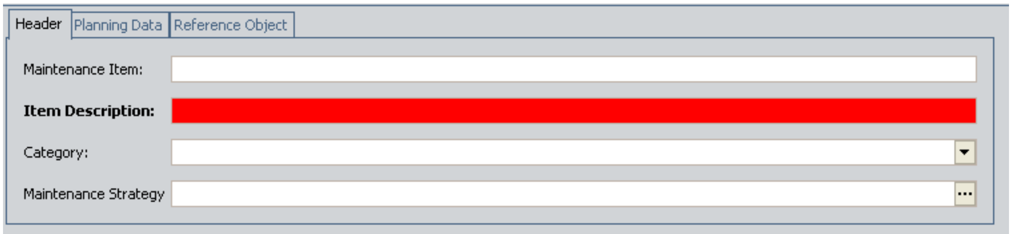
Custom forms: Datasheets that can be customized to display fields in a more advanced form. Meridium APM provides the following types of custom forms, which you can apply to any family:

<u>Master/detail</u>: A form that lets you display a record and all the records that are linked to it through a given <u>relationship definition</u>. The following image shows a master/detail datasheet that is configured by default for the Calibration Template family.



Custom-layout: A form that users can customize via the Meridium APM Framework application. Unlike standard datasheets, custom-layout datasheets provide more flexibility in the layout of fields. For example, they can contain grouped fields, fields that appear side-by-side, and so on.

The following image shows a custom form that is configured by default for the Maintenance Item family.



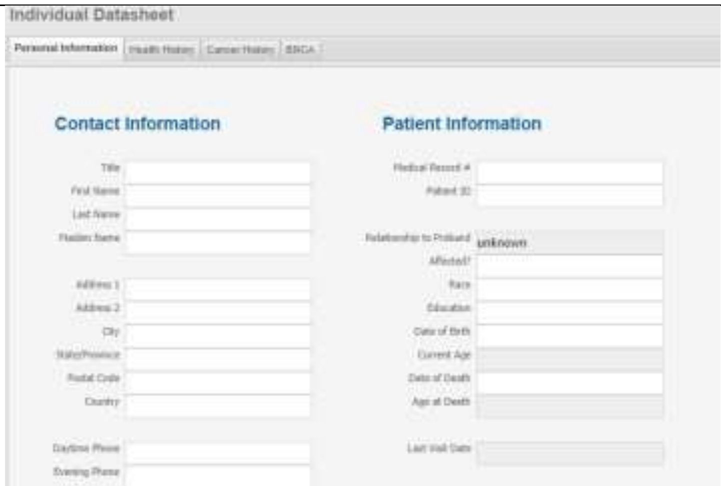
Custom-layout datasheets can be created for any entity family via the Configuration Manager. As part of this creation process, a Security Group must be associated with the custom-layout datasheet. Only Security Users that belong to this Security Group can configure the datasheet in the Meridium APM Framework.

After a custom-layout datasheet has been created in the Configuration Manager, when you create a new record or modify an existing record in the associated family, the datasheet that appears will contain ALL fields that are defined for that family. A Security User that belongs to the associated Security Group can begin customizing the datasheet layout as desired. Note that until the datasheet is customized, the fields will appear in order according to their field sequence order, which is specified via the Configuration Manager application.

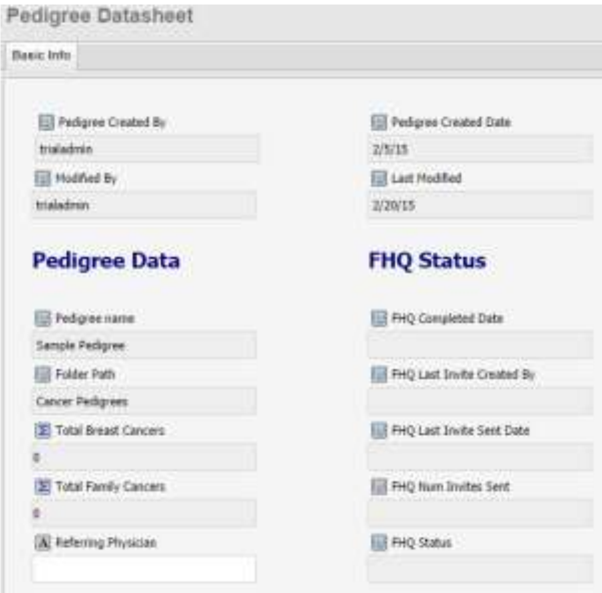
TEXT 2 DATASHEETS TYPES, CREATING AND FORMATTING DATASHEETS

Knowledgebase: Datasheet Basics

The datasheet is a paper form or document that details the properties of a particular product or component. The form contains fields for collecting specific data about the product or component. By analogy, you use datasheets in Progeny to enter and store data for individuals, pedigrees, markers, and samples. Each datasheet contains database fields that store specific data for an individual, a pedigree, a marker set, and or a sample.



Datasheet Types



There are five distinct types of datasheets that can be created in Progeny:

Individual Datasheets – The individual datasheet is used to enter and store information about individuals in your Progeny database. An Individual datasheet can contain individual database fields, pedigree database fields, and marker database fields.

Pedigree Datasheets – The pedigree datasheet is used to enter and store information about pedigrees in your Progeny database. A Pedigree datasheet can contain only pedigree database fields.

Sample Datasheets – The sample datasheet is used to enter and store information about samples in your Progeny database. Additionally, the sample datasheet is the only one of the five datasheet types that can contain all four types of Progeny database fields—individual database fields, pedigree database fields, sample database fields, and marker database fields.

Marker Datasheets – The marker datasheet is used to enter and store information about markers in your Progeny database. A Marker datasheet can contain only marker database fields. Table Datasheets – The table datasheet is a special type of datasheet as the scope of fields that can be added to it are limited to the subfields of a table. Each table datasheet can contain table subfields from only a single table. A table datasheets is, in turn, contained in one of the other four types of datasheets—individual, pedigree, sample, or marker.

Creating and Formatting Datasheets

After adding the necessary field types to your Progeny database, and you have added the necessary components for creating a specific type of datasheet (for example, you have created Individual folders

and you have added individuals to a folder in preparation for creating an individual datasheet), you can create the datasheet. When you are creating a datasheet, you have a variety of options for formatting the datasheet, including the following:

- Adding tabs to the datasheet.
- Positioning and aligning the fields on the datasheet.
- Specifying default settings for the fields on the datasheet.
- Adding static text to the datasheet.
- Creating table datasheets for table fields.

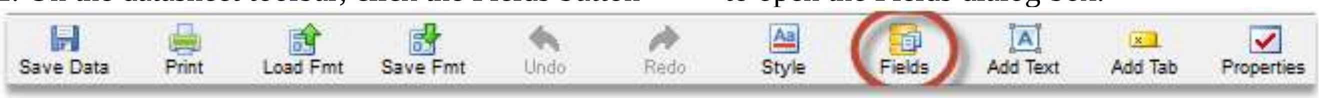
The following procedure assumes that you have already added the required components for creating a specific type of datasheet. (For example, you have created folders and added individuals to the folder so that you can create an individual datasheet.) Detailed procedures for creating the necessary components for adding a specific type of datasheet are discussed in detail in the appropriate chapter (Progeny Clinical, Progeny Lab, or Progeny LIMS) in this manual.

To create and format a datasheet

1. At the top of the blank datasheet, click Form Design.

Figure 3-1: Datasheet toolbar

2. On the datasheet toolbar, click the Fields button  to open the Fields dialog box.



3. This dialog box contains all the fields (grouped by folder) that you can add to the datasheet. It also lists the system fields that you can add to the datasheet. For example, if you are creating an individual datasheet, then the dialog box lists all the individual data fields (grouped by folders), all the pedigree data fields (grouped by folders), and all the marker sets (grouped by folder) that you can add to the datasheet. It also lists all the individual system fields that you can add to the datasheet. See Figure 3-2 below.

Figure 3-2: Fields dialog box for an Individual datasheet

System fields are read-only fields that Progeny automatically stores in its database for a record. Each record type (individual, pedigree, sample, and marker) has its own unique system fields. You can include system fields on a datasheet if there is information that you want to view at all times, but not edit, for an individual, a pedigree, a sample, or a marker. For a complete list of system fields and the read-only value that is displayed in each field, see System Fields - Individual Level, System Fields - Pedigree Level, System Fields - Sample Level, System Fields - Marker Level

4. If the datasheet is to be a single sheet, (that is, no tabs), then continue to Step 5; otherwise, for each tab that you are adding to the datasheet, on the datasheet toolbar, click the Add Tab button to open the Add Tab dialog box, enter a name for the new tab, and then click OK.

5. In the left pane of the Fields dialog box, open the folder that contains the field or fields that you are adding to the datasheet. The list of fields contained in the folder is displayed in the right pane of the Fields dialog box.

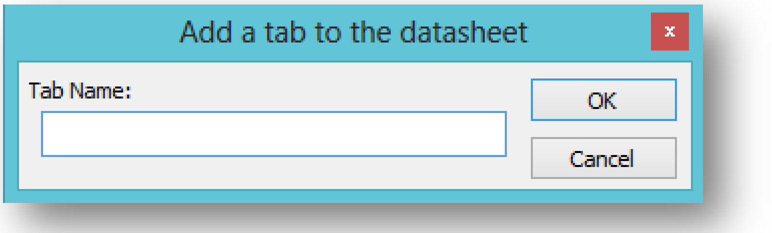
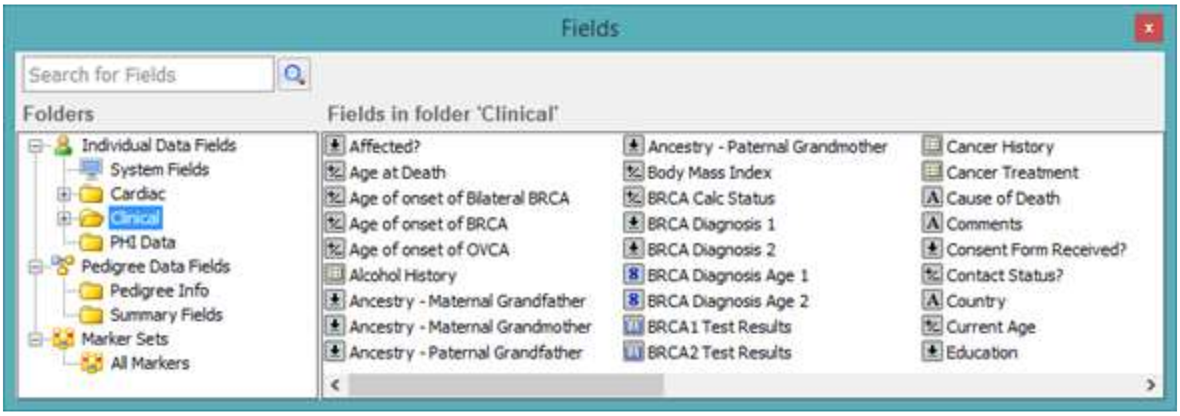
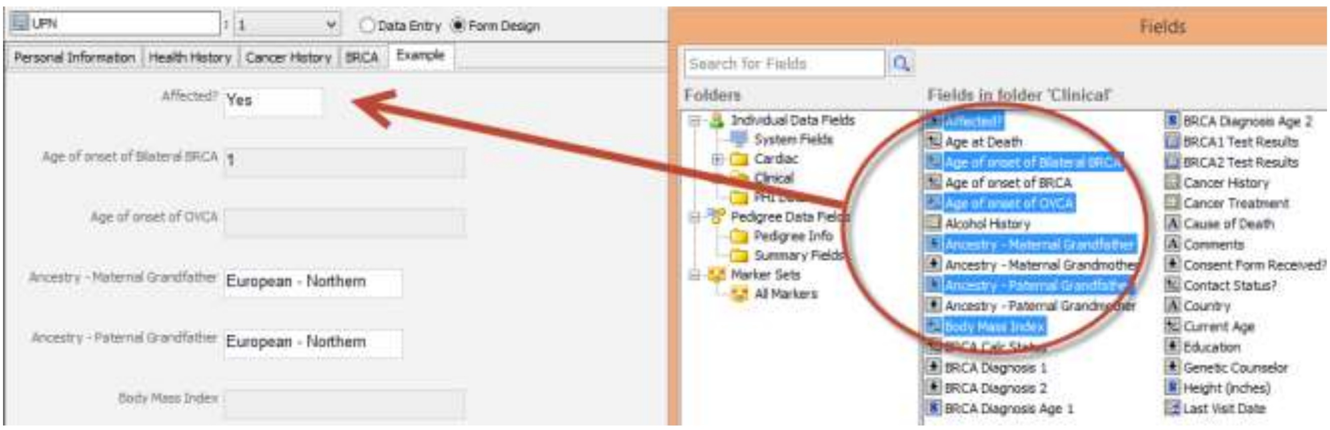


Figure 3-4: Adding Fields (Example shown here: using Clinical Folder)



6. If applicable, make sure that the correct tab is open and then from the right pane of the Fields dialog box, drag the needed field or fields (CTRL-click to select multiple fields) to the datasheet.

Figure 3-5: Adding Fields (CTRL-click to select multiple fields)



To align multiple fields

1. CTRL-click to select the fields that you are aligning.

2. On the datasheet toolbar, click the Style button to open the Style toolbar.

3. On the Style toolbar, click the Alignment button  to open a menu with a variety of options for modifying the field alignment.

Figure 3-6: Style toolbar

Alignment Button Options

Option	Description
Align Left	From top to bottom, vertically aligns the left edges of the selected fields.
Align Right	From top to bottom, vertically aligns the right edges of the selected fields.
Align Top	From left to right, horizontally aligns the top edges of the selected fields.
Align Bottom	From left to right, horizontally aligns the bottom edges of the selected fields.
Size Horz	Sets the width of all the selected fields to same width as the first selected field.
Size Vert	Sets the height of all the selected fields to same height as the first selected field.
Space Horz	Sets the horizontal spacing between all the selected fields to the same as the spacing between the first two selected fields.
Space Vert	Sets the vertical spacing between all the selected fields to same as the spacing between the first two selected fields.

To add static text to a datasheet

Static text is free-standing text that is not tied to any field on a datasheet. You can add static text anywhere on a datasheet.

1. On the datasheet toolbar, click the Add Text button.

2. A blank text box with the phrase "Static Text" is displayed on the worksheet.

Figure 3-7: Blank text box

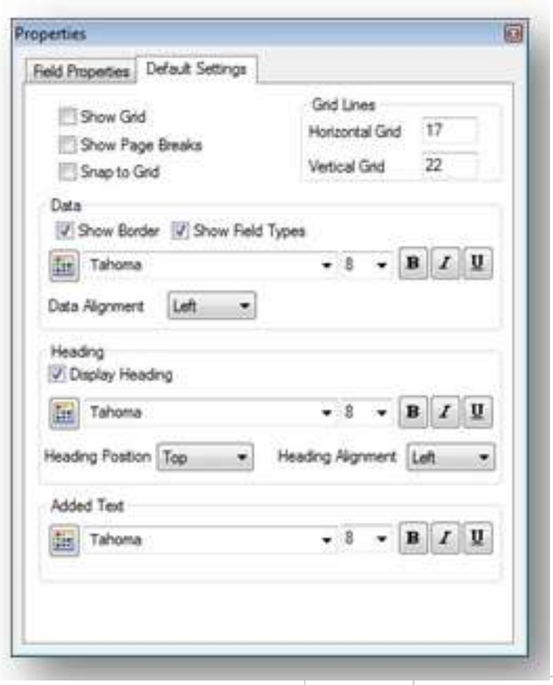
3. Click on the phrase "Static Text" to select it, and then replace the phrase with the appropriate text.
4. Drag the top, side, or corner handles to resize the text box as needed.
5. Click and hold on the center of the text box and drag the text box to the correct location on the datasheet.
6. To change the format for the static text (font size, font color, and so on), see one of the following:

To set the properties for all the fields on the datasheet

You can set the same default properties for all the fields on the datasheet and all static text in a single step.

1. On the datasheet toolbar, click the Properties button to open the Properties dialog box.

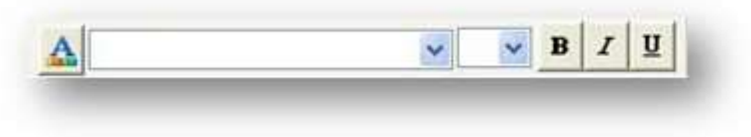
2. If needed, open the Default Settings tab.



3. Set the default values as needed

Option	Description
Show Grid	Displays a background grid (a set of intersecting lines used to align objects) on the datasheet.
Show Page Breaks	Displays the edges of the print pages in Print Preview mode.
Snap to Grid	When moving a field, aligns (or "snaps") the field to the nearest

	intersection of lines in the grid, even if the grid is not visible.
Data	Show Border—Shows the border around all fields. Show Field Type—Displays the icon for each field at the top left corner of the field. Data Alignment—The horizontal alignment of the data that is displayed in the fields. Values are Left, Center, and Right.
Heading	Display Heading—Displays the field name as the field heading for each field. Heading Position—The location of the field heading relative to the field. Values are Top, Left, Bottom, and Right. Heading Alignment—The alignment of the field heading relative to the field. Values are Left (aligned with the left edge of the field), Center (centered relative to the field), and Right (aligned with the right edge of the field.



Use the formatting options to format the font color, font type, font size, and font properties (Bold, Italics, or Underline) for the data that is entered into a field, the field headings, and any static text on the datasheet.

Figure 3-9: Properties dialog box, tab

To set the field properties on a field by field basis

You can set the properties for all fields on the datasheet, including static text fields, on a field by field basis.

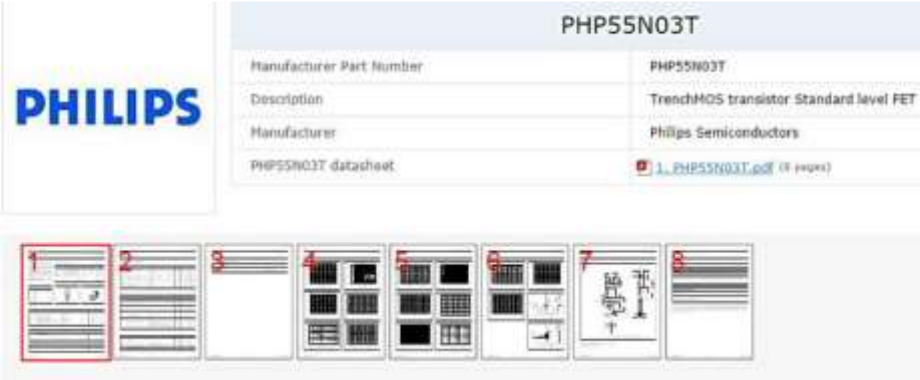
1. Select the field for which you are setting the properties.
2. On the datasheet toolbar, click the Properties button 

 to open the Properties dialog box.
3. If needed, open the Field Properties tab. The database name of the selected field (including the name of its folder) is displayed in the Field Name field and you cannot change this value.
4. Set the default values as needed.

Option	Description
General	Show Border – Shows the border around the field. Show Field Type – Displays the icon for the field at the top left corner of the field. Tab Order – The order in which a user tabs through the fields on a datasheet. The default tab order is the order in which you added the fields to the datasheet.
Data	Data Alignment – The horizontal alignment of the data that is displayed in the field. Values are Left, Center, and Right.
Heading	Display Heading – Displays a user-defined value as the heading for the field. Note: Any value that you enter here does not overwrite the database name for the field. It is simply a display value for the field on the datasheet. Heading Position – The location of the field heading relative to the field. Values are Top, Left, Bottom, and Right. Heading Alignment – The alignment of the field heading relative to the field. Values are Left (aligned with the left edge of the field), Center (centered relative to the field), and Right (aligned with the right edge of the field.
Use the formatting options to format the font color, font type, font size, and font properties (Bold, Italics, or Underline) for the data that is entered into the field, the field heading, or any static text on the datasheet.	

Additional Data

ЧТО ТАКОЕ ДАТАШИТ И ЗАЧЕМ ОН НУЖЕН



Вы слышали это словечко — даташит? Наш лексикон последние годы изрядно обогатился англицизмами. Люди, которые занимаются электроникой и разбирают компьютеры, наверняка знакомы с этим термином. Те, кто только готовится окунуться в это увлекательное дело, читаем дальше!

Даташит — это транслитерированное **data sheets**, справочные листы с информацией. Представляет собой официальный документ производителя электронных компонентов.

Там приводятся техническое описание компонента, его параметры, режимы эксплуатации, схемы включения и другая информация.

НЕМНОГО ИСТОРИИ

Сейчас абсолютное большинство электронных компонентов, которые присутствуют на рынке, изготовлены зарубежными производителями. В Советском Союзе было наоборот: при изготовлении электроники использовали в большинстве своем отечественные компоненты.

На каждый компонент изготовителем поставлялись технические условия (ТУ), которые найти можно было только на заводах, где электронную аппаратуру изготавливали. В свободном доступе их не было.

В технических условиях было все то (и даже больше), что имеется в нынешних даташитах. Существовали бумажные справочники, где была собрана самая необходимая информация, которые найти было уже легче.

Сейчас любой data sheets можно очень легко найти. Надобность в толстых бумажных справочниках отпала.

ЧТО МОЖНО НАЙТИ НА ПЕРВОЙ СТРАНИЦЕ ДАТАШИТА?

Philips Semiconductors — Product specification

TrenchMOS™ transistor
Standard level FET — **PHP55N03T**

GENERAL DESCRIPTION

N-channel enhancement mode standard level field-effect power transistor in a plastic envelope using 'trench' technology. The device features very low on-state resistance and has integral zener diodes giving ESD protection up to 2kV. It is intended for use in DC-DC converters and general purpose switching applications.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MAX.	UNIT
V_{DS}	Drain-source voltage	30	V
I_D	Drain current (DC)	55	A
P_{tot}	Total power dissipation	103	W
T_j	Junction temperature	175	˚C
$R_{DS(ON)}$	Drain-source on-state resistance V_{GS} = 10 V	18	mΩ

Сразу отметим, что первую страницу даташита формируют не только техники-инженеры, но и специалисты по маркетингу и рекламе. Электронные компоненты производят для того, чтобы их покупали, поэтому надо показать товар лицом. На первой странице data sheets приводятся:

- **свойства компонента (features),**
- его основные параметры (quick reference data),
- **обозначение на принципиальных схемах (symbol),**
- краткое описание (general description).

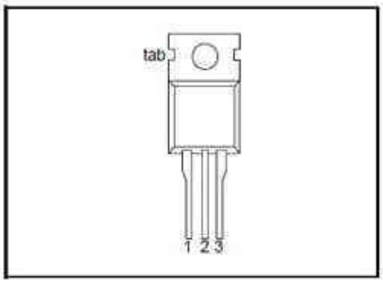
Могут описываться предельные режимы эксплуатации (limiting values, absolute maximum rating) или что-то в этом роде. Часто приводят изображения корпуса компонента и назначение выводов (pinning information, pin description).

С первого листа должно быть понятно, что за штуковина перед нами.

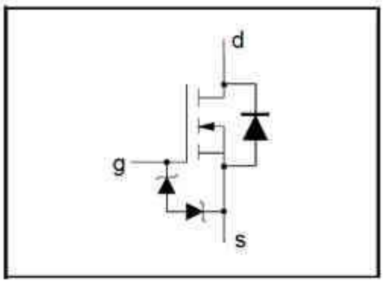
PINNING - TO220AB

PIN	DESCRIPTION
1	gate
2	drain
3	source
tab	drain

PIN CONFIGURATION



SYMBOL



Вот как выглядит, например, первый лист даташита на MOSFET (полевой транзистор) 55N03T. Мы сразу видим, что это транзистор very low on-state resistance (имеет низкое сопротивление открытого канала сток-исток Rds), 18 мОм при напряжении затвор-исток Vgs 10 В.
Такое сопротивление получено с помощью trench-технологии. Область применения (applications) — сильноточные ключи (high current switching), высокочастотные (high-frequency) dc-dc конверторы для компьютерных материнских плат (computer motherboard).
И действительно, этот транзистор я выдрал с неисправной материнской платы компьютера. Конвертер на материнской плате из напряжение 12 В блока питания выдает напряжение 1 с лишним В для питания ядра процессора.

Ниже расположена цоколевка (pinning) транзистора, разновидности корпусного исполнения. В конце первого листа приведена таблица предельных режимов, из которых видно, что максимально мощность, рассеиваемая транзистором (total power dissipation), не должна превышать 103 Вт. Естественно, с наличием радиатора.

LIMITING VALUES

Limiting values in accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{DS}	Drain-source voltage	-	-	30	V
V_{DGR}	Drain-gate voltage	R_{GS} = 20 kΩ	-	30	V
$\pm V_{GS}$	Gate-source voltage	-	-	20	V
I_D	Drain current (DC)	T_{mb} = 25 °C	-	55	A
I_D	Drain current (DC)	T_{mb} = 100 °C	-	38	A
I_{DM}	Drain current (pulse peak value)	T_{mb} = 25 °C	-	220	A
P_{tot}	Total power dissipation	T_{mb} = 25 °C	-	103	W
T_{stg}, T_j	Storage & operating temperature	-	- 55	175	°C

Температура (рабочая и хранения) транзистора должна лежать в пределах от минус 55 до плюс 175.

ЧТО ЕЩЕ ЕСТЬ В ДАТАШИТЕ?

STATIC CHARACTERISTICS

T_j= 25°C unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{(BR)DSS}$	Drain-source breakdown voltage	V_{GS} = 0 V; I_D = 0.25 mA;	30	-	-	V
		T_j = -55°C	27	-	-	V
$V_{GS(TO)}$	Gate threshold voltage	V_{DS} = V_{GS}; I_D = 1 mA	2.0	3.0	4.0	V
		T_j = 175°C	1.0	-	-	V
		T_j = -55°C	-	-	4.4	
I_{DSS}	Zero gate voltage drain current	V_{DS} = 30 V; V_{GS} = 0 V;	-	0.05	10	μA
		T_j = 175°C	-	-	500	μA
I_{GSS}	Gate source leakage current	V_{GS} = ±10 V; V_{DS} = 0 V	-	0.02	1	μA
		T_j = 175°C	-	-	20	μA
$\pm V_{(BR)GSS}$	Gate source breakdown voltage	I_G = ±1 mA;	16	-	-	V
$R_{DS(ON)}$	Drain-source on-state resistance	V_{GS} = 10 V; I_D = 25 A	-	15	18	mΩ
		T_j = 175°C	-	-	33.5	mΩ

Далее идут электрические и температурные характеристики, причем параметры содержат минимальное, типовое и максимальное значение. Как ни отлаживай технологию производства, всегда будет существовать разброс параметров.

Типовое — это наиболее вероятное значение.

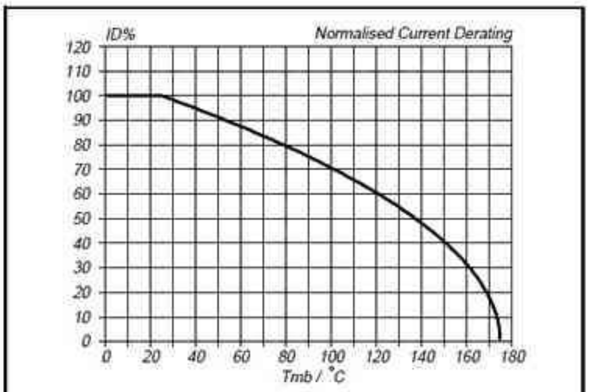


Fig.2. Normalised continuous drain current.
$ID\% = 100 \cdot I_D/I_{D\,25\,°C} = f(T_{mb})$; conditions: $V_{GS} \geq 10$ V

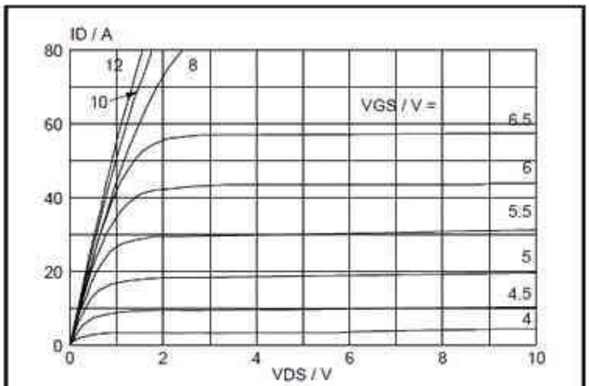


Fig.5. Typical output characteristics, T_j = 25 °C.
$I_D = f(V_{DS})$; parameter V_{GS}

Даташиты могут содержать графики зависимости одного параметра другого. Например, в нашем случае зависимость тока стока от напряжения сток-исток при определенных значениях напряжения исток-затвор. В заключение приводится информация о температурном режиме при монтаже (пайке) компонента, его упаковки маркировки и схемах включения.

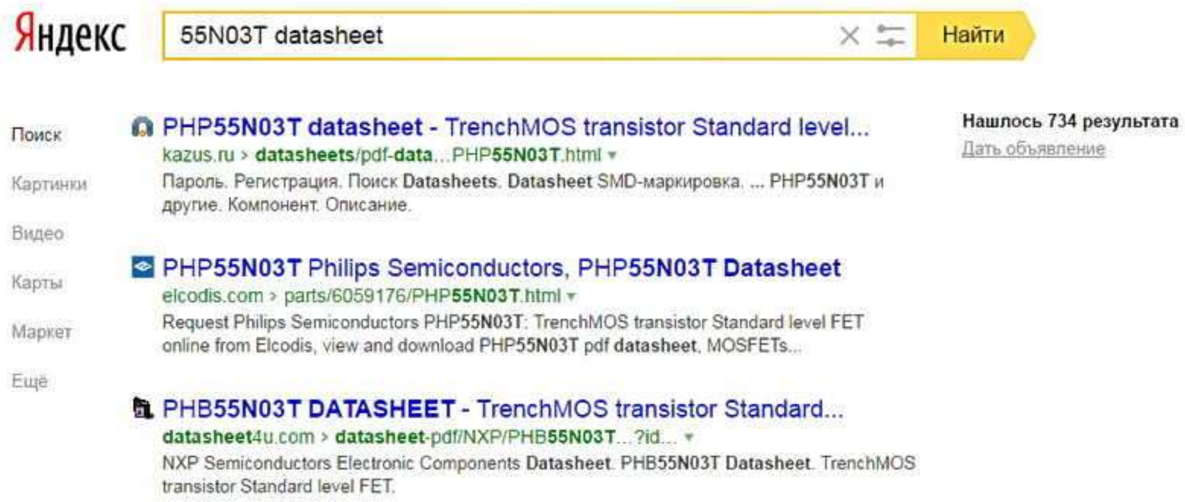
ЗАЧЕМ НУЖЕН ДАТАШИТ?

Из всего сказанного понятно, что datasheet нужен *разработчикам электронных изделий*, чтобы правильно использовать электронный компонент при разработке аппаратуры.

В то же время справочными данными могут пользоваться и ремонтники, чтобы заменить вышедшую из строя «железку» аналогичной.

В этом случае используются только некоторые данные из даташита — *предельно допустимые режимы или типовые значения параметров.*

ГДЕ МОЖНО НАЙТИ ДАТАШИТ?



Его можно найти в интернете. Достаточно вбить в поисковую систему фразу «маркировка компонента datasheet». Например, в нашем случае будет «55N03T datasheet». Маркировка (или часть ее) наносится на корпус электронного элемента. Существует множество сайтов- каталогов электронных компонентов. Как правило, даташиты приводятся в формате PDF. Заканчивая, отметим, что иногда официальные документы могут содержать некоторые неточности. Поэтому хорошо бы скачать разные даташиты одного и того же компонента и сравнить.

Раздел 3 Монтаж и сборка средней сложности узлов, блоков, приборов радиоэлектронной аппаратуры. Тема 3.1 Элементы и узлы радиоэлектронной аппаратуры

PRACTICAL MATERIAL

TEXT 3 MAIN COMPONENTS OF A CIRCUIT (Resistors)

Now any circuit consists essentially of a combination of resistance, inductance and capacitance with one or more sources of electromotive force. Let us consider these main components of a circuit. At first let us speak about resistance and resistors. The property of “opposing” or weakening the current is called electrical resistance. Georg Ohm in the early part of the 19th century performed a series of experiments which established the law connecting voltage and current.

Symbolically, Ohm’s law is often written: $R = U/I$

Resistance equals voltage divided by current. The unit of resistance is the Ohm. An ohmmeter is used to measure the value of resistance in a circuit. Different materials have different resistances. All substances may be divided into three groups according to their resistivities: conductors, semiconductors and dielectrics or insulators. A good conductor is a material of low resistivity. An insulator is a material of very high resistivity. The resistance of a conductor depends on a) the length, b) the cross-sectional area, c) the material of the conductor and its temperature. A resistor is a device employed to limit the value of current. Resistors may be fixed or variable. Fixed resistors have a constant value. The value of variable or adjustable resistors may be varied. A rheostat is another type of a variable resistor.

Active Vocabulary

1. adjustable resistor - резистор переменного сопротивления
2. capacitance - емкость
3. to consist of - состоять из
4. cross-sectional area - площадь в поперечном разрезе
5. to depend on - зависеть от
6. to divide - делить; разделять
7. electromotive force - электродвижущая сила
8. to equal - равняться
9. essentially - по существу
10. to establish - устанавливать; учреждать
11. fixed resistor - резистор постоянного сопротивления
12. insulator - изолятор
13. inductance - индуктивность
14. law - закон
15. length - длина
16. to measure - измерять
17. to oppose - сопротивляться, противодействовать
18. to perform an experiment - проводить опыт
19. resistivity - удельное сопротивление
20. semiconductor - полупроводник
21. series - серия, ряд
22. source - источник
23. substance - вещество
24. unit - единица
25. value - значение; величина
26. variable resistor - регулируемое сопротивление, переменный резистор
27. to vary - изменяться
28. voltage - напряжение
29. to weaken - ослаблять

Exercise 1. Answer the next questions

1. What main components does a circuit consist of? 2. What’s electrical resistance? 3. What is the unit of resistance? 4. Is an ohmmeter used to measure the value of resistance? 5. Into what groups may all substances be divided according to their resistivities? 6. What substance is called a good conductor? 7. What does the resistance of a conductor depend on? 8. Have insulators a very low or high resistance? 9. What two types of resistors do you know?

Exercise 2. Find suffixes in nouns. Translate the new noun

to resist - resistance - resistor; to insulate – insulator; to - conduct – conductor - conduction; to depend – dependence; to discover - discovery; to produce – production; to equal – equality; to consider - consideration; to measure - measurement; to improve - improvement; to invent - inventor - invention.

Exercise 3. Group the couple of synonyms

1. substance a) chief; 2. main b) to change; 3. to use c) to regulate; 4. fixed d) to produce; 5. to make e) stable; 6. to adjust f) material; 7. to vary g) to employ

Exercise 4. Fill in the blanks in the next sentences, choosing one of the three words related to the meaning. Translate the sentences into Russian

1. Current passes through . . . with great difficulty. a) conductors; b) insulators; c) metals. 2. Fixed resistors have a . . . value. a) varied; b) constant; c) changeable. 3. The value of a . . . is varied. a) variable resistor; b) fixed resistor; c) very stable resistor (высокостабильное сопротивление) 4. Current equals . . . divided by resistance. a) resistivity; b) inductance; c) voltage. 5. A . . . which is a good insulator at low temperature may be a good conductor at high temperatures. a) property; b) substance; c) source. 6. An ohmmeter is used to . . . the value of resistance in a circuit. a) divide; b) measure; c) transmit. 7. An engineer must know physical and mechanical . . . of materials. a) components; b) achievements; c) properties. 8. Mendeleyev discovered the periodic. . . . a) application; b) unit; c) law.

Exercise 5. Use the verbs given in brackets in the necessary form of Active Voice

1. A rheostat (to be) a resistor whose resistance value may be varied. 2. Last week they (to make) many experiments. 3. Any circuit (to consist of) a combination of resistance, inductance and capacitance. 4. Next week he (to demonstrate) this new device. 5. Popov (to invent) the first radio-set. 6. A resistor (to be) a device to limit the value of current. 7. An ohmmeter (to measure) the value of resistance in a circuit. 8. Resistance (to equal) voltage divided by current.

Exercise 6. Open the brackets and use the Participle II

1. The work (to do) by these scientists resulted in many new discoveries. 2. A new transmitting station (to build) in our region is very powerful. 3. The phenomenon (to study) by this engineer is of great importance for our work. 4. Radio waves (to radiate) by the antenna travel in all directions. 5. The experiments (to make) by him were very useful for our work. 6. New measuring instruments (to develop) in this laboratory will be used in this experiment. 7. A device (to employ) to limit the value of current is a resistor. 8. The antenna receives only a small part of energy (to radiate) by the transmitter.

TEXT 4 A CAPACITANCE AND CAPACITORS

Resistance and resistors were discussed in text 4. In this text capacitance and capacitors will be considered. If two conductors are separated by an insulating space and a charge is given to the plates, the opposite sort on each side, then a potential difference exists between the plates. The two plates, together with the insulating space, have capacitance. Devices which have the ability to condense the charge are called condensers or capacitors. The simplest condenser consists of two plates separated by an insulator. Its capacitance depends on its shape, size and material. Every condenser does not consist merely of two plates, there may be very many, but they are connected together in such a way that one group is separated from the other by the dielectric. In practice the most common types of dielectrics are: air, mica, paper, plastics, etc. Two common types of condensers are in use nowadays: a fixed condenser and a variable one. There are three quantities which can be varied: the plate area, the distance between the plates and the dielectric. The basic unit of capacitance is the farad. The farad (F) is too large a unit for practical purposes and the practical units in use are the microfarad (mF) and the micromicrofarad (mmF), sometimes called the picofarad (pF).

Active Vocabulary

1. ability - способность
2. charge - заряд
3. common - общеизвестный; обычный
4. to insulate - изолировать
5. merely - только, просто
6. mica - слюда
7. plate - пластина; обкладка (конденсатора)
8. potential difference - разность потенциалов
9. purpose - намерение; цель
10. quantity - количество; величина
11. to separate - отделять, разделять
12. side - сторона
13. size - размер
14. shape - форма
15. space - пространство

Exercise 1. Answer the next questions

1. What devices are called condensers? 2. What does the simplest condenser consist of? 3. What does the capacitance of a condenser depend on? 4. In what way are the plates of a condenser connected together if a capacitor consists more than of two plates? 5. What are the most common types of dielectrics? 6. What types of condensers are in use nowadays? 7. What quantities can be varied in a condenser? 8. What is the basic unit of capacitance?

Exercise 2. Translate the next verbs considering the prefixes

reproduce, repay, recreate, remark, reform, retell, rebuild, reconstruct, readjust.

Exercise 3. Find the Russian equivalents for the English words and word combinations

1. device а) ослаблять; 2. size б) слюда; 3. charge в) поток; 4. potential difference г) заряд; 5. exist д) электродвижущая сила ЭДС; 6. mica е) существовать; 7. electromotive force ж) устройство, прибор; 8. flux з) разность потенциалов; 9. weaken и) величина, размер

Exercise 4. Fill in the blanks un the sentences choosing the one from three words related to the meaning. Translate the sentences

1. The unit of measurement of . . . is the Ohm. a) capacitance; b) resistance; c) conductor. 2. The . . . of capacitance is called the farad. a) device; b) po1e; c) unit. 3. The main parts of a . . . are metal plates and insulators. a) resistor; b) amplifier; c) capacitor. 4. The . . . of a variable capacitor move. a) insulators; b) plates; c) units. 5. Both electromotive force and . . . are measured in volts. a) resistance; b) potential difference; c) capacitance. 6. The plates of a . . . cannot be moved. a) variable capacitor; b) fixed capacitor; c) insulator. 7. Capacitance is the . . . of a circuit that opposes any change of voltage in a circuit. a) property; b) application; c) source. 8. A fixed capacitor has . . . produced of paper, mica and other materials. a) insulators; b) plates; c) oscillators.

Exercise 5. Change the sentences from Present Indefinite Passive into Past (Future) Indefinite Passive.

1. Fixed capacitors are used in telephone and radio devices. 2. Automatic devices are made in our laboratory. 3. The plates of a condenser are separated by an insulator. 4. Scientific reports are published in our magazine. 5. The two parts of a magnet that show the strongest magnetism are called the north pole and the south pole.

Exercise 6. Use the verbs in brackets in Present, Past или Future Indefinite Passive Voice

1. This phenomenon (to study) by a group of scientists two months ago. 2. A device which has the ability to condense a charge of electricity (to call) a capacitor. 3. A new transmitting station (to build) in this region next year. 4. Copper (to use) to produce wire conductors. 5. Yesterday a very interesting experiment (to make) in our laboratory. 6. The properties of silver (to discuss) next week.

Exercise 7. Use the verbs in brackets in Present, Past, Future Indefinite Active or Passive Voice

1. Every student knows that an insulator (to call) a dielectric. 2. The engineer (to find) practical application of these circuits, the results were good. 3. The simplest condenser (to consist) of two plates separated by an insulator. 4. These three quantities (to measure) in our experiment next week. 5. Radio (to invent) in Russia. 6. When the current is small, a galvanometer (to use). 7. They (to measure) these quantities tomorrow. 8. This young engineer (to make) a new device and we used it in our experiment.

Exercise 8. Ask questions to the marked parts of the sentence

1. **Devices** which have the ability **to condense** the charge are called condensers. 2. An ohmmeter **is used to measure** the value of resistance in a circuit. 3. The proton was discovered **by Rutherford**. 4. Many technical problems will be solved **by Russian scientists in the near future**. 5. Electromagnetic waves are used **in radio and television transmission**. 6. A rheostat is used **to change resistance of circuits**, and in this way **to vary the value of current**. 7. **The theory of radio-transmitting and radio receiving devices** was improved by Russian scientists. 8. Amplifiers are used when **we want to make signals bigger.**

TEXT 4 B CAPACITANCE AND CAPACITORS

Exercise 1. Read the text trying to understand the point of it

Capacitance is the property of a circuit which makes it possible to store* a charge of electricity. Capacitance is a very important property of electrical and electronic circuits. Without capacitance radio and television could not exist. A capacitor is a device which has the ability to store a charge of electricity. When we speak of a capacitor we mean a system of two conductors which are insulated from one another. The main parts of a capacitor are metal plates and insulators. The simplest capacitor or condenser consists of 2 plates separated by an insulator. There are two common types of capacitors: a fixed capacitor and a variable one. The capacitance of a condenser is measured in farads.

Notes

* to store - накапливать, запасать

Exercise 2. Answer the questions

1. What property of a circuit is called capacitance? 2. Why is capacitance a very important property of electrical and electronic circuits? 3. What device is called a capacitor? 4. What are the main parts of a capacitor? 5. What does the simplest capacitor consist of? 6. What are the common types of capacitors?

Exercise 3. Finish the sentences choosing one of the given variants which matches the text point

1. Capacitance is the property of a circuit which makes it possible a) to store a charge of electricity; b) to reduce the current in the circuit; c) to increase the voltage output. 2. The main parts of a capacitor are a) insulators only; b) metal plates and insulators; c) metal plates only. 3. Capacitance is a very important a) function of the electric and electronic circuits; b) part of any circuit; c) property of electrical and electronic circuits. 4. When we speak about a capacitor we mean a) a combination of 2 resistors; b) a system of 2 electric cells, c) a system of 2 conductors insulated from one another.

Exercise 4. Retell the text using the next words and group of words

Capacitance, a property of a circuit, to store a charge of electricity, property of electrical and electronic circuits, a system of 2 conductors insulated from one another, the main parts of a capacitor, two types of capacitors, a fixed capacitor, a variable capacitor, to measure in farads.

TEXT 5 INDUCTANCE AND INDUCTORS

If a piece of wire is wound into a coil it is found that when a steady voltage is applied across it, the current does not immediately reach its final value but slowly builds up the final value. The property of the coil which gives rise to this phenomenon is called its inductance, for which the symbol L is used. Elements of a circuit with a definite value of inductance are coils of wire called inductors. The practical unit of inductance is the Henry. Most inductors are rated in millihenries and in microhenries. The inductors may be variable or adjustable and fixed. In modern electronic equipment the variable inductors have a powdered-iron core* that can be moved in and out of the coil. As this powdered-iron core is moved further into the windings the lines of magnetic force become more concentrated and increase the inductance. Powdered-iron core inductors are used as antenna coils (often also serve as the antenna), primary and secondary windings of i.f. transformers, etc. Fixed inductors may have either air or iron for cores. Iron-core inductors are very heavy. Air-core inductors are generally used as antenna coils, primaries and secondaries of some i.f. transformers.

Notes:
*powdered iron-core - сердечник из прессованного порошкового железа.

Active Vocabulary

1. to apply a steady voltage - подавать постоянное напряжение
2. coil - катушка
3. core - сердечник
4. either . . . or - или . . . или
5. equipment - оборудование
6. to give rise to - вызывать (что-либо)
7. i.f. transformer - трансформатор промежуточной частоты
8. immediately - немедленно, тотчас
9. to increase - увеличивать, усиливать
10. to move - двигать(ся)
11. piece - кусок
12. primary winding - первичная обмотка
13. secondary winding - вторичная обмотка
14. to serve - служить
15. to wind - наматывать

Exercise 1. Modal Verbs and their equivalents. Translate the sentences considering the modal verbs

1. All substances may be divided into conductors, semiconductors and insulators. 2. Atoms must be used for peace. 3. For a long time scientists could not discover the secret of the atom. 4. They were allowed to take part in this discussion. 5. I think that I shall be able to explain this phenomenon. 6. You mustn't take these materials. 7. They will have to listen to this lecture. 8. There is hardly any sphere of life where the atom may not find useful application. 9. Every radio engineer ought to know the fundamentals of radio engineering. 10. This important information should be transmitted as soon as possible. 11. The inventor is to come at 10 o'clock in the morning.

Exercise 2. Answer the next questions

1. What is called an inductor? 2. What is the unit of practical inductance? 3. What types of inductors do you know? 4. What types of cores are used for inductors? 5. In what way can you increase the inductance of a variable inductor? 6. Are inductors used as antenna coils, primaries and secondaries of i.f. transformers?

Exercise 3. Make adverbs from adjectives

slow, wide, general, simple, great, deep, complete, negative.

Exercise 4. Find Russian equivalents for English ones

1. give rise to smth а) оборудование; 2. wire б) явление; 3. steady в) наматывать; 4. powder г) постоянный, неизменный; 5. wind (wound, wound) д) достигать, доходить; 6. reach е) трансформатор; промежуточной частоты7. equipment ж) проволока; 8. phenomenon з) вызывать что-либо; 9. i.f. transformer и) порошок; 10. powdered iron-core к) сердечник из прессованного порошкового железа

Exercise 5. Find the antonyms (a, b, c) to the underlined words

1. The primary question. a) principal, b) different, c) secondary. 2. A constant value. a) variable, b) high, c) low. 3. Similar problems. a) well-known, b) different, c) important. 4. The same conductors. a) different, b) similar, c) good. 5. Modern electronic equipment. a) new, b) old, c) good.

Exercise 6. Change the Russian words with English ones and translate them into Russian

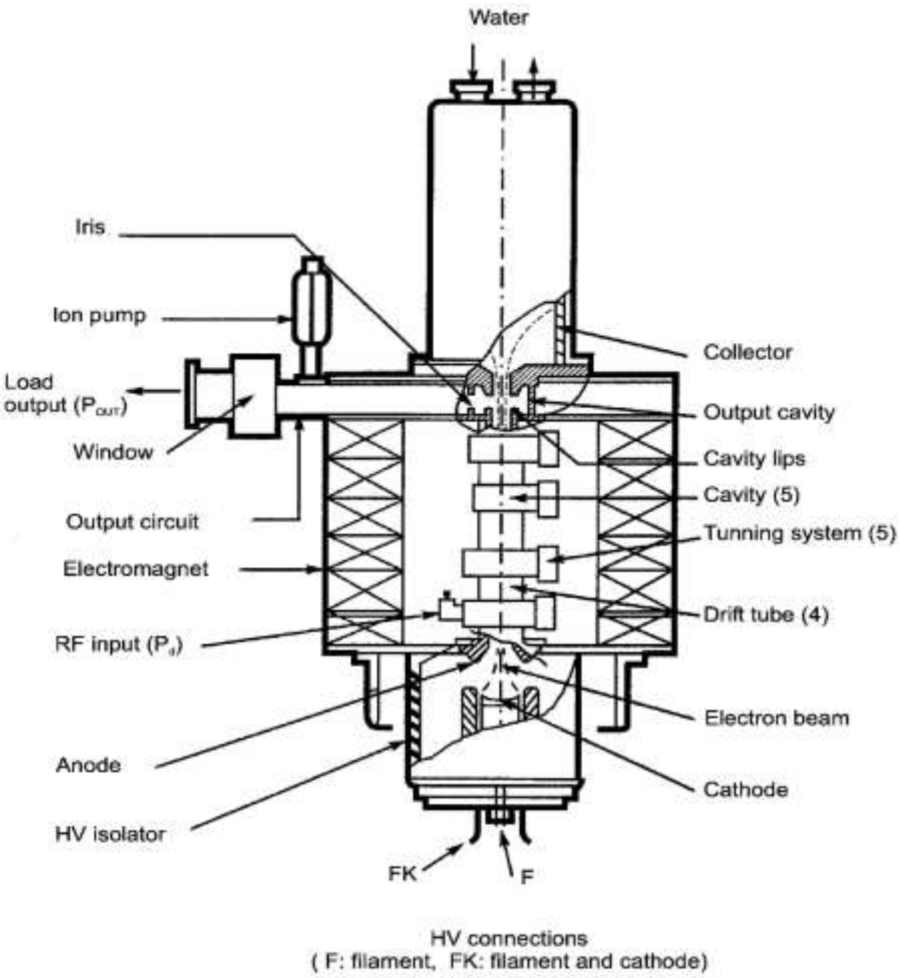
1. The core (можно) be moved in and out in variable inductors. 2. Last summer we (предстояло, должны) to take part in the construction of a new building of our Institute. 3. Radioactive elements (можно) be widely used in medicine, agriculture and other fields of scientific research. 4. Theory (не может) exist alone without practice. 5. You (должны) know the properties of this metal well. 6. He (вынужден, пришлось) to stay at the Institute yesterday.

Exercise 7. Translate the sentences into English

1. Мы должны закончить этот эксперимент через 2 месяца. 2. Сопротивления могут быть постоянными и переменными. 3. Герц смог доказать существование электромагнитных волн. 4. Вам придется использовать этот прибор. 6. Мы знаем, что теория не может существовать без практики

TEXT 6 KLYSTRONS. KLYSTRONS AMPLIFIERS

Klystrons are designed to produce high-power microwaves from a relatively low-power input. These tubes consist of a beam tube with two toroidal resonator cavities. The tube has a cathode and anode that are set up to produce a high-energy electron beam. An RF signal is introduced into the left hand cavity and, in turn, modulates the electron beam. The modulated electron beam resonates in the right hand cavity and generates a modulated microwave output. These tubes are commonly used on military radar sets. ***Fig. 1.*** *Klystron cross-section*



Introduction

Klystrons are amplifier microwave tubes, designed mainly for use at high frequencies from about 0.3 GHz to approximately 30 GHz. They are characterized by high gains (around 50 dB) and high output powers:

- 3 kW CW tunable from 14 to 14.5 GHz with efficiency η = 40%,
- 60 MW with 4 µs pulses at 3 GHz (η = 38%),
- 1.3 MW CW at 352 MHz with η going up to 65%,
- 500 kW CW at 3.7 GHz with η = 45%.

However, almost all klystron instantaneous bandwidths are fairly limited. In a klystron (Fig. **1**.), the main functions are separated, which means that design and technology factors can be optimized for each function. These functions are the electron emission, the magnetical beam focusing, the electron bunching or the beam density modulation, the extraction of the microwave energy and, lastly, the dissipation of residual energy.

Interaction in a Klystron: Modulations and Energy Extraction

Thanks to a high voltage $-V0$ applied to the cathode in regard the anode, a Pierce type electron gun generates an electron beam which carries the current $I0 = PV03/2$ according to (1.2) and which is maintained approximately cylindrical thanks to a magnetic field *Bz(z)* over the entire length of the tube. After leaving the anode, the electrons travel across the first cavity, or the input cavity. This cavity is excited by the weak input signal *P*d which is to be amplified and whose frequency *f* is about *f* 0, the cavity's resonance frequency. This cavity is designed to resonate at its fundamental mode TM110 (rectangular) or TM010 (circular) with a maximum electric field *E*1 at the center where the electrons pass. Moreover, this electric field is increased by the fact that the drift tubes, placed on both sides of the cavity, are reentrant (Fig. **2**). Electrons traveling across this narrow gap of the cavity are under action of the periodic electric field *E*1ej*ωt*. They are accelerated for a half of period and decelerated for the other half (Fig. **3**). Consequently, the fast moving electrons from a given half-period catch up with slow moving electrons from the preceding half-period, resulting in the creation of electron bunches. In other words, the velocity modulation produced in the first cavity creates a beam current modulation in the following drift tube, which is expressed as $I_b(z,t)$.

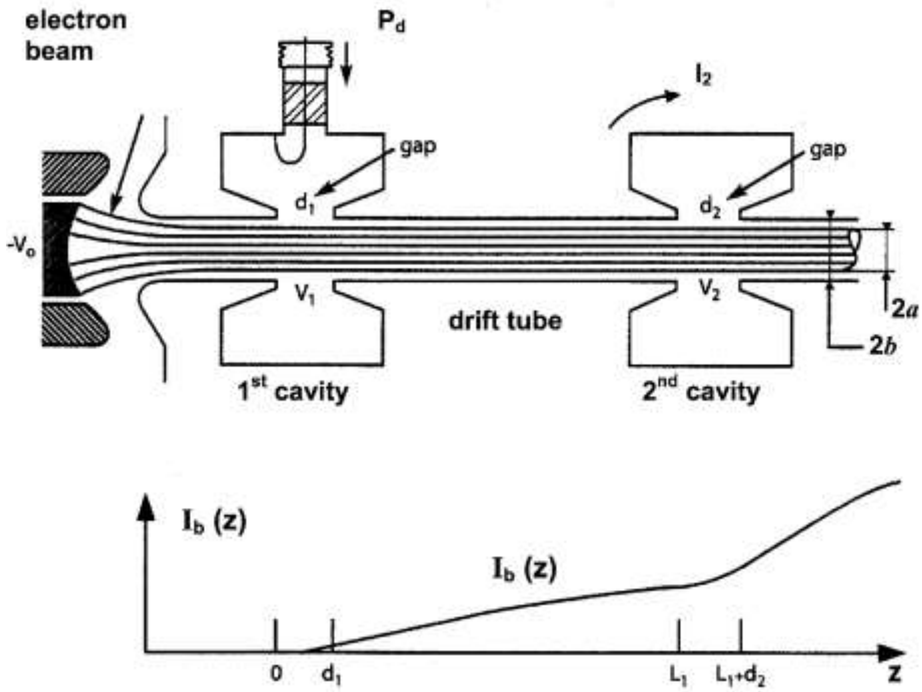


Fig. 2. *Beam modulation along a klystron*

Klystrons Engineering and Technologies

This presentation of different steps of the interaction in a klystron allows us to understand the klystron structure which is designed around the electron beam on one hand and the cavities and the drift tubes on the other hand. From a technological point of view, as shown in Fig. **1**, the constitutive elements of the klystron tube are:

• The Pierce type electron gun, especially with the high voltage insulator and the cathode. The high voltage insulator is a cylinder made of alumina located between the anode and the cathode. Its dimensions are such that the DC electric fields are smaller than the breakdown limit. The electron emissions from the triple point are minimised thanks to a screen, called anticorona ring. The anode is grounded for electrical safety reasons, explaining why the gun and the cathode are usually raised to a negative voltage;
• The modulating cavities (usually frequency tunable in a factory);
•The last or output cavity coupled to the output waveguide thanks to a coupling loop or iris;
•The output window(s) which is located in the waveguide(s) and which separates the external atmosphere from the internal vacuum (≈10-8 Torr) inside the tube. The drive power to be amplified is usually injected inside the first cavity through a coaxial connection which is also vacuum tight thanks to a small input window;
•The collector whose function is to collect the electrons after their interaction in
the last cavity and to dissipate their remaining energy. Moreover, it must be able to dissipate the whole electron beam energy, when $P_d = 0$ and then $P_{OUT} = 0$.
Therefore, it has to be efficiently cooled. The collector is usually at the same potential than the body or the anode;
•The magnetic circuit including an electromagnet, or permanent magnet(s), and the two pole pieces located near the anode and between the collector and the output cavity. These pole pieces concentrate the magnetic flux to get the required focusing B_Z parallel to the axis (B_R/B_Z better than several ‰). The vacuum is usually maintained thanks to a small ion getter pump. However, this pump is not always necessary, because the beam itself has also a pumping function. The accelerated electrons ionize the residual gases. Then the generated ions are electrically attracted by the beam and slowly drained toward the cathode.

We have all watched TV or sat staring at the screens of our computers. The displays for these devices are actually large vacuum tubes, referred to as a cathode ray tube or CRT. The CRT has a cathode grid similar to an ordinary vacuum tube, except that the geometries are designed to produce an electron beam. The beam is directed through a set of focusing plates and finally through an acceleration plate. The result is a high-energy, focused electron that impinges on a coated screen. The coating fluoresces at any point where the beam hits. By sweeping the beam both vertically and horizontally and turning it on and off at precisely timed intervals, an image can be generated on the screen. We have here a commercial CRT of the type that might be found in an oscilloscope.

Photosensitive Tubes

Certain materials exhibit the characteristic of emitting electrons when exposed to light. In the case of a photosensitive vacuum tube electrons are ejected as light impacts the cathode. If a bias voltage is applied across the cathode and anode, then current flows when the tube is exposed to light and doesn't flow when it is in the dark. Similarly, the rate of electron flow can be controlled by the amount of light to which the tube is exposed.

Cathode Ray Tubes (CRT)

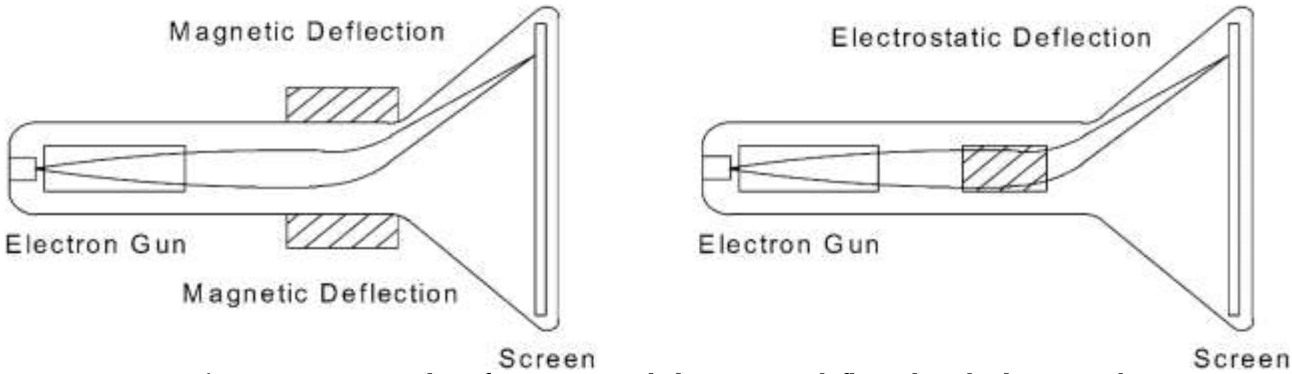


Fig. 1. Basic principles of magnetic and electrostatic deflected Cathode Ray Tube

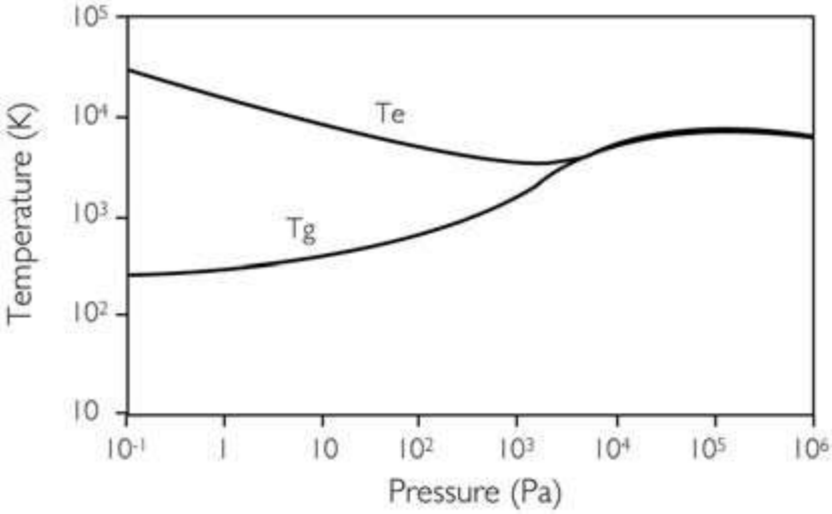
There are only a very few inventions in the modern world which changed the way of life so dramatically like the Television did. Almost no other means opened the eyes of so many million people to the world. The Cathode Ray Tube as the key component is still the magic focus point of countless people every day and night.

Historical Development

If in the year 1897 Ferdinand Braun, the inventor of the Cathode Ray Tube, would have asked a banker for any amount of venture capital to finance the development of the "future billion pieces display", very most likely he would have exposed himself to ridicule. Hundred years later still more than hundred million CRT's are manufactured every year. Despite the upcoming of flat panels in the beginning of twenty first century with reasonable quantities, the vast majority of all displays used worldwide are still using the same basic principle of Mr. Braun's invention. Countless publications on all kind of CRT details were made; gives an excellent review of CRT technologies with a lot of further references.

TEXT 8 GAS DISCHARGE LAMPS

Fig. 1. *Temperatures of electrons and neutral gas as a function of gas pressure*



A gaseous discharge (plasma) is obtained by driving an electric current between two adjacent electrodes through a partially ionized gas enclosed in a discharge tube, typically made of quartz. Also, pulsed discharges with a dielectric barrier between the electrodes and the plasma are used for plasma display applications. Also, electrodeless microwave excited discharges can be used as light sources. Many physical factors influence the electrical and light technical properties of a gas discharge, such as the type and pressure of the gas, electrode material, operating temperature of the electrodes, shape and surface structure of the electrodes, electrode distance, geometry of the discharge vessel, and current density. For the purpose of light generation, two basic types are distinguished: low-pressure and high-pressure discharge lamps. For lighting applications, both are operated in the arc discharge mode, which is characterized by high current densities, more than 1 A/cm2. Electric currents are limited by using inductances or electronic ballasts. In low-pressure discharge lamps, the gas pressure is typically less than 100 Pa. Consequently, the mean free path length of electrons is larger or in the order of the discharge tube diameter, e.g. a few cm. Under these conditions, they gain high energies of more than 1 eV from the applied electric field due to low collision rates with the neutral gas atoms. Finally, the cold atoms are effectively excited by inelastic collisions with the hot electrons. The temperature difference of electrons and atoms reflects the situation of non-thermal equilibrium, as shown in Fig**. 1.** In high-pressure discharge lamps the operating pressure is typically in the range between 10 kPa and 10 MPa. Under these conditions, collisions between electrons and atoms or ions are much more frequent, and a local thermal equilibrium (LTE) with close by or equal particle temperatures is established. In low-pressure gas discharge lamps, atomic line radiation is emitted preferably from resonance transitions of the element with the lowest excitation potential. For mercury these transitions are in the deep UV wavelength region at 185 nm and 254 nm, whereas from sodium visible radiation at 589 nm is emitted. In high-pressure discharge lamps various contributions to the spectrum are obtained: spectrally broadened atomic lines (resonance-, Van der Waals- and Stark broadening), molecular radiation bands and quasi-continuous emission due to free free (Bremsstrahlung) and free-bound (recombination of electrons with ions and atoms) transitions. As a result, the colour rendering properties of high-pressure discharge lamps are fair to excellent, depending on the type of filling.

Review of Gas Discharge Lamps

The light sources differ with respect to the emission spectra and application fields. Luminescent materials are applied for conversion of UV-radiation into visible light for low-pressure mercury, sodium and xenon excimer lamps.

TEXT 9 PLASMA PANEL DISPLAYS (PDP)

Plasma Displays, an emissive flat panel technology combined with a relative large pixel size, are highly suitable for computer data, images and video heading public information, presentation and TV sets.

Historical Development

Electrical discharge in gases is one of the oldest known phenomenon to produce light. Around 1900 this effect became understood as electron beams. Gas discharges are the basis of devices like gaseous triode, rectifying tubes and surge arresters. They break up neutral atoms or molecules into ions and electrons, this state is called plasma – often named as fourth state of matter. An often unknown fact is that the first display application of plasma was the NIXIE tube, as briefly described in the historical development of vacuum displays (Sect. 2.1.1). The technology of plasma displays was invented in the early 1960s, being commercialized about 10 years later with monochrome displays using the orange-red emission of neon gas. Plasma phosphors are based on oxides, while CRTs rely on sulphides.

Colour PDPs

were introduced around 1995, while mass production started 5 years later. The most widespread screen size was 42 (1.06 m) with an aspect ratio of 16:9 and WVGA (832 × 480) resolution. Nowadays (2007) PDPs address the HDTV market. In the mid 1990s plasma driven LCDs were developed but never became a product.

Electrophysical Fundamentals

The basic principle of all plasma displays is to discharge and generating a glow by exciting ions that collide with each other. This effect is also the basis of fluorescent neon tube lighting. If a voltage is applied to a capacitor within a tube filled with a low-pressure gas, several states can occur. At low voltages the gas acts as insulator. By increasing the voltage, a breakdown occurs, the gas becomes ionized and the current through the tube increases by some orders of magnitude. This current has to be limited for display applications.

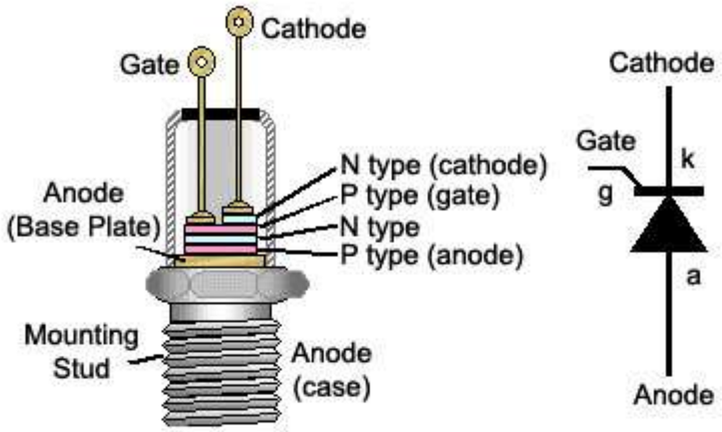
The waveform of the driving signal to generate the plasma is the main categorization characteristic. Plasma devices can be driven either by directed (DC) or alternating (AC) current. DC electrodes interface directly with the gas, while AC electrodes, to enhance their lifetime, are shielded by dielectric films from the plasma. The electrodes form, in the simplest case, a capacitor with gas in between the plates. When they are covered by a dielectric, charges can be stored on theses films forming a capacitor – it results in the memory type. However, there is no plasma display technology available which uses the DC memory effect. Another advantage of the ‘internal’ capacitor is the limitation of the breakdown current when igniting the plasma. The refresh type uses a resistor in series to the pixel capacitor; one DC application was the NIXIE tube. For typical luminance required in applications, the dot matrix refresh types are limited to around 200 lines, which is too small for computer or video applications.

Fig. 1 Typical SCR Packages

Thyristor (SCR) Packages

Thyristor is a general name for a number of high speed switching devices frequently used in AC power control and AC/DC switching, including triacs and SCRs (Silicon Controlled Rectifiers). The SCR is a very common type of thyristor and several examples of common SCR packages are shown in Figure 1. Many types are available that are able to switch loads from a few watts to tens of kilowatts. The circuit symbol for a SCR is shown in Figure 2. and suggests that the SCR acts basically as a **SILICON RECTIFIER** diode, with the usual anode and cathode connections, but with an additional **CONTROL** terminal, called the GATE. Hence the name Silicon Controlled Rectifier. A trigger voltage applied to the gate whilst the anode is more positive than the cathode will switch the SCR on to allow current to flow between anode and cathode. This current will continue to flow, even if the trigger voltage is removed, until anode to cathode current falls to very nearly zero due to external influences such as the circuit being switched off, or the AC current waveform passing through zero volts as part of its cycle.

Fig. 2 Typical SCR Construction & Circuit Symbol



The Silicon Controlled Rectifier (SCR)

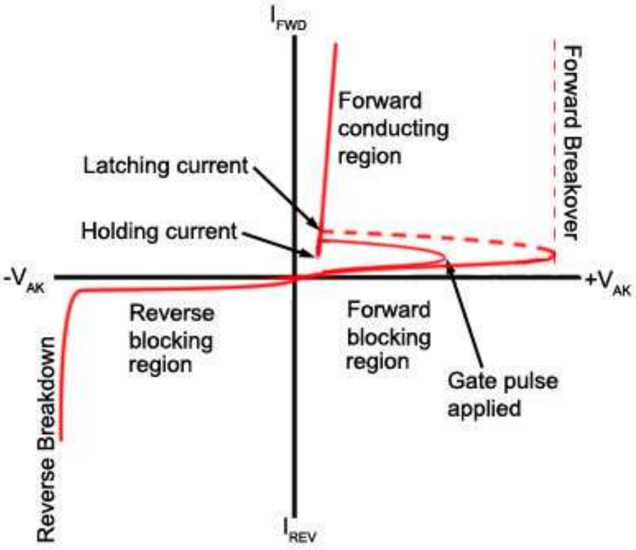
SCRs, unlike normal two-layer PN junction rectifiers, consist of four layers of silicon in a P-N-P-N structure, as can be seen in the cut-away view of a SCR in ***Fig 2.*** The addition of the gate connection to this structure enables the rectifier to be switched from a non-conducting 'forward blocking' state into a low resistance, 'forward conducting' state (see also ***Fig. 3***). So, a small current applied to the gate is able to switch on a very much larger current (also at a much higher voltage) applied between anode and cathode. Once the SCR is conducting, it behaves like a normal silicon rectifier; the gate current may be removed and the device will remain in a conducting state.

The SCR is made to conduct by applying the trigger pulse to the gate terminal while the main anode and cathode terminals are forward biased. When the device is reverse biased a gating pulse has no effect. To turn the SCR off, the anode to cathode current must be reduced below a certain critical "holding current" value, (near to zero).

A common application for SCRs is in the switching of high power loads. They are the switching element in many domestic light dimmers and are also used as control elements in variable or regulated power supplies.

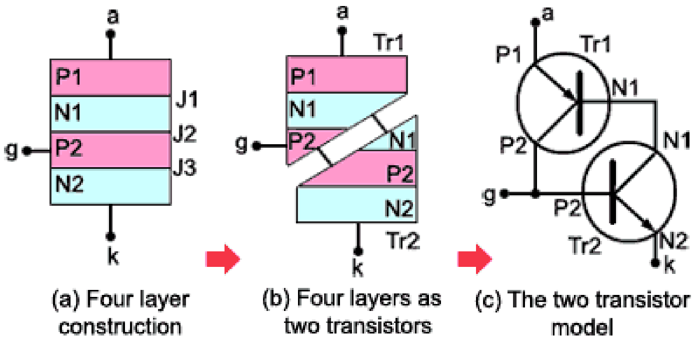
SCR Characteristics

Fig. 3 shows a typical characteristic curve for a SCR. It can be seen that in the reverse blocking region it behaves in a similar way to a diode; all current, apart from a small leakage current is blocked until the reverse breakdown region is reached, at which point the insulation due to the depletion layers at the junctions breaks down. In most cases, reverse current flowing in the breakdown region would destroy the SCR.



When the SCR is forward biased however, unlike a normal diode, rather than current beginning to flow when just over 0.6V is applied, no current apart from a small leakage current flows. This is called the forward blocking mode, which extends to a comparatively high voltage called the 'Forward Breakover Voltage'. The SCR is normally operated at voltages considerably less than the forward break over voltage as any voltage higher than the forward break over voltage will cause the SCR to conduct in an uncontrolled manner; the SCR then suddenly exhibits a very low forward resistance, allowing a large current to flow. This current is 'latched' and will continue to flow until either the voltage across anode and cathode is reduced to zero, or the forward current is reduced to a very low value, less than the 'Holding Current' shown in Fig. 6.0.3. However, the forward break over conduction may occur if the SCR is being used to control an AC (e.g. mains or line supply) voltage and a sudden voltage spike occurs, especially if it coincides with (or close to) the peak value of the AC. If the SCR is accidentally pushed into the forward break over condition, this can produce a sudden but short-lived surge of maximum current, which could prove disastrous to other components in the circuit. For this reason, it is common to find that SCRs have some method of spike suppression included, either within the SCR construction or as external components usually called a 'snubber circuit'. The correct way of triggering the switch on of the SCR is to apply a current to the gate of the SCR whilst it is operating in the ´forward blocking region´, the SCR is then ´triggered´ and its forward resistance falls to a very low value. This produces a ´latching current´, which, due to the low forward resistance of the SCR in this mode, allows very large (several amperes) currents to flow in the ´forward conducting region´ with hardly any change in the forward voltage (notice that the characteristic curve, once the SCR is triggered is practically vertical). In this region current will flow, and may vary, but if forward current falls below the ´holding current´ value or the anode to cathode voltage is reduced to very near 0V, the device will return to its forward blocking region, effectively turning the rectifier off until it is triggered once more. Using the gate to trigger conduction in this way allows conduction to be controlled, allowing the SCR to be used in many AC and DC control systems.

Fig. 4 The SCR 'Two Transistor Model'



How the SCR Works

The SCR Two Transistor Model

The actual operation of the SCR can be described by referring to ***Fig. 6.0.4*** (a) & (b), which shows simplified diagrams of the SCR structure with the P and N layers and junctions labelled. To understand the operation of a SCR, the four layers of the SCR can theoretically be thought of as a small circuit comprising two-transistors (one PNP and one NPN) as shown in Fig. 6.0.4 (b). Notice that layer P2 forms both the emitter of Tr1 and the base of Tr2, while layer N1 forms the base of Tr1 and the collector of Tr2.

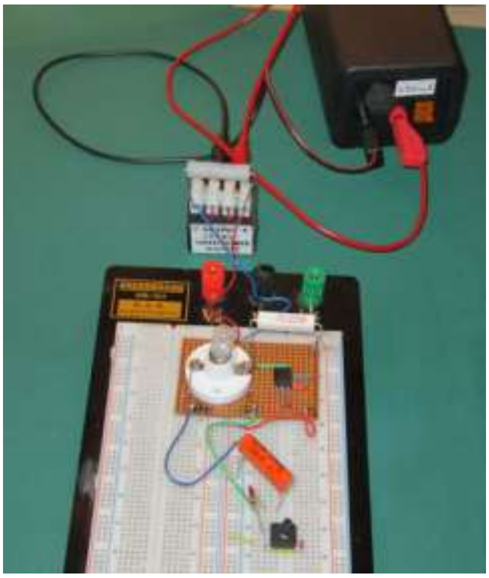
The 'Off' Condition

Referring to the Fig. 6.0.4(c), with no gate signal applied and the gate(g) at the same potential as the cathode (k), any voltage (less than forward break over voltage) applied between the anode(a) and cathode(k) so that the anode is positive with respect to the cathode will not produce a current through the SCR. Tr2 (the NPN transistor) has 0v applied between base and emitter so will not be conducting, and as its collector voltage provides the base drive for Tr1 (the PNP transistor), its base/emitter junction will be reverse biased. Both transistors are therefore switched off and no current (apart from a tiny reverse leakage current) will be flowing between the SCR anode and cathode, and it is operating in its forward blocking region.

Triggering the SCR

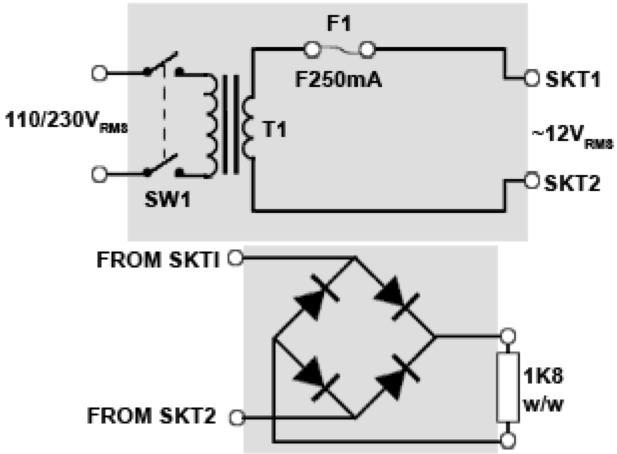
When the SCR is operating in the forward blocking region (see the SCR characteristics in ***Fig. 3***), if the gate and therefore the base of Tr2, see ***Fig 4*** (c) is made positive with respect to the cathode (also Tr2 emitter) by the application of a gating pulse so that a small current, typically a few μA to several mA depending on SCR type, is injected into Tr2 base, Tr2 will turn on and its collector voltage will fall. This will cause current to flow in the PNP transistor Tr1 and a rapid rise in voltage at Tr1 collector and therefore at Tr2 base. Tr2 base emitter junction will become even more forward biased, rapidly turning on Tr1. This increases the voltage applied to Tr2 base and keeps Tr2 and Tr1 conducting, even if the original gating pulse or voltage that started the switch on process is now removed. A large current will now be flowing between the P1 anode(a) and N2 cathode(k) layers. The resistance between anode and cathode falls to near zero ohms so that the SCR current is now limited only by the resistance of any load circuit. The action described happens very quickly, as the switching on of Tr2 by Tr1 is a form of positive feedback with each transistor collector supplying large current changes to the base of the other. As Tr1 collector is connected to Tr2 base, the action of switching on Tr1 virtually connects Tr2 base (the gate terminal) to the high positive voltage at the anode(a). This ensures that Tr2 and therefore Tr1 remain conducting, even when the gating pulse is removed. To turn the transistors off, the voltage across the anode(a) and cathode(k) must either have its polarity reversed, as would happen in an AC circuit at the time when the positive half cycle of the AC wave reached 0V before going negative for the second half of its cycle or, in a DC circuit the current flowing through the SCR is switched off. In either of these cases the current flowing through the SCR will be reduced to a very low level, below the holding current level (shown in ***Fig. 3***), so the base emitter junctions no longer have sufficient forward voltage to maintain conduction.

Fig. 5 Low Voltage SCR Supply



Because SCRs are normally used for controlling high power high voltage loads, this presents considerable risk of electric shock to users in any experimental or educational environments. The circuits are designed to demonstrate the various control methods used with SCRs using low voltage ($12V_{RMS}$) AC as illustrated in ***Fig. 5*** rather than exposing the user to the dangers of using mains (line) voltage. Note that the circuits shown in this module are intended as low voltage demonstrations only, not as working control circuits for mains (line) circuits. For real working examples you should consult application notes produced by SCR manufacturers. The section of the circuit containing the SCR (a C106M SCR), together with a 33R current limiting resistor and a 12V 100mA lamp is constructed on a small piece of Veroboard (protoboard), which can be easily attached to a breadboard using 'Blu Tack' or similar temporary adhesive, allowing various drive circuits to be constructed experimentally on the breadboard. The SCR is supplied with AC via a double pole switch and a 230V to 12V isolating transformer (a small medical isolation transformer is ideal) with a 250mA fuse in the secondary circuit, all housed in a double insulated box.

Fig. 6 Low Voltage SCR Supply Circuits



A bridge rectifier is contained within a separate insulated enclosure with a 1K8 wirewound resistor connected across the output to ensure there is always some load present. This ensures that output waveforms of the 12V full wave rectified output can be reliably displayed on an oscilloscope. These separate circuits, illustrated in ***Fig. 6*** are simply constructed and comprise a useful set for demonstrating and experimenting with different types of SCR or power supply operation at a low voltage.

TEXT 11 SOLID STATE RELAYS

Solid State Relays

Low power solid state relays, consisting basically of an opto triac circuit, such as the type illustrated in ***Fig.1*** can be used as conventional integrated circuits, mounted on a printed circuit board. Alternatively these low power optocouplers can be enclosed within an insulated case along with high power triacs or SCRs and extra safety components, such as heat sinks and pulse suppression components, in larger rack mounted Solid State Relays (SSRs) with just four or five screw type heavy duty terminals that can be treated as mains (line) power switches and can replace many types of electromechanical relays.

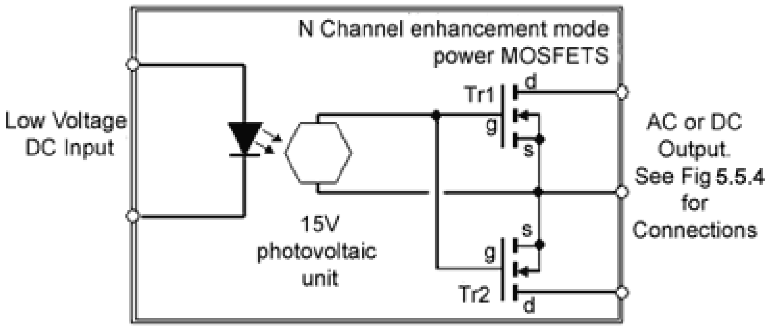


Fig. 3 MOSFET Solid State Relay

One of the most important features of SSRs is for the optocoupling to provide complete electrical isolation between its low power input circuit and its high power output circuit. When the output switch is 'open' (i.e. the MOSFETs are turned off) the SSR has a **nearly** infinite resistance across its output terminals, and an **almost** zero resistance when 'closed' (i.e. MOSFETs conducting heavily). Even so, some power will be dissipated by the semiconductor switch when in either 'on' or 'off' state with either AC or DC currents. For this reason adequate heat sinks are required to prevent overheating.

A typical circuit of a basic MOSFET SSR is shown in ***Figure 3***. A current of about 20mA through the LED is sufficient to activate the MOSFETs that take the place of mechanical relay contacts. The (infra red) light from the LED falls on the Photovoltaic unit that comprises a number of photodiodes. Because a single photodiode will only produce a very low voltage, the diodes in the photovoltaic unit are arranged in a series/parallel array to produce sufficient voltage to turn on the MOSFETS.

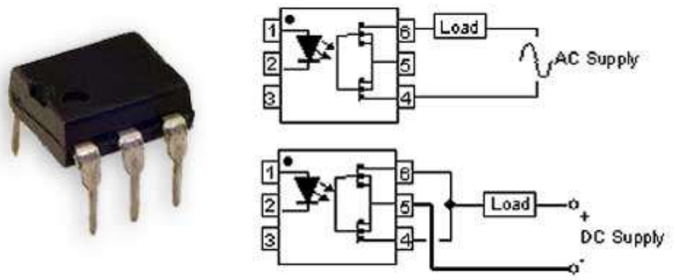


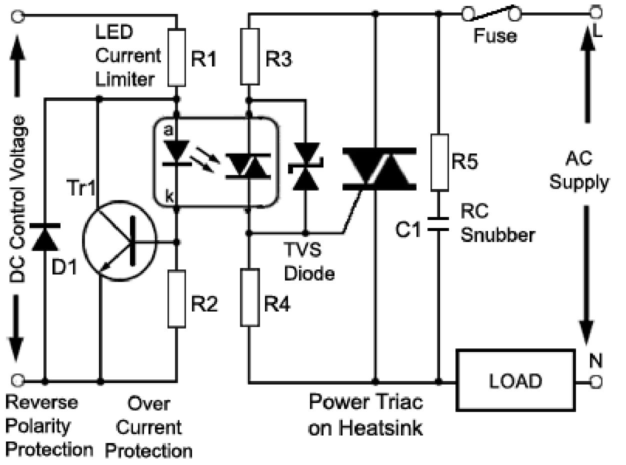
Fig. 4 *Using a MOSFET Relay chip for switching A.C. or D.C.*

Figure 4 represents a basic example of a MOSFET SSR, showing how the outputs can be arranged to allow the SSR to switch either AC or DC loads. A number of similar SSRs are available to meet different AC and DC output voltage and current requirements, a typical example is the PVT412SSR from International Rectifier (now part of Infineon Technologies) manufactured in several versions as a 6 pin DIL package and capable of replacing a single pole mechanical relay to switch AC or DC voltages up to 400V (peak) with currents up to 140mA AC or 210mA DC. Other chips are available that act as double pole, Normally Closed (NC), Normally Open (NO), and Changeover relays with a wide variety of extra facilities. SSRs are also manufactured in a range of output voltages and current ratings, with a range of package types ranging from small surface mount components through complex multi pin chips and large heavy current examples for rack mounting in electrical control cabinets. More information on SSRs can be found by searching for Solid State Relays on manufacturers websites such as Infineon Technologies or at semiconductor suppliers such as RS Components

SSR Safety Features

SSRs consist basically of an optocoupler driving some high power switching device such as a power triac, MOSFETS or a SCR, but as their purpose is to switch high power electrical loads, often in safety critical situations SSRs are manufactured with a wide variety of features, designed to allow for safe and reliable operation. Some of these are illustrated in the circuit shown in Fig 6.6.5:

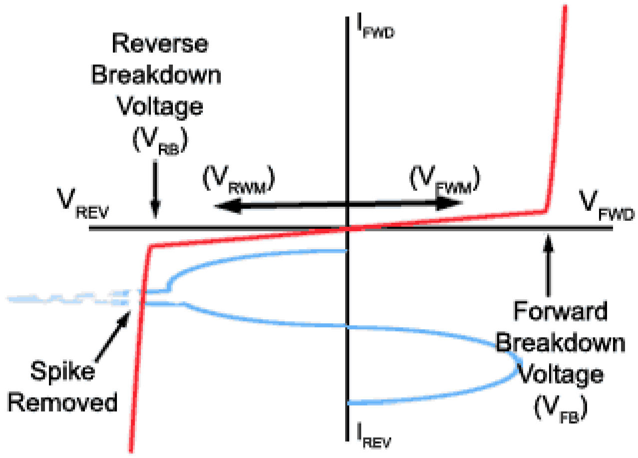
Fig. 5 *Solid State Relay Safety Features*



Reverse Polarity Protection. If the input terminals are connected in the wrong polarity, diode D1 conducts and reduces the voltage at the bottom of R1 to about 0.7V, thereby saving the optocoupler LED from damage. Note that the diode and the current limiting resistor R1 power ratings must be able to withstand the reverse polarity current at maximum input voltage without damage, otherwise a suitably rated input fuse may be inserted between the input positive terminal and the current limiting resistor.

Over Current Protection. It is common for SSRs to be able to work from a range of DC input voltages, for example 5v to 24V. These higher voltages can cause the current through the optocoupler LED to rise higher than its required maximum, in this case the over current protection circuit operates to maintain a suitable current level through the LED. R2 is a low value resistor for current sensing; it's value is chosen so that under normal operating conditions Tr1 is biased just below its cut-off threshold, but if the current through the optocoupler input LED increases due to an excessive input voltage, the extra current through R2 will cause Tr1 to conduct, diverting some of the LED current through Tr1 reducing the voltage at the bottom of R1 and the current though the LED to a safe level.

Fig. 6 Transient Voltage Suppression



Transient Voltage Suppression (TVS) Diode. SSRs used in control situations can be liable to damage caused by sudden and short lived (i.e. transient) voltage spikes, which can be caused by external events such as back emf pulses when switching inductive loads; also remote lightning discharges and other electromagnetic or electrostatic discharges are high risk occurrences for semiconductor devices. Such voltage spikes may be very short in duration but can be hundreds or thousands of volts in amplitude, and although the current they create may be very small, the stress caused by such voltages can cause total failure in the semiconductor devices used in SSRs. One way to reduce these dangerous events is the use of a transient voltage suppressor (TVS) diode connected in parallel with sensitive devices such as the optocoupler as shown in ***Fig. 5***.

Fig. 6 illustrates the action of the TVS diode and shows a sine wave output superimposed on the TVS diode characteristics. The bi-directional TVS diode works rather like two back to back Zener diodes, where above a certain reverse voltage, current breakdown occurs and the diode conducts heavily. As the TVS diode in this case is bi-directional, breakdown occurs in both forward and reverse conditions. In use, a TVS diode must have a breakdown voltage higher than the peak voltage of the AC wave, which is 1.414 x V_{RMS} so a TVS diode with a breakdown voltage about 1.5 times greater than the RMS voltage of the sine wave is normally used. A voltage spike exceeding this limit causes the diode to conduct heavily, limiting its voltage to the breakdown voltage of the diode. A notable difference between a Zener and a TVS diode is that the TVS diode has a more rugged junction area, to cope with the sudden heavy current rush during spike events. Once the spike is over however, the diode stops conducting (apart from a small reverse leakage current) and has no further effect on the output wave until any further spikes occur. TVS diodes are also available in single directional types that may also be used in the input side of the optocoupler in SSRs using a DC input if there is high risk of spikes occurring. However, because the DC input is usually fed from a smoothed DC power supply, this would normally be expected to minimise the risk, therefore the use of TVS diodes across the input components is rarely considered necessary.

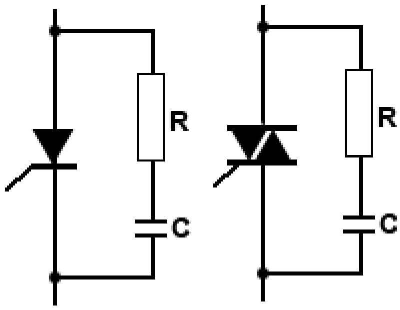


Fig. 7 *RC Snubber Circuits*

RC Snubber Circuits. These circuits provide a method of reducing the damaging effect of spikes occurring on the AC mains supply, or the very large and fast voltage changes that can occur when an inductive load is switched on or off (Commutated). With older types of triacs or SCRs this RC network (R5 and C1) is connected across the output triac or SCR as shown in ***Fig. 5*** and ***Fig 7***. Its effect is to slow the rapid increase or decrease of voltage during the spike. The use of a snubber circuit can also reduce the radio interference caused by the triac or SCR switching. By choosing a suitable time constant for R5/C1 the capacitor will not have time to charge as the spike voltage rises, before the voltage is reducing once more and discharging the capacitor. In this way the amplitude of any fast voltage spikes is reduced. Typical values for R would be about 39 to 100Ω for R5 and 22 to 47nF for C1. The capacitor would also need to be a pulse type having a very high maximum working voltage, much higher than the peak value of the output wave, to allow for the added stress caused by any voltage spikes. The design of snubber circuits is more complex however, than simply choosing typical R and C values, and must take into account a number of factors that will be unique to the circuit or component the snubber is protecting and to the loads the circuit may be driving. A useful application note on snubber design and component calculator is provided on line by HIQUEL (High Quality Electronics).

Alternistors

Alternatively there are modern Triacs available, which can also be called ´Alternistors´ or ´Alternistor Triacs´ that are much less prone to damage or random false triggering caused by fast transient voltages. Several semiconductor manufacturers have their own range of devices, such as the ´Snubberless$_{TM}$´ range from ST Microelectronics or the ´Hi-Com$_{TM}$´ range from WeEn Semiconductors that are able to handle the voltage spikes as well as the fast dV/dt events encountered during commutation (switch off) with inductive loads. The internal design of these triacs is different to the original types, making them much better at handling the fast high voltage changes that can happen as inductive loads are switched off, due to the phase difference between current and voltage in inductors. In this case it is possible that when the triac switches off as the mains (line) current passes through zero volts, the mains voltage across the triac can be at its maximum value. While such events in original triac designs could cause problems with uncontrolled re-triggering, this has been greatly reduced in modern designs.

Advantages of SSRs against electromechanical relays

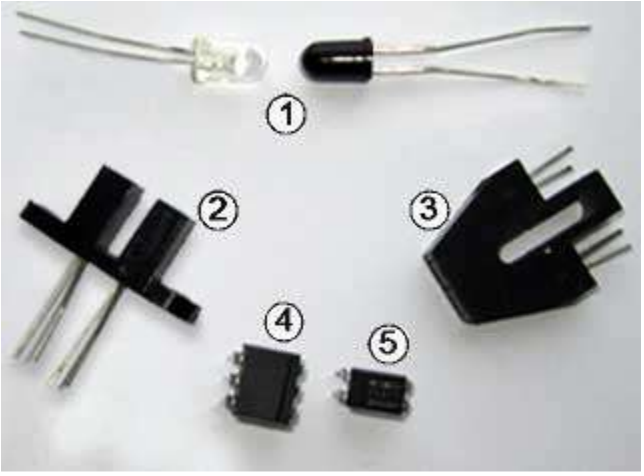
1. Because SSRs have no inductive coils or moving contacts they do not generate electromagnetic interference.
2. SSRs do not cause any potentially dangerous arcing.
3. SSRs are silent in operation.
4. SSRs are not subject to mechanical wear, so will potentially perform many more switching operations than electromechanical relays (however either type may be designed to perform more operations than is required during the lifetime of the equipment they are used in).
5. SSRs do not suffer from contact bounce.
6. SSRs have a faster switching time than electromechanical relays.
7. For switching AC, Zero Crossing SSRs are available that only switch on at, or close to the time when the AC waveform passes through zero volts, so reducing the occurrence of voltage spikes that occur if a circuit is switched on when the AC voltage is at a maximum.
8. SSRs can be physically smaller than comparable types of electromechanical relays.

Disadvantages of SSRs against electromechanical relays

1. When SSRs are switched on there is a measurable resistance between the output terminals, therefore SSRs produce some heat as well as a voltage drop in their ‘on’ condition.
2. When SSRs are in their ‘off’ state, there is still a small reverse leakage current flowing in the output. Unlike electromechanical relays, SSRs are therefore neither totally ‘on’ or ‘off’. Therefore they may not be permitted for use under some safety regulations.
3. Because SSRs are able to switch on very quickly (in milliseconds) random interference spikes in their input circuits or sudden fast voltage changes at their outputs can cause unwanted switching of some SCRs or triacs.

Failure of an SSR will usually cause a short circuit (switch on) whereas failure in an electromechanical relay will usually cause an open circuit (switch off). Because of this, using SSRs may cause some concern in safety critical systems.

Fig. 1 Transistor Optocouplers & Opto Sensors

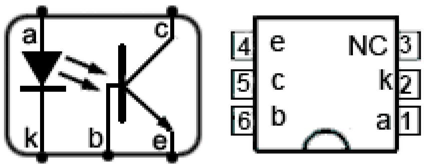


Opto Devices & Photo transistors

Optocouplers or opto isolators consisting of a combination of an infrared LED (also IRED or ILED) and an infra red sensitive device such as a photo diode or a photo transistor are widely used to pass information between two parts of a circuit that operate at very different voltage levels. Their main purpose is to provide electrical isolation between two parts of a circuit, increasing safety for users by reducing the risk of electric shocks, and preventing damage to equipment by potential short circuits between high-energy output and low-energy input circuits. They are also used in a number of sensor applications to sense the presence of physical objects.

Transistor Optocouplers

The devices shown in ***Fig. 1*** use photo transistors as their sensing elements as they are many times more sensitive than photo diodes and can therefore produce higher values of current at their outputs. Example 1 in Fig. 5.0.1 illustrates the simplest form of opto coupling consisting of an infrared LED (with a clear plastic case) and an infrared photo transistor with a black plastic case that shields the photo transistor from light in the visible spectrum whilst allowing infrared light to pass through. Notice that the photo transistor has only two connections, collector and emitter, the input to the base being infrared light. Examples 2 and 3 in ***Fig. 1*** are typical opto coupled devices widely used as position and proximity sensors. *Fig. 2 The 4N25 Optocoupler*



Example 4 in ***Fig. 1*** is a 4N25 opto coupler in a 6 pin DIL integrated circuit from Vishay. It uses an output photo transistor with a base connection that is also connected to an external pin for applying an external circuit if required. This allows the opto coupler to have a DC bias applied to prevent the transistor from producing current at very low light levels. Biasing the photo transistor can also enable it to be used with signals such as analogue audio. In this case the emitter connection can be left unconnected and the base connection used as an output, then the output photo transistor collector/base junction operates as a photo diode, greatly increasing the frequency range of the opto coupler, but at the expense of greatly reducing the available signal amplitude at the output. The 4N25 can also operate as a digital opto coupler with logic 1 and logic 0 inputs. The isolation between input and output on the 4N25 is a minimum of 5.3 kV. Example 5 in ***Fig. 1*** is a PC817 4 pin single channel opto isolator chip from Sharp, which uses an integral infra red LED and a photo transistor to produce an output of up 50mA and provides electrical isolation up to 5kV. It is also available in 2, 3 and 4 channel versions.

Fig. 3 Basic Photo transistor Structure

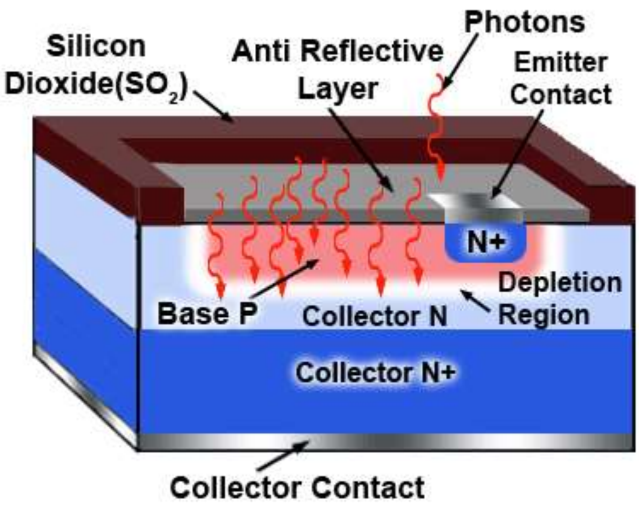


Photo transistors

Fig. 3 shows the basic structure of a photo transistor. However because the conversion from light to current takes place in a transistor, the tiny current produced by a particular level of photon input to the base can be amplified to produce a collector current 200 times greater or more, depending on the h_{fe} of the transistor, making the photo transistor much more efficient than a photo diode However, because of the large junction area (and therefore much higher junction capacitance) of a photo transistor, its response at high frequencies is poor, and the switching time is much slower, compared to a photo diode Also the relationship between changes in light input and changes in output voltage is not as linear as in photo diodes Consequently photo transistors, though less useful than photo diodes for high frequency data transmission, are widely used in control applications such as opto couplers/isolators, and position sensors.

Photo transistor Operation

In a photo transistor, light, in the form of photons is collected in the base layer, which occupies the major part of the visible window on the top surface of the device, as illustrated in Fig. 5.0.3. The emitter area is therefore reduced in size to maximize light absorption in the base. The conversion between photons and current takes place largely in the depletion region around the base/collector PN junction where photons absorbed via the anti-reflective layer into the base layer dislodge electrons to create electron/hole pairs in a similar manner to that in photo diodes, but now the free electrons created by this process are the source of base current in the transistor and are now amplified by an amount equal to the h_{fe} of the transistor. The N type collector immediately beneath the depletion layer has a higher resistance than the N+ layer next to the collector terminal. Because of this higher resistance close to the PN junction, there is a large voltage gradient in the collector close to the base/collector junction. This provides a higher positive voltage close to the depletion layer to attract and accelerate the negatively charged electrons in the depletion layer towards the collector terminal. Compared to photo diodes however, photo transistors do have some drawbacks; their response to varying levels of light is not quite so linear, making photo transistors less suitable than photo diodes for accurate light measurement. Although photo transistors can be used to detect light sources across the visible light spectrum, they are most sensitive to wavelengths in the near infrared range around 800 to 900nm, and are most often used with infrared emitting sources such as infrared emitting LEDs (also called IREDs or ILEDs) as their light source. Photo transistors are generally not as fast as photo diodes at reacting to abrupt changes in light levels. For example, the time taken for the photo transistor output to change between 10% and 90% in response to a sudden change in light level at the input can be between 30 and 250µs whereas high speed photo diodes can have rise and fall times as low as 20ps (pico seconds) or less. Manufacturers normally quote these figures for rise time (t_r) and fall time (t_f) under particular conditions of temperature and collector current. The main reason for the much slower response in photo transistors is due to the much larger area of the base/collector junction, and the fact that the capacitance that exists across this junction is further magnified by the 'Miller Effect', which causes the junction capacitance to be magnified by the current gain (h_{fe}) of the transistor. In practice this means that the more sensitive the transistor (i.e. the larger the base area) and/or the higher the current gain of the transistor, the longer the rise and fall times will be. For these reasons photo transistors are mostly used for switching DC or low frequency AC applications.

Photo transistor Connections

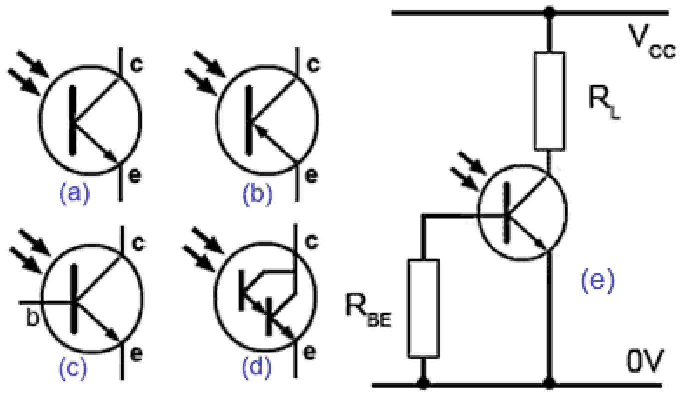


***Fig. 4** Photo transistor Connections*

Photo transistors are available in several forms such as NPN (***Fig. 4a***) or PNP (***Fig. 4b***). Many photo transistors only have connections for the emitter and collector, as the base input is provided by light; however a base connection is provided on some types (***Fig. 4c***). Darlington photo transistors (***Fig. 4d***) are also available; using a Darlington pair transistor configuration gives even greater current gain. At low or even no light levels, photo transistors can still produce a small amount of current due to random collisions in the depletion layer. Applying base bias as shown in ***Fig. 4e*** can have the effect of preventing this 'Dark Current', so reducing the effect of random noise and giving a better defined on/off level to the output current. Optocouplers have many uses and are available in many varied types, a few examples are illustrated in ***Fig. 5***. Use the type numbers to search for data sheets and use them to identify the purpose of each design.

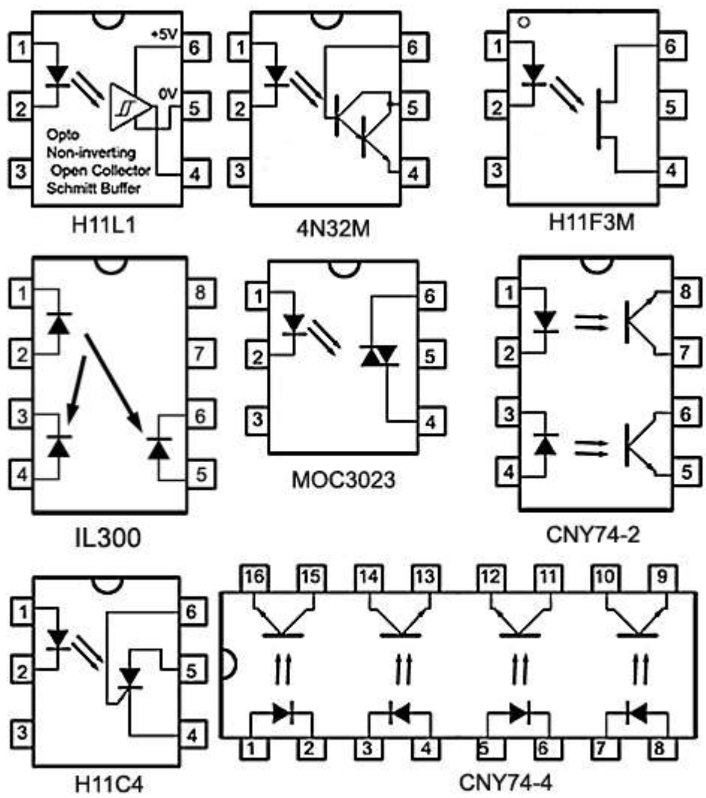


***Fig. 5** Opto coupler Examples*

Раздел 4 Монтаж и сборка средней сложности узлов, блоков приборов радиоэлектронной аппаратуры, элементов узлов импульсной и вычислительной техники.
Тема 4.1 Узлы радиоэлектронной аппаратуры. Элементы цифровой и импульсной техники

THEORETIC MATERIAL

TEXT 13 A SIGNAL

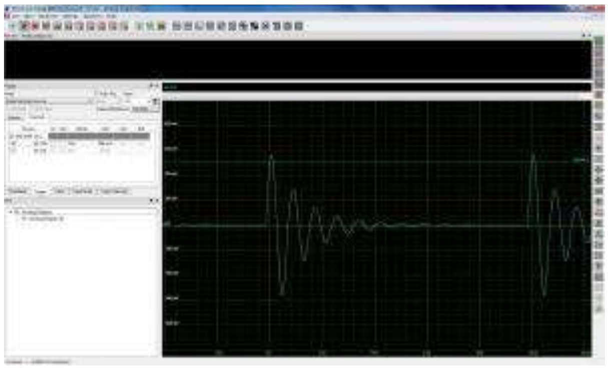
- is created when a command or data is sent to a device. It has implementation in electrical and electronic components as well, but it mainly refers to analog and digital communication technologies and devices. Each signal carries data in some form. The data is fed into the signal using analog or digital modulation techniques, depending upon the source and destination device and/or medium. Besides communication devices that broadcast a signal externally to the host system, signals are also used to communicate and send instructions by:

- **Processors**
- **Memory**
- **Storage**
- **Numerous other components**

Electrical signals are everywhere, since they are used in communications, in entertainment devices, in measuring instruments, in imaging devices, in control systems, and in computers. Such signals are of two types: analog, where the signals are carried by continuously varying quantities, and digital, where the signals are restricted to a finite set of discrete values (often just two, symbolized by 0 and 1). The traditional telephone uses analog signals, since the continuously varying pressure associated with sound waves is converted into continuously varying voltages of an electrical signal. Computers, by contrast, usually deal with so-called binary signals, sequences of zeros and ones. A historical trend of the last half-century is the replacement of analog signals by digital signals. For example, music was always recorded and transmitted in analog form until the 1980s when the CD player made digital recording of music common. When a CD is made in the studio, the music is first converted into an electrical analog signal by a microphone, but then the electrical signal is converted into a sequence of zeros and ones by sampling (measuring the intensity of the sound at specific points in time, many thousands of times a second) and quantizing (assigning each intensity to one of a finite number of intensity levels). It is this sequence of zeros and ones that is etched into the spiral track of the CD. There are two very important advantages to digital signals. First, digital signals can be reproduced exactly. All you have to do is be sure that a zero doesn't get turned into a one or vice versa. (You can do this by making the physical signals for zero and one quite different, and also by building in redundancy, so that even if a zero occasionally gets turned into a one the error is automatically corrected.) Second, digital signals can be manipulated easily. Since the signal is just a sequence of zeros and ones, and since a computer can do anything specifiable to such a sequence, you can do a great many things with digital signals. And what you are doing is called digital signal processing. So what is it you might do with the signals? One thing you can do is filter out unwanted parts of the signal, such as noise. Another thing you can do is combine several signals into one; this is called multiplexing. Yet another thing you can do is build in error detection and error correction; you make the signal longer in such a way that any distortion of the signal during transmission or recording can be detected and corrected. You can also compress the signal, so that it can be transmitted more rapidly. Another thing you can do is enhance certain parts of a signal to make it easier to use. For example, the drought-affected regions of a continent can be given a different color in a satellite image.All these things—and many more—are digital signal processing. It was in the 1960s that a discipline of digital signal processing began to form. At that time **digital signals** were becoming more common, and advances in microelectronics (the ability to build extremely complex circuits in a very small space) made it possible to carry out some of the tasks mentioned above. Today digital signal processing is a major branch of engineering.

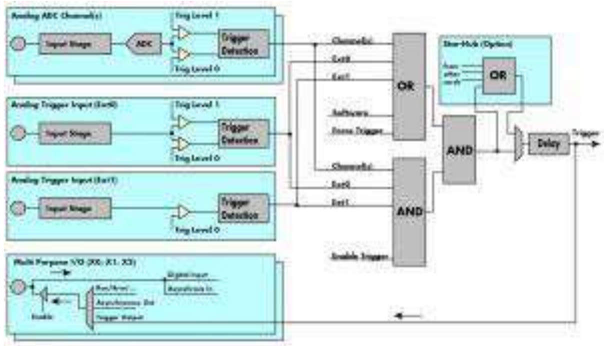
TEXT 14 TRIGGER AND SYNCHRONIZATION SPECTRUM

Introduction



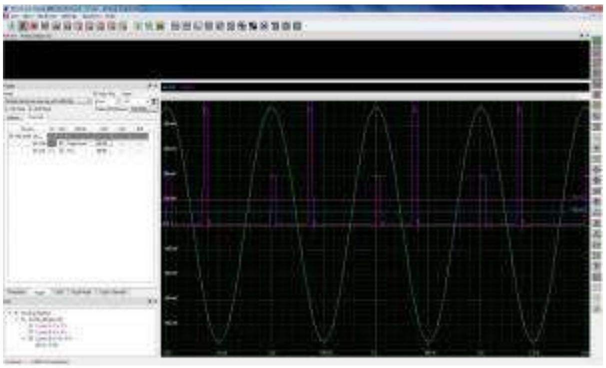
Digitizers are used to convert electrical signals into a series of measurements that are then output as a numerical array of amplitude values versus time. To make this information useful the time information is typically related to a specific reference point which is most commonly the trigger position. The trigger point can be something that occurs within the measured signal or it can be from other external sources. The function of triggering is to link the time measurements to a specific known point in time. For repetitive signals the trigger must be stable in order to enable measurements from one acquisition to be compared with others. When multiple digitizers or related acquisition instruments are integrated into a multi-channel system meaningful data can only be obtained when all channels are referenced to a common time axis. This requires time synchronization of the data acquisition elements of the system with all the digitizer channels normally being triggered by the same event. This application note will focus on the related topics of triggering and synchronization.

Triggering



Triggering is an essential function for any instrument that acquires and digitizes signals. The most common trigger method uses the signal that is input into one of the digitizers channels. The basic principle is that a defined point on the waveform is detected and this ‘trigger event’ is marked as a known position on the acquired data. Figure 1 provides an example of a basic edge trigger. The signal source is the input channel with the trigger event occurring when the waveform crosses the trigger level at 500mV with a positive slope. When this occurs, that position on the acquired signal is marked as the zero time point on the time axis as shown by the cursor position in the figure. If the signal is repetitive the digitizer will be triggered at the same point each time a new acquisition is made, resulting in a stable display. The wide variation in possible signal waveforms, levels, and timing requires that the digitizers trigger circuit be extremely flexible. Figure 2 shows a block diagram of the trigger ‘engine’ of a Spectrum **M4i.4451** series digitizer. This provides an example of the wide range of trigger conditions that are supported in modern digitizers. The hardware trigger sources are shown on the left hand side of the block diagram. They include any of the input channels and either of the two external trigger inputs (Ext0 or Ext1). Each of these sources is capable of supporting multiple trigger types. The multipurpose I/O lines can be used to report the digitizers run/arm state as well as to provide a trigger output signal among other functions. In addition to the hardware trigger sources there is also a software trigger which allows triggering under program control. This digitizer also includes powerful trigger AND/OR logic elements that are used to combine inputs from multiple sources into a complex multi-element trigger. The functionality can be used to ensure the digitizer will only trigger when specifically defined patterns occur. Yet another feature is the ability to cross trigger with up to seven other digitizer cards via the Star-Hub synchronization option.

Trigger Modes



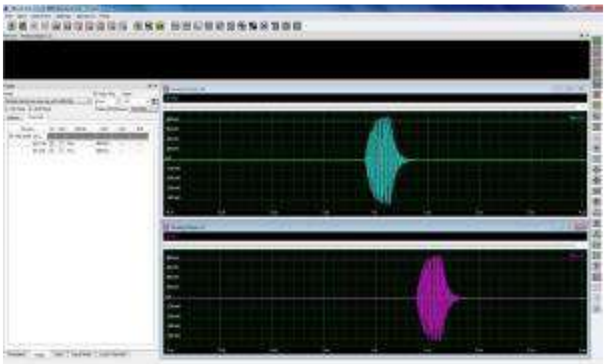
The principal trigger sources contain dual trigger level comparators and support multiple trigger modes. These include single and dual slope edge triggers, re-arm (hysteresis) triggers, window triggers, and for the multiple source trigger there are related trigger gate generators.

Edge triggers are the most basic trigger type. The user sets a trigger level and selects the desired trigger slope. When the trigger source crosses the trigger threshold with the selected slope the digitizer triggers. The slope selection is positive, negative, or both. Edge trigger is the most commonly used trigger mode.

Re-arm or Hysteresis triggers set two levels, the first is the arm level the second is the trigger level. As with the edge trigger the user also selects a slope. The signal must cross the arm level with the selected slope first to arm the trigger. The digitizer will then only trigger when the signal subsequently crosses the trigger level with the same slope. The re-arm trigger modes can be used to prevent the digitizer from triggering on the wrong edges of noisy signals.

Window triggers use two trigger thresholds per trigger source to define an amplitude window. There are two operational modes for the window trigger; trigger upon entering the window and trigger upon exiting the window. Trigger on entering will trigger whenever the source signal crosses one of the threshold levels and enters the window. The trigger on exiting triggers when the source signal has been between the two trigger thresholds and then leaves the window. Window triggers are used when the source signal can change states in either direction. When using a multi-source trigger mode with the built-in trigger logic it is often necessary to use one channel to create a gate waveform to enable a trigger from another channel. This can be done using the hi level, low level, inside window, or outside window selections. These trigger modes generate an internal gate signal that can be used together with a second trigger source and AND logic to gate the trigger. Figure 3 shows an example of using the high level trigger to gate a trigger source on another channel.
Whenever the sine wave on channel CH0 exceeds the trigger level a positive gate is generated for the entire time that the signal is above the threshold. This gate signal is AND'ed with the signal on channel CH1; since the gate signal is positive only while the low amplitude pulse is present on CH1 the digitizer triggers when the pulse waveform crosses the trigger level shown as a horizontal, red dashed line in the figure.

Summary Table of M4i Series Modular Digitizer Trigger Modes



- Positive Edge Trigger: The trigger occurs if the trigger source signal goes from a lower value to higher values (positive slope or rising edge) crossing the predefined trigger level.
- Negative Edge Trigger: The trigger occurs if the trigger source signal goes from a higher value to lower values (negative slope or falling edge) crossing the predefined trigger level.
- Dual Edge Trigger: The trigger occurs if the programmed trigger level is crossed by the trigger source signal with either a rising or falling edge.
- Re-arm (Hysteresis) trigger on positive edge: The trigger circuit is armed when the source signal crosses the re-arm level with a positive slope. After arming, if the programmed trigger level is then crossed by the source signal with a rising edge, the trigger is generated and the trigger circuit will be disarmed. A new trigger event is only detected if the trigger engine is armed again.
- Re-arm trigger (Hysteresis) on negative edge: The trigger circuit is armed when the source signal crosses the re-arm level with a negative slope. After arming, if the programmed trigger level is then crossed by the source signal with a falling edge, the trigger is generated and the trigger circuit will be disarmed. A new trigger event is only detected if the trigger engine is armed again.
- Channel window trigger for entering signals: The upper and the lower level define an amplitude window. Every time the source signal enters the window from the outside, a trigger is generated.
- Channel window trigger for exiting signals: The upper and the lower level define an amplitude window. Every time the signal leaves the window from the inside, a trigger is generated.
- High level trigger: This mode generates an internal gate signal that can be used together with a second trigger mode to gate the trigger. If using this mode with a single trigger source then the card only triggers when the source signal exceeds the trigger level (acting like positive edge trigger).
- Low level trigger: This mode generates an internal gate signal that can be used together with a second trigger mode to gate the trigger. If using this mode with a single trigger source then the card only triggers when the source signal is below the trigger level (acting like negative edge trigger).
- Inside window trigger: This trigger mode will generate an internal gate signal that can be used together with a second trigger mode to gate the trigger. If using this mode as a single trigger source then the card will only trigger when entering the window defined by the two trigger levels (acting like window enter trigger).
- Outside window trigger: This trigger mode will generate an internal gate signal that can be used together with a second trigger mode to gate the trigger. If using this mode as a single trigger source then the card will only trigger when leaving the window defined by the two trigger levels (acting like window exit trigger)

Trigger Logic

The example in Figure 3 shows one use for the available trigger logic when dealing with multiple trigger sources. Both AND and OR logic elements are supported. Inputs to the OR function include any of

the channels, the external trigger inputs, the software trigger and the force trigger function. The logical OR function permits any of these trigger sources to trigger the digitizer. Inputs to the AND logic function include all the channels, the external trigger inputs and the enable trigger function. The AND function requires that all selected trigger inputs be asserted at the same time in order to initiate a digitizer trigger. Keeping in mind that the gating trigger modes like hi level and low level provide the ability to logically invert inputs other logic such as NAND and NOR can be realized.
Figure 4 is an example of a radio location application that uses the OR trigger logic. Each of the input channels is connected to a sensor. Direction to the source is determined by the arrival time of the emitted pulse at each sensor. The location of the source determines which channel sees it first. The OR trigger logic allows the channel with the earliest burst to trigger the digitizer, guaranteeing that both sensor outputs will be captured.

Synchronization

Theoretically, there are two issues when synchronizing instruments. The first is to arrange for a common trigger. The second is to have both instruments operate from a synchronized clock. As simple as this seems there are issues that arise when attempting to synchronize multiple digitizers. The clock can be synchronized by using an external clock at the desired clock rate. A second method is to supply an external reference such as 10 MHz, this is then applied to a phase locked loop (PLL) which is used to multiply the frequency of the reference clock to the desired clock rate. The Spectrum M4i series digitizers used in this article handle both types of external clock through a common external clock input. The external clock input is connected to an internal PLL and this is set by the user to either multiply a reference clock or to phase lock to the external clock and pass it through without changing the frequency. This guarantees the correct frequency for the clock but does not guarantee that the clock in each digitizer has the identical phase. On the trigger side of the synchronization process we have to consider that each digitizers external trigger input uses a separate comparator to detect the trigger level crossing. Small differences in reference level and differences in setup and hold times can result is discrete changes in the trigger point location in time, a form of trigger jitter. The only way to guarantee exact synchronization of multiple digitizers is to distribute the clock to each module and to synchronize the trigger event to the system clock. In the Spectrum digitizers this can be done with the optional Star Hub module.

Synchronizing multiple digitizers

The Spectrum M4i series digitizer used in the examples in this article also has an optional synchronization accessory called Star Hub. The star hub module allows the synchronization of up to 8 cards of the same family. The module acts as a star connected hub for clock and trigger signals. The digitizer with the module acts as the clock master and that card or any other card can be the trigger master. All the trigger modes that are available on the master card are also available if the star-hub module is used. It also expands the AND/OR trigger logic to accommodate inputs from any of the attached digitizers. The star-hub also synchronizes different pre-trigger, memory segment size and post trigger settings among digitizers by synchronizing the ARM signals from the digitizers. The Star Hub is the preferred method for synchronizing multiple digitizers.

Conclusion

Digitizers require a trigger in order to relate the acquisition to a known point in time. Multiple trigger sources and modes make it easy to select the desired trigger point. Additionally, the ability to synchronize the time base via the Star-Hub allows multiple instruments to be coupled together offering a large number of acquisition channels. Digitizers with smart trigger engines make it possible to trigger on and capture a wide variety of complex signals. This feature is further enhanced when combined with innovative acquisition modes such as ring buffer, FIFO, memory segmentation and gated sampling with time stamps marking trigger events.

TEXT 15 A ENCODERS AND DECODERS

Multiplexing is defined as the process of feeding several independent signals to a common load, one at a time. The device or switching circuitry used to select and connect one of these several signals to the load at any one time is known as a multiplexer. The reverse function of multiplexing, known as demultiplexing, pertains to the process of feeding several independent loads with signals coming from a common signal source, one at a time. A device used for demultiplexing is known as a demultiplexer. Multiplexing and demultiplexing, therefore, allow the efficient use of common circuits to feed a common load with signals from several signal sources, and to feed several loads from a single, common signal source, respectively. In digital circuits, the term 'multiplexing' is also sometimes used to refer to the process of encoding, which is basically the generation of a digital code to indicate which of several input lines is active. An encoder or multiplexer is therefore a digital IC that outputs a digital code based on which of its several digital inputs is enabled. On the other hand, the term 'demultiplexing' in digital electronics is also used to refer to 'decoding', which is the process of activating one of several mutually-exclusive output lines, based on the digital code present at the binary-weighted inputs of the decoding circuit, or decoder. A decoder or demultiplexer is therefore a digital IC that accepts a digital code consisting of two or more bits at its inputs, and activates or enables one of its several digital output lines depending on the value of the code. Multiplexing and demultiplexing are used in digital electronics to allow several chips to share common signal buses. In demultiplexers, for instance, the output lines may be used to enable memory chips that share a common data bus, ensuring that only one memory chip is enabled at a time in order to prevent data clashes between the chips. If a demultiplexer or decoder has 2^N output lines, then it has N input lines. A common example of a decoder/demultiplexer IC is the 74LS138, which is a Low-Power Schottky TTL device that has 3 input lines and 8 output lines. Of course, a decoder IC such as the 74LS138 also has chip control lines that need to be 'enabled' for the decoding function to take place. In the case of the 74LS138, these control lines consist of one active high control line (G1, pin 6) and two active-low control lines (G2A, pin 4 and G2B, pin 5). Thus, the 74LS138 will only be in its 'decoding' mode if G1 is at logic '1' and G2A and G2B are at logic '0'. The 74LS138, whose generic product name is '3-to-8 Line Decoder/Multiplexer', obeys the truth table shown in Table 1. The outputs of the 74LS138 are 'active-low', i.e., the enabled output goes to logic '0' while all the other outputs are at logic '1'.

TEXT 15 B MORE COMBINATIONAL CIRCUITS – MULTIPLEXERS, DEMULTIPLEXERS, ENCODERS AND DECODERS

Written By: Hari Prasaath K.

In digital systems, any information is represented by binary codes. There are many binary code systems as mentioned in the first tutorial of this series. A binary code of n bits can represent 2^n discrete symbols or elements of coded information. The digital circuits that perform encoding of digital information are called encoders while digital circuits that decode the coded digital information are called decoders. An encoder with enable pins is called multiplexer while a decoder with enable pins is called demultiplexer. The encoder, decoder, multiplexer as well as demultiplexer are combinational logic circuits as their output at any time depends upon the combination of the input signals present at that instant only and does not depend on any past conditions. Let us learn about each in this tutorial.

Decoders -

The decoders are used to decode binary information in a digital system. The input lines to a decoder are used to feed binary data while based on the binary data, one of the output lines is selected which represents the respective minterm. If a decoder has n input lines then, it can have maximum 2^n output lines. With n number of input lines, the decoder can decode n-bit digital data. Like with 3 input lines, a decoder can decode 3-bit binary data and so maximum 2^3 or 8 binary symbols. If there are some unused combinations in n-bit coded information, the decoder can have fewer than 2^n output lines. So, any decoder is n-to-m line decoder where $m <= 2^n$. In a decoder, each output line represents a minterm which is selected based on the input binary data. For any input data only one output line is activated at a time. It can be noted that in a decoder, the number of output lines is always greater than number of input lines. If the number of inputs and outputs in a decoder circuit are equal, it is then called converter. The decoders are usually constructed using AND or NAND Gates. The output of an AND gate is only HIGH when all the inputs are HIGH. So, AND gate is the basic decoding element in a decoder circuit. For example, in a 4-to-16-line decoder, the digital circuit used in decoding the binary code 1001 will be as follow -

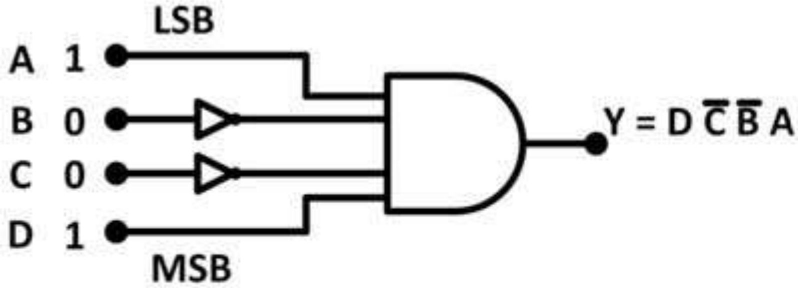


Fig. 1: Image showing Decoding Circuit Built using AND Gate

In the decoding element (of the 4-to-16-line decoder) shown above, to make all the inputs of the AND gate HIGH, the two middle bits must be inverted by using two NOT gates. So, when the input binary data will be 1001, the only output line connected to the above decoding circuit will be activated and set HIGH. For simplicity let us take 2-to-4-line decoder as an example. A 2-to-4-line decoder has two input line (say A and B). With 2 inputs, 4 binary codes can be represented, so there can be 4 output lines (say D0, D1, D2 and D3). Each output line represents a minterm like D0 represents A'B', D1 represents A'B, D2 represents AB' and D3 represents AB. A 2-to-4-line decoder can be represented by the following block diagram -

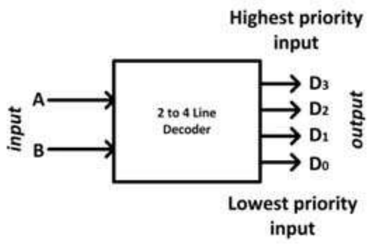


Fig. 2: Block Diagram of 2-to-4-Line Decoder

It will have the following truth table -

Fig. 3: Truth Table of 2-to-4-Line Decoder					
INPUTS		**OUTPUTS**			
A	**B**	**D0**	**D1**	**D2**	**D3**
0	0	1	0	0	0
0	1	0	1	0	0
0	1	0	0	1	0
1	1	0	0	0	1

From the above truth table, the digital circuit for 2-to-4-line decoder can be constructed using AND gates and NOT gates as follow -

If a decoder is constructed using NAND gates, then the respective output line is set LOW instead of HIGH for a binary code. For example, the digital circuit for 2-to-4-line decoder constructed using NAND gates will be as follow -

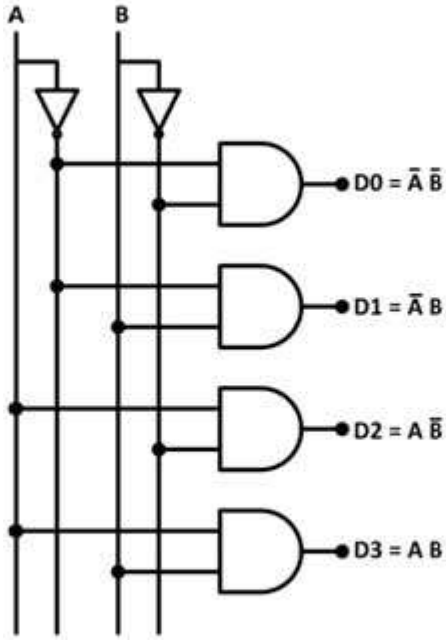


Fig. 4: Circuit Diagram of 2-to-4-Line Decoder

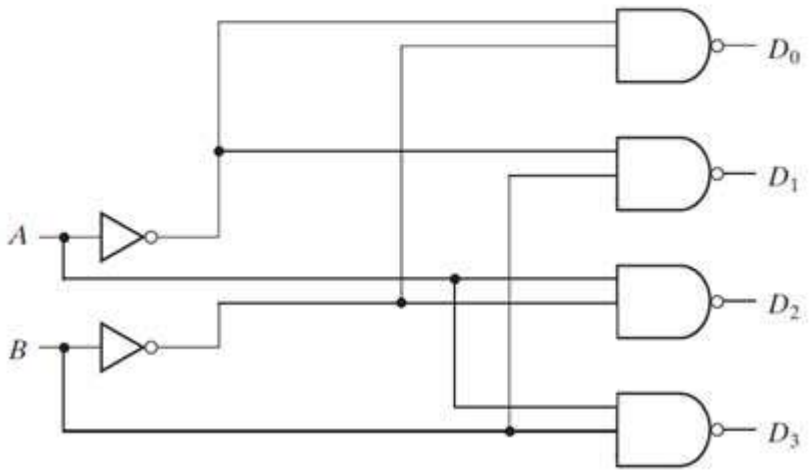


Fig. 5: Image showing Implementation of 2-to-4-Line Decoder with NAND Gates

The decoders are used in many applications like data demultiplexing, digital display, digital to analog converters, memory addressing etc.

De-Multiplexers -

De-Multiplexers are digital circuits that are used to transmit binary data from one line to many. The word “demultiplexer” itself means one into many. So, Demultiplexing is the process of taking information from one input and transmitting the same over one of several outputs. The demultiplexers have digital circuit similar to decoders except that they have a single input line and have select lines to determine the output line for data transmission. The data is transmitted over a single output line at a time. Like decoder, if a de-multiplexer has n select lines, there can be 2^n or less output lines controlled by them in a demultiplexer. A de-multiplexer can be represented by the following block diagram

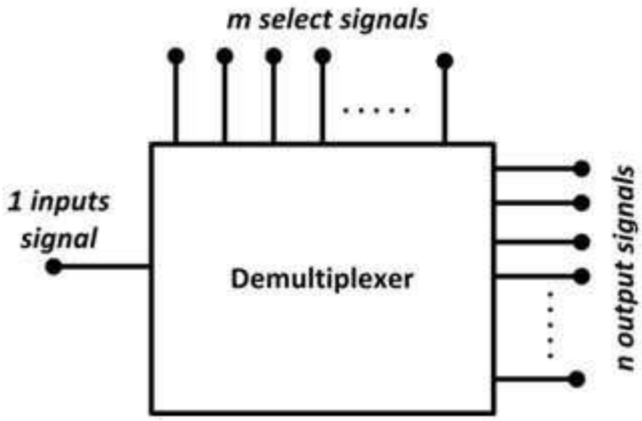


Fig. 6: Block Diagram of Demultiplexer

It can be noted that a demultiplexer has one input signal, m select signals and n output signals where $n <= 2^{m}$. The select inputs determine that to which output line the data input will be connected. With the help of a demultiplexer, serial data is converted to parallel data.

For example, in a 1-to-4-line demultiplexer, there is a single input (say D), four outputs (say Y0 to Y3) and two select lines (say S1 and S2). The truth table of the 1-to-4-line demultiplexer is as follow -

Data Input	Select input		Outputs			
D	S1	S0	Y3	Y2	Y1	Y0
D	0	0	0	0	0	D
D	0	1	0	0	D	0
D	1	0	0	D	0	0
D	1	1	D	0	0	0

Fig. 7: Truth Table of Demultiplexer

From the truth table, it can be noted that the data input is connected to output Y0 when S1 = 0 and S0 = 0. The data input is connected to output Y1 when S1 = 0 and S0 = 1. The data input is connected to output Y2 when S1 = 1 and S0 = 0. The data input is connected to output Y3 when S1 = 1 and S0 = 1. A demultiplexer can be constructed using AND gates and NOT gates like the decoder circuits. From the above truth table, the digital circuit for 1-to-4-line demultiplexer is as follow -

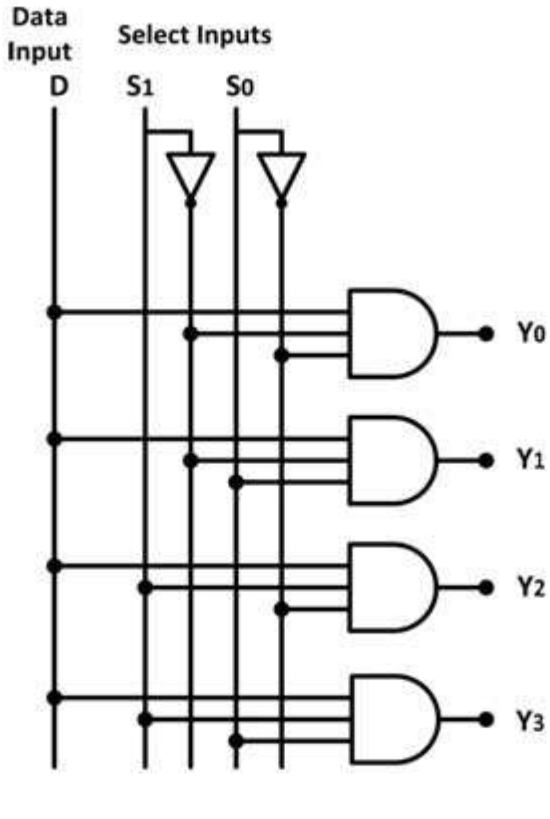


Fig. 8: Circuit Diagram of 4-Output Demultiplexer

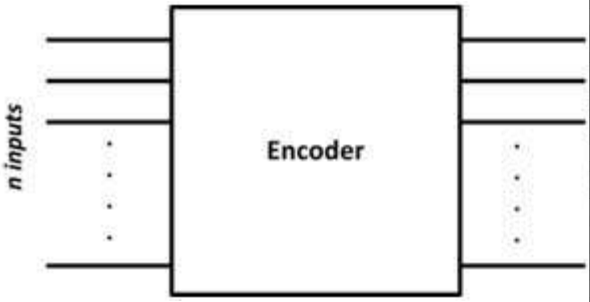
So, the 1-to-4-line demultiplexer can be implemented using four 3 – input AND gates and two NOT gates. The input data line is connected to all the AND gates. The two select lines S1 and S0 enable only one gate at a time and the data that appears on the input line passes through the selected gate to the associated output line. The demultiplexers are used in communication systems, computers chips for connecting ALU with registers and in serial to parallel converters.

Encoders -

The encoders are used for coding binary data. They are opposite to decoders. So, they perform inverse operation of a decoder. The opposite of the decoding process is called encoding. The encoder is a combinational logic circuit that converts an active input signal into a coded output signal.

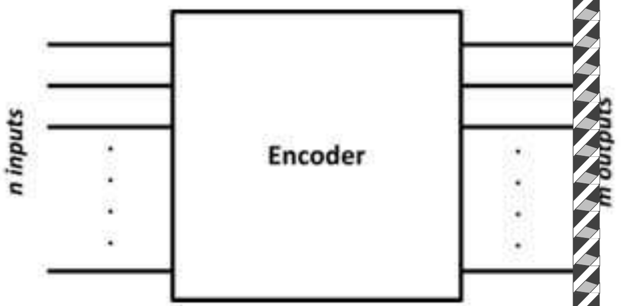
It has n input lines, only one of which is active at any time and m output lines. It encodes one of the active inputs to a coded binary output with m bits. In an encoder, the number of output lines is less than the number of inputs. If an encoder has n input lines and m output lines than $n <= 2^m$. An encoder can be represented by the following block diagram -

Fig. 9: Block Diagram of Encoder



For example, let us consider Priority Encoder. It is a special type of encoder in which priority is given to the input lines. If two or more input lines is HIGH at the same time, then the input line with highest priority is considered. In a 4-to-2-line priority encoder, there are four inputs say D0, D1, D2 and D3 and two outputs say Y0 and Y1. Out of the four inputs D3 has the highest priority and D0 has the lowest priority. That means if D3 = 1 then Y1 Y0 will be equal to 11 irrespective of the other inputs. Similarly if D3 = 0 and D2 = 1 then Y1 Y0 will be equal to 10 irrespective of the other inputs. A 4-to-2-line priority encoder can be represented by the following block diagram -

Fig. 10: Block Diagram of 4-Input Priority Encoder



It has the following truth table -

An encoder can be constructed using AND, OR and NOT gates. From the above truth table, the digital logic circuit for 4-to-2-line encoder can designed as follow -

Fig. 11: Truth Table of 4-Input Priority Encoder

HIGHEST	*INPUTS*		*LOWEST*	*OUTPUT*	
D3	**D2**	**D1**	**D0**	**Y0**	**Y1**
0	0	0	0	X	X
0	0	0	1	0	0
0	0	1	X	0	1
0	1	X	X	1	0
1	X	X	X	1	1

Fig.12: Circuit Diagram of 4-Input Priority Encoder

Multiplexers -

The multiplexers are used for routing digital data from many to one line. They convert parallel data into serial data. The term multiplex itself means many to one. Multiplexing is the process of transmitting a large number of information over a single line. A digital multiplexer is a combinational circuit that selects single digital information from several resources and transmits the selected information on a single output line. A multiplexer is also called a data selector, where it selects one of many inputs and sends the information to the output. The multiplexers are similar to encoders except that they have several data – input lines and a single output line. The selection of a particular input line is controlled by a set of select lines. A multiplexer can be represented by the following block diagram -

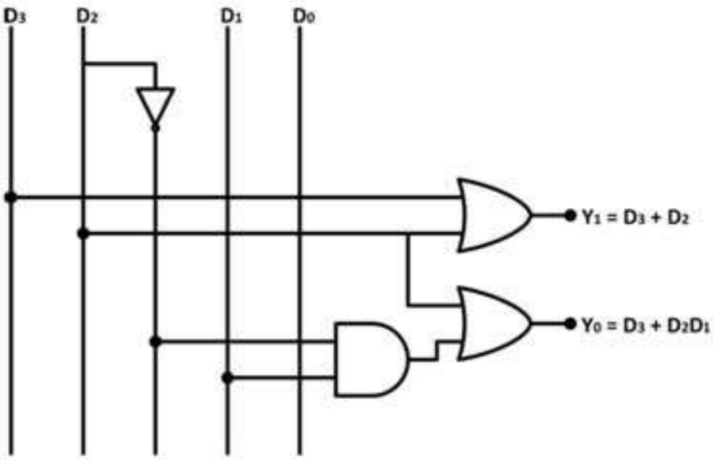
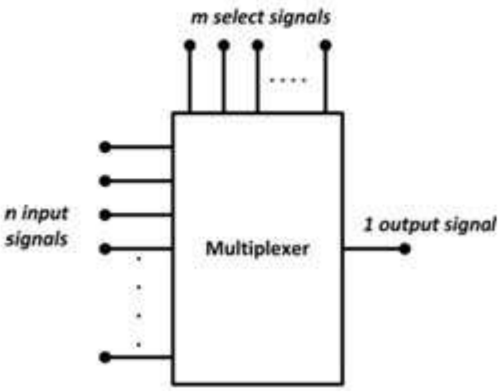


Fig. 13: Block Diagram of Multiplexer



It can be noted that a multiplexer has n input lines, m select signals and one output line where n <= 2^m. The selection line decides the number of input lines of a particular multiplexer. If the number of the n input lines is equal to 2^m, then m select lines are required to select one of n input lines. For example, to select one out of 4 input lines, two select lines are required and to select one out of 8 input lines, 3 select lines are required.

Like in a four inputs multiplexer, there has four data input lines (say D0 to D3), single out line (say Y) and two select lines (say S0 and S1) to select one of the four input lines. A 4-input multiplexer can be represented by the following block diagram -

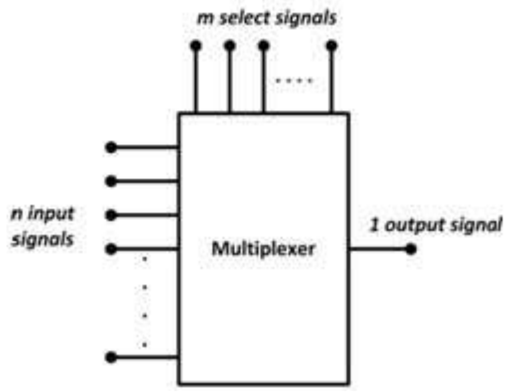


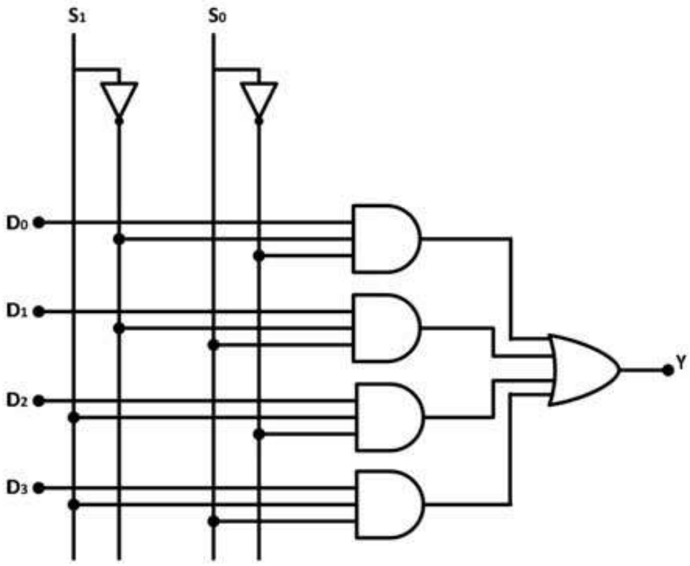
Fig. 14: Block Diagram of 4-Input Multiplexer

It has the following truth table

Fig. 15: Truth Table of 4-Input Multiplexer

Data Select Lines		*Output*
S1	***S0***	***Y***
0	0	D0
0	1	D1
1	0	D2
1	1	D3

A multiplexer circuit is similar to encoder circuit. Like encoders, the multiplexers can be constructed using AND, OR and NOT gates. From the above truth table, the logic gate diagram for 4-input multiplexer is as follow – *Fig. 15: Truth Table of 4-Input Multiplexer*



From the logic circuit, it can be seen that when S1S0 equal to 00 is applied to select lines, the two input to the AND gate associated with D0 is equal to 1 and third input is connected to D0 Data. The other 3 AND gates have 0 in at least one of their inputs, so that their outputs will be equal to 0. Hence the OR output Y will be equal to D0. When S1S0 equal to 01 is applied to select lines, the Data on the input D1 appears on the data output line. Similarly, when S1S0 equal to 10 is applied to select lines, the Data on the input D2 appears on the data output line. When S1S0 equal to 11 is applied to select lines, the Data on the input D3 appears on the data output line.

Fig. 16: Circuit Diagram of 4-Input Multiplexer.

The multiplexers are used in telephony, communication systems and computer memories. They are also used as parallel to serial data converters.

UNIT 4

Тема 4.2 Электромонтажные работы

THEORETIC MATERIAL

TEXT 16 ELECTRICAL INSTALLATION WORK

E. M. FES'KOV and IA. M. BOIAZNYI

Electrical Installation Work

specialized construction work that is performed during the erection or reconstruction of buildings orst ructures intended for various purposes and that entails the installation of electric wiring and electrical equipment. The electric wiring may be overhead power lines, cable lines, current leads, or interior wiring. Examples of electrical equipment include electric machinery, distribution centers, and control consoles. The electrical installation work is usually carried out in two stages.

The first stage, which coincides in time with general construction work, includes the installation of fasteners or inserts in structural elements for the subsequent attachment of electrical equipment andstr uctures for the installation of electric wiring. It also includes the installation of conduits for electric w iring in the foundations and floors of buildings or structures and the installation of wall sockets for ou tlets and switches. In the first stage, the preassembly of electrical equipment and wiring structures, the fabrication of conduit sections, and the board lacing of wires and cables for lighting an d other circuits are carried out away from the construction site in specially equipped electrical-installation prefabrication shops.

In the second stage, the electrical equipment and the structures for the installation of wiring ar e transported to the construction site, installed in the planned locations, and assembled.

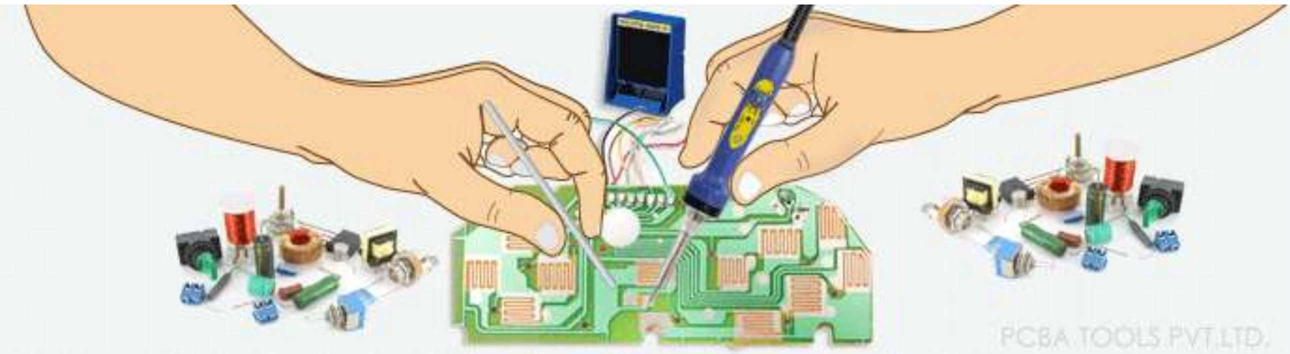
In addition,cables and wires are laid and are connected to the installed electrical equipment. E lectrical installation work is completed when the installed equipment is actuated and adjusted. The m ost complicated work in this respect is the adjustment of relay protection and automatic control syste ms for electric drives.Electrical installation work is mechanized through the use of generalpurpose co nstruction machinery—for example, lift trucks, hoists, and truck cranes and of specialized electrical installation machinery, devices, and tools.

The time required for electrical installation work is reduced and the productivity of labor in such work is raised primarily through the use of industrial methods of installing electrical equipment and through the delivery to construction sites of structures for the installation of wiring and elements of electric wiring in consolidated subassemblies and units, which are fabricated and assembled in electricalinstallation prefabrication shops. The level of industrialization of electrical installation work is due in large part to the output by industry of complete sets of electrical equipment and of electric wiring that can be easily installed and adjusted.

One of the main trends in the further industrialization of electrical installation work is the use of large-scale electrical engineering facilities, for example, the rooms of electric drive control stations and of urban transformer substations. Such facilities are delivered by industryw ith the electrical equipment completely installed and adjusted. In this case, electrical installation work is reduced to the installation of such facilities and the connection of the facilities to external power networks.

TEXT 17 SOLDERING ELECTRONICS

BY SANTOSH DAS



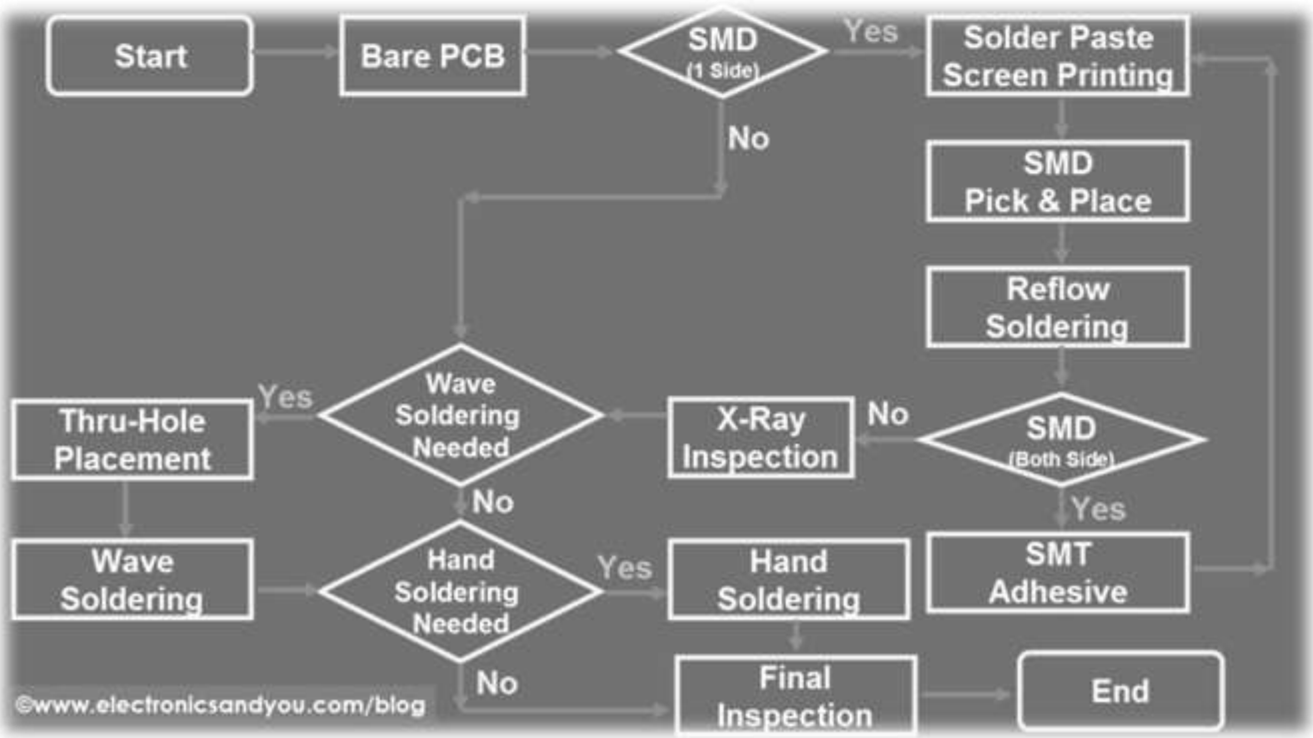
Soldering in electronics is all about joining electronic components to the PCB by hand using soldering station or soldering iron. Automatic Mass Soldering is done by wave soldering using wave soldering machine or reflow soldering using reflow machine. Soldering can be either hand soldering or automated soldering. It can also be either thru-hole soldering or SMT Soldering using Surface Mount Technology.

Hand Soldering in Electronics

Hand soldering is done for thru-hole electronic components using soldering iron or soldering station. Hand soldering is not meant for mass production. It is generally done for repairing and repair of rejected PCBs during mass production or for repairing of faulty Printed Circuit Boards after using electronic products for a long time.

Automated Soldering in Electronics

Automated soldering is done for mass production. It can be done by using wave soldering machine, reflow machine or Automatic SMT Machine.



SMT Soldering in Electronics

SMD or surface mount electronic components (ICs and Chips) are soldered to the PCB using Surface Mount Technology. The process uses Reflow soldering machine and automated pick and place machines. Sometime repairing and replacement of SMD components is also done by hand.

BGA Soldering in Electronics

BGA or Ball Grid Array are small tiny electronic components without any leads. They have tiny ball underneath the IC. These ICs or BGAs are soldering so the PCB using Automated BGA Soldering Machine or Hot air Reflow Machine. Visit – SMT Expert – Ray Prasad

Important components of electronic soldering:

1. Soldering Flux – Needed for all processes of soldering.
2. Solder Wire – Needed for Hand Soldering.
3. Solder Bar – Needed for Wave Soldering.
4. Solder Balls – Needed for BGA Soldering.
5. Soldering Iron and Soldering Station – Needed for Hand Soldering.
6. Wave Soldering Machine – Needed for Automated Wave Soldering.
7. Reflow Soldering Machine – Needed for Automated Reflow soldering of SMD Components.
8. BGA Soldering Machine – Needed for BGA Soldering.

TEXT 18 SOLDERING TOOLS

Various tools are necessary for facilitating soldering work. The most essential tool in the soldering practice is the soldering iron.

Soldering Iron

A soldering iron is the basic tool for hand soldering. It generates the heat required to heat the surfaces to be soldered and to melt the solder. It should supply sufficient heat to melt solder by heat transfer when the iron tip is applied to a connection to be soldered. Soldering irons used for soldering electronic components consist of the following three main parts: (i) a handle, (ii) a heating element, and (iii) a bit/tip. Handle: This is made of a good electrical and thermal insulator having an ergonomic shape so that it is comfortable for the operator. Soldering, Assembly and Re-working Techniques **467** Heating Element: This must have sufficient thermal capacity so that the set and working temperatures are, as much as possible, the same. The state-of-the-art hand irons are microprocessor controlled. They compare the tip temperature sensed with a sensor with the set temperature. The heating element responds immediately to heat loss at tip while soldering and returns lost heat to the tip. The heating element must be properly insulated so that there is no electrical leakage appearing on the tip of the bit to cause damage to the components. Bit/Tip: This is made of copper to provide good heat transfer. It is plated to prevent the solder dissolving them. Iron on the other hand is not attacked by solder, so iron plated copper bits are normally used. Unfortunately, iron is not readily wetted by solder, so the bit is further covered by nickel or chromium in order to provide a hard outer surface that will wet properly by the solder. With the passage of time and usage, the outer plated coat (nickel or chrome) will dissolve away. The bit then must be replaced. Since a bit is the tip of the hand soldering iron, it is often called 'tip'. Traditional soldering tips which are made of copper, conduct heat well and are inexpensive. However, they have the disadvantage that the tip oxidizes heavily when heated and copper particles are set free into the solder until it has been corroded entirely. New soldering iron tips have been designed which are galvanically plated with an iron coating and is then shielded against oxidation and corrosion by a layer of chrome. The heating element of the soldering iron is protected against over-heating and premature wear due to quick heat transfer. Such tips are available from M/s ERSA GmbH and are called ERSADUR soldering tips. The selection of a soldering iron is made with regard to its tip size, shape, operating voltage and wattage. Soldering iron temperature is selected and controlled according to the work to be performed. The temperature is normally controlled through the use of a variable power supply and occasionally by tip selection. Soldering irons are available in various forms. These are delineated below. Soldering Pencils: Soldering pencils (Figure 13.4) are lightweight soldering tools which can generate as little as 12 watts or as much as 50 watts of heat. A 25 watt unit is well suited for light duty work such as soldering on printed circuit boards. Modular soldering irons use interchangeable heating elements and tips which mate to a main pencil body. Such elements screw into a threaded receptacle at the end of the pencil. A variety of tips (Figure 13.5) are available to handle most soldering tasks. Very fine, almost needle-like tips are used on printed circuit boards with IC component foil pads which are closely spaced. Larger, chisel and pyramid tips can store and transfer greater amounts of heat for larger, widely spaced connectors. Bent chisel type tips can get into difficult-to-reach areas. Regardless of the type of the tips, it is best to use plated, as opposed to raw copper tips, as these have much longer life.

A pencil type soldering iron takes a few minutes to attain working temperature and it is better to keep it continuously powered even for interrupted type of soldering work. This would need to keep the iron secured in a safe place at working temperature. One method is to keep it in special soldering iron holder which may be a coiled steel form into which the hot soldering iron can be inserted. Most stands of this type also include a sponge which is kept moistened and used periodically to clean the soldering tip. Soldering Gun: A gun is usually heavier and generates more heat than the average pencil. Soldering of heavy duty conductors or connectors requires the use of a gun because it can generate enough heat to quickly bring a heavy metal joint up to the proper soldering temperature. These soldering tools are called guns simply because they resemble pistols. The gun's trigger (Figure 13.6) is actually a switch that controls application of ac power to the heating element. The working temperature is reached instantaneously. Some guns provide for selection of different heat levels through multi-position trigger switch. Soldering Stations: Soldering stations (Figure 13.7) contain an iron and a control console that offers switch selectable temperatures, marked low, medium and high. Obviously, this is more convenient than waiting for a modular pencils' heating element to cool, unscrewing it from the holder and then replacing it with another heater tip combination. The tip temperature is controlled by using a heat sensor and closed-loop feedback control to gate power to heating element. Obviously, soldering stations are expensive compared to basic soldering pencils.

Battery-operated Irons: Sometimes, it is inconvenient to depend on the mains power supply for operating a soldering iron. Battery-operated soldering irons are available which depend upon rechargeable batteries as a power source. Recharging is done automatically when the iron is placed in its charger, which is built on the stand, and is connected to an ac power source. In these soldering irons, the tips attain working temperature in 5-8 seconds and cool off to ambient temperature in about one second. Typically, about 125 connections can be made on one charge. For a standard iron, a typical charging interval of approximately fourteen hours is required to return the cells to full strength. Of course, there are quick change irons also. Sometimes, the soldering irons have built-in light to illuminate the work area whenever battery power is applied to the heating element. Soldering irons are best used along with a heat-resistant bench-type holder, so that the hot iron can be safely parked in between use. Soldering stations generally have this feature. Otherwise, a separate soldering iron stand, preferably one with a holder for tip-cleaning sponges, is essential. Electronics catalogues often include a range of well-known brands of soldering iron. The following factors should be kept in mind when selecting a soldering iron for a particular application (Winstanely, 2003). Voltage: Most soldering irons run from mains supply at 230 V. However, low voltage (12 V or 24V) type irons are also available and they generally form part of a "soldering station". Wattage: Typically they may have a power rating of between 15-25 watts which is adequate for most work. A higher wattage does not mean that the iron runs hotter. It simply means that there is more power in reserve for coping with larger joints. Higher wattage irons are required for heavy duty work because it would not cool down so quickly. Temperature Control: The simplest and cheapest type irons do not have any form of temperature control. Unregulated irons form an ideal general purpose iron for most users as they generally cope well with printed circuit board, soldering and wiring. A temperature controlled iron has a built-in thermostatic control to ensure that the temperature of the bit is maintained at a fixed level, within preset limits. This is desirable especially during more frequent use, since it helps to ensure that the temperature does not over shoot in between times and also the output remains relatively stable. Some versions have built-in digital temperature readout and a control knob to vary the temperature setting. A K-type thermocouple may be used to measure the temperature of the tip and heating rate is controlled by means of a thyristor. Thus, the temperature can be boosted for soldering larger joints. The necessity of measuring the temperature by means of a sensor as close as possible to the end of the soldering tip is a fundamental principle of a rapid response. The closer to the end of the soldering tip the measurement is taken, the quicker the control system can respond. Anti-static Protection: For soldering static-sensitive components such as CMOS and MOSFET transistors, special soldering iron stations having static-dissipative materials in their construction are required. These irons ensure that static-charge does not build up on the iron itself. These irons are “ESD safe” (Electrostatic Discharge Proof). The general purpose irons which may not be necessarily ESD-safe, but can be safely used if the usual anti-static precautions are taken when handling CMOS components. In this case, the tip would need to be well-grounded. BITS: Bits are available in various shapes and sizes. Keep in mind that the size of a screwdriver bit/tip should be approximately equal to the diameter of the pad. A large tip selection for maximum flexibility should be offered along with the soldering iron to meet the requirements. The choice of the tip is very important and the shape of its end must be selected so that good heat transfer to the parts to be joined is possible. The lifetime of the bit/tip depends on the structure and thickness of the material used as well as on proper handling. It is useful to procure a small selection of manufacturer’s bits (soldering iron trips) with different diameters and shapes, along with the soldering iron. They can be changed depending upon the type of work in hand. Bit/Tip Maintaining: Excess solder and burnt flux should be removed by wiping the bit on water soaked sponge. The following points should be kept in mind for good maintenance of the tips. Never clean the bit/tip with a file or any abrasive tools; not even with brass brushes. Never wipe the tip against the surface to be soldered. Clean and tin the bit before turning the iron off. Turn the iron off when it is not used for more than 15 minutes. Clean and wet the bit with some flux cored solder wire after the work is finished. Keep all the soldering irons in their respective holders. Don’t put more than one soldering iron per holder. Never put the iron in any form of a muffle, but keep it in its open spring holder. Spare Parts: It is preferable to ensure that the spare parts may be available for the iron. So, if the element blows, you don't need to replace the entire iron. This is especially so with expensive irons. Soldering, Assembly and Re-working Techniques **471**

Selection of Soldering Iron

The soldering iron should be of the precision type, small but powerful enough to reliably solder components to printed circuit boards. An iron between 25 and 40 watts with a nickel plated tip, or one of the miniature irons capable of a tip temperature of 205 °C are most suitable. Hotter temperatures run a real risk of spoiling the adhesive bond that holds the copper foil to the board. Do not use a higher temperature to make up for an improperly-tinned tip. The ideal tip is a single flat or chisel tip of about 2.5 mm. The old style unplated copper tips are not very suitable, as they wear away very quickly. The soldering iron should be examined carefully every time it is to be used. The soldering iron tip should be properly connected or screwed into the holder and it should be free from oxides. The shape of the tip must meet the requirements of the task to be performed. If any one of these items is not as good as it should be the following steps are adopted: The oxides from the tip surface are removed by using an abrasive cloth or sand paper. The tip generally is made in its proper shape by filing. This is normally done on the unplated copper tip. The iron is heated to the minimum point at which the solder melts. Before using the iron to make a joint, the tip is coated or tinned lightly by applying a few millimeters of solder. For keeping the tip clean, after it has been prepared, the heated surface of the tip should be wiped with a wet sponge. This is to remove dirt, grease or flux which, if allowed to remain, can become part of the joint and make the joint dry and defective. If during soldering, excessive heat is generated at the soldering iron tip and the component gets heated beyond its maximum temperature, the component may be permanently damaged, weakened, or affected drastically in value or characteristics. Such effects may not be noticed during assembly or test but may show up later when the equipment is in use. The tip temperature to be selected must be based on the temperature limitation of the substrate. The circuit boards which have a substrate of fibre-glass epoxy of 280 °C should not be heated for more than 5 minutes. Hotter temperatures reduce the time in inverse relationship; the higher the temperature, the less time the boards will stand it before damage. Further, heat transmitted along the leads may cause unequal expansion between leads and packages, resulting in cracked hermetic seals. In general, for hand soldering, the recommended soldering iron wattage is 20 watts to 25 watts for fine circuit board work, 25–50 W iron for general soldering of terminals and wires and power circuit boards, 100–200 W soldering gun for chassis and large area circuit planes. With a properly sized iron or gun, the task will be fast and will result in little or no damage to the circuit board plastic switch housings, insulation etc.. For iron temperatures of between 300 °C and 400 °C, the tips of the soldering iron should be in contact with the lead for not more than five seconds. Particularly, the ICs and transistors should be soldered quickly and cleanly. Temperature: An important step to successful soldering is to ensure that the temperature of all the parts is raised to roughly the same level before applying solder. Heating one part but not the other will produce an unsatisfactory solder joint. The melting point of most solder is in the region of 188 °C (370 °F) and the iron tip temperature is typically 330–350 °C (626°–662 °F). Figure 13.8 shows the temperature range for ideal soldering work. Above this temperature range, there is a risk of thermal damage whereas below this range, cold junctions are likely to develop. Time: Next, the joint should be heated with the bit for just the right amount of time. Excessive time will damage the component and perhaps the circuit board copper foil. The heating period depends on the temperature of your iron and size of the joint. Larger parts need more heat than smaller ones while some parts (semiconductor devices) are sensitive to heat and should not be heated for more than few seconds. In such cases, thermal shunts or heat sinks are used to protect heat-sensitive components from damage due to heat while soldering. These devices are placed or clamped in place to prevent the heat from reaching the component while its leads are being soldered. Solder Coverage: In order to achieve a successful solder joint, it is essential to apply only an appropriate amount of solder. Too much solder is an unnecessary waste and may even cause short circuits with at the end joints. Too little solder may not fully form a successful joint or may not support the component properly. How much solder to apply only really comes with practice.

Other Hand Soldering Tools

The soldering workstation should be clean, ESD-controlled and organized for an easy access to all the tools. The typical tools may include:
Solder iron;
Cleaning material;
Cored solder;
Pliers (bent, nose and straight);
Wire stripper;
Lead forming tools;
Toolbox
Fume absorber;
Solder iron station including holder;
Set of soldering iron bits;
Flux; sponge; soldering braid;
Tweezers;
Wire cutter; Screwdriver set;
Board holder; and Cleaning solvent and brush.

TEXT 19 SOLDER PASTES FOR SMDS

Solder pastes, often called solder creams, are used in “reflow-soldering” of surface mount components, where the application of solder and the heat supply are separate steps in the fabrication process. A solder paste basically consists of solder in powder form and a flux with some additives necessary to produce the desired behaviour of the paste during or after its application. Solder pastes are applied either by stencil or by screen-printing method. Pick-and-place throughput is an important issue in deciding the type of solder paste dispensing system. Erdmann (1991) brings out the stenciling technique including stencil development, stencil cleaning and printing etc. He points out that the demands of stencil are more rigid than that of ordinary SMT screen printing and stenciling, particularly for maintaining near perfect registration. Large pick-and-place systems require volumes that only screen printers can provide. Pick-and-place throughput in the range of 1500 to 3000 components per hour, however, is ideal for today’s dispensing equipment, which can produce 16000 dots per hour in a typical production environment (Cavallaro and Marchitto, 1991). A rotary positive displacement programmable pump as shown in Figure 13.23(a) can be effecttively used for solder paste dispensing involving high speed application of a large number of very small dots. The pump is driven by a DC motor. An electro-magnetic clutch engages and disengages the Archimedian screw. Mounted above the screw is a bellows coupling that aligns the clutch and lead screw and reduces the impact of the Z-axis sensor by more than 60 per cent. The combination of constant motor speed, low air pressure, the software controlled clutch, and the precise rotation of the Archimedian screw ensures a repeatability that is far superior to pulsed air or piston dispensing systems (Cavallaro, 1994). The pump can be programmed in one-milliseconds (ms) increments from 10 to 10,000 ms. Most solder paste applications require a shot size of 15 to 20 ms for fine-pitch devices and 50 to 100 ms for 50-mil devices. This short cycle time allows the automated dispensing system to dispense up to 16,000 dots per hour, making it compatible with most pick-and-place machines in the marketplace. The real advantage of dispensing over screen printing is programmability. For example, a 25-milpitch application, requires a dot diameter of 0.014 to 0.016 inch (0.35 to 0.40 mm) while a 50-milpitch application requires a 0.020 to 0.030 inch (0.50 to 0.75 mm) diameter dot. Dual-height dispensing systems are important to accommodate different dispensing requirements without the need to change either the needle or the programme. Dispensing systems are particularly effective for re-work and mixed technology applications.

Requirements of Solder Pastes

Solder pastes must meet the following requirements: The individual powder particles of the solder alloy should have a homogeneous distribution of the metal within the paste as well as a fair equality of shape and surface roughness of the individual powder particles. It should develop an adhesive action in order to hold the components in place until the reflow operation has been finished.

It must not tend to solder balling; if they become detached on the substrate, they may cause short circuits. It has to maintain its shape during curing and reflow and must remain on the pads, not leaking to unsolderable parts of the PCB. It must have sufficient activity as the solder paste is sometimes in contact with the parts for several hours.

Composition of Solder Pastes

Solder pastes are available with several fluxes and alloy compositions. Their consistency may vary from liquid cream to thick paste. Solder pastes usually contain a certain percentage of silver, most commonly 2 per cent, that gives a solder alloy of 62 % tin (Sn) + 36 % lead (Pb) + 2 % of Silver (Ag). This alloy has a melting temperature of 179 °C. The powder must contain granules of the alloy and not of the individual metals, which make up the solder. This will help to melt the solder at the temperature of the alloy used. Beside homogeneity, an important element in solder powder is the structure and shape of the alloy particles. Therefore, microscopic control of the solder particles is essential. An acceptable solder paste should contain alloy-particles only with the shape of a “sphere”, an “ellipsoid” a “tear” or a “dog bone”. Chilton and Gaugler (1990) describe the design of solder paste to meet the exacting requirements of fine pitch reflow.

A spherical shape minimizes the surface area and so reduces oxidation at best. However, on melting, the liquid flux flows outwards, also carrying with it the solder particles. The particles with a dog bone shape or a shape of an ellipsoid lock the solder better in place. Solder pastes having particles with extended irregular shapes, shapes of needles or even showing dust are not acceptable. The solder particles are typically 20 mm to 80 mm in diameter. For screen printing, usually a smaller particle size is advisable. Solder pastes can be manufactured either with rosin based or water soluble fluxes. The paste contains not only alloy powder and flux, but also organic solvents, thickeners and lubricants to determine paste rheology. With screen or stencil printing of solder paste, rheology is critical to ensure excellent print definition. With the development of lead-free soldering alloys, solder pastes without lead are also available. For low temperature soldering, a composition of 42 per cent tin, 42 per cent lead, 14 per cent bismuth and 2 per cent silver is commonly used.

Solder Paste Application

The reflow soldering process starts mostly with the application of solder paste to the specific areas of the circuit board where the components will be attached. Solder paste printing is commonly applied by stencil or screen-printing. It is wiped across the stencil or screen with a squeegee, which pushes the paste through the openings, depositing it on the lands at the right places. With solder paste printing, the entire amount of solder is deposited on the PCB in one operational step. Solder paste application with dispenser is generally used for laboratory applications because of its flexibility. With a dispenser, the solder paste can be applied not only in form of dots, but also in stripes, which may be more useful and accurate in certain cases.

Handling of Solder Paste

Solder paste ages and changes with temperature, humidity and light. The following precautions may be taken while handling solder paste, keeping in view the recommendations of the paste supplier; Store solder paste in a clean, cool, dry and dark location. Before opening refrigerated solder paste, keep it for 24 hours at room temperature to avoid water condensation. Do not mix old and new pastes since the fluxes and thinners will evaporate at different rates. Stir solder paste at least 30 seconds before applying to the stencil/screen. Use only clean and inert tools (Such as made of stainless steel, Teflon, Polyethylene). Apply to the stencil/screen the amount of paste just required for printing.

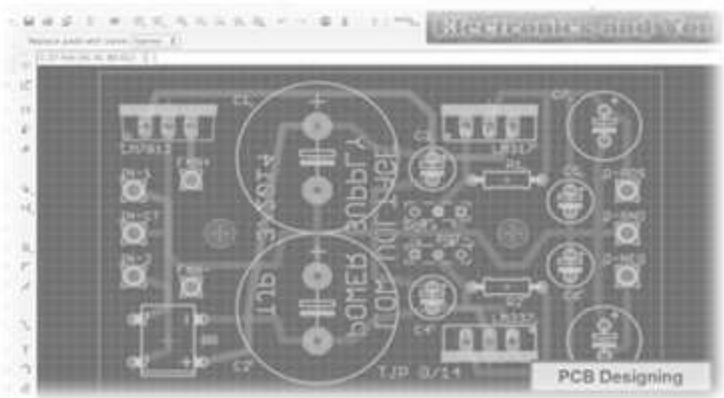
UNIT 5

Тема 4.3 Технология монтажа радиоэлектронных устройств

THEORETIC MATERIAL

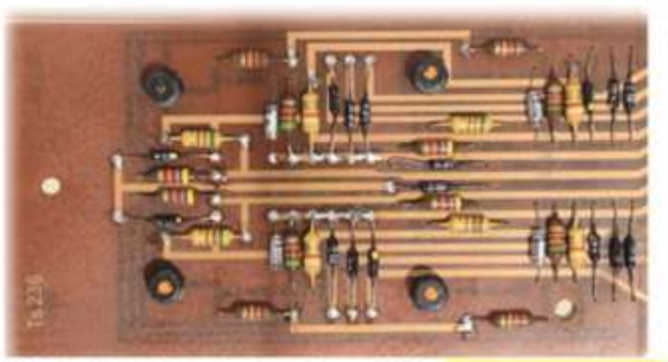
TEXT 20 PRINTED CIRCUIT BOARD DESIGN, DIAGRAM AND ASSEMBLY

Printed Circuit Board Design, Diagram and Assembly Process *BY SANTOSH DAS*



Printed Circuit Board Design or Printed Circuit Board (PCB) or Printed Wiring Board (PWB), is a board made out of non-insulating and highly heat-resistant insulating material such as fiberglass. These boards are also called substrates. A substrate or board may have only one single layer (single-layer circuit board) or more than one layer (multilayer circuit board). A conductive metal such as copper is used to make conductive pathway or traces to facilitate flow of electricity. Once these conductive traces are etched on the substrate, it is termed as “printed circuit board”

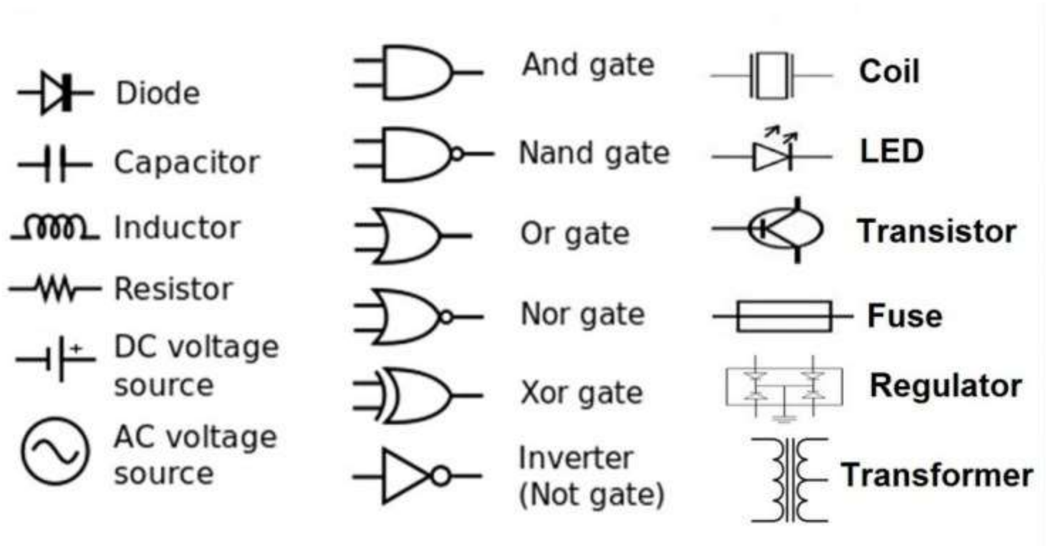
Printed Circuit Board Diagram



PCBA (Printed Circuit Board Assembly)

A circuit diagram is a *diagram* showing and explaining how and where electronic components will be mounted to achieve the target product. Each component on a circuit board diagram is represented by a circuit symbol. Making a *circuit diagram* prior to production is critical. It gives an idea of how the circuit will work and how to achieve the target product. A *circuit diagram* is essential for any new electronic product, device or gadget.

Circuit Symbol of Electronic Components



How to Draw a Circuit Diagram?

Drawing a circuit diagram is not that difficult if you know the basics. Here are some Tips, Tutorial and Guidelines:

1. Learn and understand all the common symbols and abbreviations for electronic components to be used on the diagram.

2. Using a ruler, draw connecting wires as straight lines. Use following symbols: ‘blob’ **()** at each junction between wires, label components (resistors, capacitors, diodesetc) with their values, the positive (+) supply should be at the top and the negative (–) supply at the bottom. Negative supply is usually labeled 0V, zero volts.

3. For complex circuit diagrams, start from left to right. So that signals flow from left to right (*inputs and controls should be on the left, outputs on the right*).Printed Circuit Board Assembly

Mounting electronic components on the circuit board and getting it ready for use is what is called circuit board assembly. A *Circuit Board Assembly Process* may use through-hole assembly technology or surface mount technology (SMT) or a mix of both.

Once the circuit board is assembled with components it is ready for testing and finally to be assembled with the product. But it is not guaranteed that a circuit board assembly will give 100% zero defect production. There will be defects and these defect need to be reworked / repaired.

TEXT 21 PRINTED CIRCUIT BOARD – MATERIALS, DESIGN

RoHS compliant PCB

The European Union bans the use of lead (among other heavy metals) in consumer items, a piece of legislature called the RoHS, for Restriction of Hazardous Substances, directive. PCBs to be sold in the EU must be RoHS-compliant, meaning that all manufacturing processes must not involve the use of lead, all solder used must be lead-free, and all components mounted on the board must be free of lead, mercury, cadmium, and other heavy metals.

Laminates

Laminates are manufactured by curing under pressure and temperature layers of cloth or paper with thermoset resin to form an integral final piece of uniform thickness. The size can be up to 4 by 8 feet (1.2 by 2.4 m) in width and length. Varying cloth weaves (threads per inch or cm), cloth thickness, and resin percentage are used to achieve the desired final thickness and dielectric characteristics. Available standard laminate thickness are listed in ANSI/IPC-D-275. The cloth or fiber material used, resin material, and the cloth to resin ratio determine the laminate's type designation (FR-4, CEM-1, G-10, etc.) and therefore the characteristics of the laminate produced. Important characteristics are the level to which the laminate is fire retardant, the dielectric constant (e_r), the loss factor (tδ), the tensile strength, the shear strength, the glass transition temperature (T_g), and the Z-axis expansion coefficient (how much the thickness changes with temperature). There are quite a few different dielectrics that can be chosen to provide different insulating values depending on the requirements of the circuit. Some of these dielectrics are polytetrafluoroethylene (Teflon), FR-4, FR-1, CEM-1 or CEM-3. Well known pre-preg materials used in the PCB industry are FR-2 (phenolic cotton paper), FR-3 (cotton paper and epoxy), FR-4 (woven glass and epoxy), FR-5 (woven glass and epoxy), FR-6 (matte glass and polyester), G-10 (woven glass and epoxy), CEM-1 (cotton paper and epoxy), CEM-2 (cotton paper and epoxy), CEM-3 (non-woven glass and epoxy), CEM-4 (woven glass and epoxy), CEM-5 (woven glass and polyester). Thermal expansion is an important consideration especially with ball grid array (BGA) and naked die technologies, and glass fiber offers the best dimensional stability. FR-4 is by far the most common material used today. The board stock with unetched copper on it is called "copper-clad laminate". With decreasing size of board features and increasing frequencies, small non-homogeneities like uneven distribution of fiberglass or other filler, thickness variations, and bubbles in the resin matrix, and the associated local variations in the dielectric constant, are gaining importance.

Key substrate parameters

The circuit board substrates are usually dielectric composite materials. The composites contain a matrix (usually an epoxy resin) and a reinforcement (usually a woven, sometimes nonwoven, glass fibers, sometimes even paper), and in some cases a filler is added to the resin (e.g. ceramics; titanite ceramics can be used to increase the dielectric constant). The reinforcement type defines two major classes of materials: woven and non-woven. Woven reinforcements are cheaper, but the high dielectric constant of glass may not be favorable for many higher-frequency applications. The spatially nonhomogeneous structure also introduces local variations in electrical parameters, due to different resin/glass ratio at different areas of the weave pattern. Nonwoven reinforcements, or materials with low or no reinforcement, are more expensive but more suitable for some RF/analog applications. The substrates are characterized by several key parameters, chiefly thermomechanical (glass transition temperature, tensile strength, shear strength, thermal expansion), electrical (dielectric constant, loss tangent, dielectric breakdown voltage, leakage current, tracking resistance...), and others (e.g. moisture absorption). At the glass transition temperature the resin in the composite softens and significantly increases thermal expansion; exceeding T_g then exerts mechanical overload on the board components - e.g. the joints and the vias. Below T_g the thermal expansion of the resin roughly matches copper and glass, above it gets significantly higher. As the reinforcement and copper confine the board along the plane, virtually all volume expansion projects to the thickness and stresses the plated-through holes. Repeated soldering or other exposition to higher temperatures can cause failure of the plating, especially with thicker boards; thick boards therefore require a matrix with a high T_g. The materials used determine the substrate's dielectric constant. This constant is also dependent on frequency, usually decreasing with frequency. As this constant determines the signal propagation speed, frequency dependence introduces phase distortion in wideband applications; as flat a dielectric constant vs frequency characteristic as is achievable is important here. The impedance of transmission lines decreases with frequency, therefore faster edges of signals reflect more than slower ones. *Dielectric breakdown voltage determines* the maximum voltage gradient the material can be subjected to before suffering a breakdown (conduction, or arcing, through the dielectric). Tracking resistance determines how the material resists high voltage electrical discharges creeping over the board surface. Loss tangent determines how much of the electromagnetic energy from the signals in the conductors is absorbed in the board material. This factor is important for high frequencies. Low-loss materials are more expensive. Choosing unnecessarily low-loss material is a common engineering error in high-frequency digital design; it increases the cost of the boards without a corresponding benefit. Signal degradation by loss tangent and dielectric constant can be easily assessed by an eye pattern. Moisture absorption occurs when the material is exposed to high humidity or water. Both the resin and the reinforcement may absorb water; water also may be soaked by capillary forces through voids in the materials and along the reinforcement. Epoxies of the FR-4 materials aren't too susceptible, with absorption of only 0.15%. Teflon has very low absorption of 0.01%. Polyimides and cyanate esters, on the other side, suffer from high water absorption. Absorbed water can lead to significant degradation of key parameters; it impairs tracking resistance, breakdown voltage, and dielectric parameters. Relative dielectric constant of water is about 73, compared to about 4 for common circuit board materials. Absorbed moisture can also vaporize on heating, as during soldering, and cause cracking and delamination, the same effect responsible for "popcorning" damage on wet packaging of electronic parts. Careful baking of the substrates may be required to dry them prior to soldering.

Common substrates

Often encountered materials:

- FR-2, phenolic paper or phenolic cotton paper, paper impregnated with a phenol formaldehyde resin. Common in consumer electronics with single-sided boards. Electrical properties inferior to FR-4. Poor arc resistance. Generally rated to 105 °C.
- FR-4, a woven fiberglass cloth impregnated with an epoxy resin. Low water absorption (up to about 0.15%), good insulation properties, good arc resistance. Very common. Several grades with somewhat different properties are available. Typically rated to 130 °C.
- Aluminum, or *metal core board* or insulated metal substrate (IMS), clad with thermally conductive thin dielectric - used for parts requiring significant cooling - power switches, LEDs. Consists of usually single, sometimes double layer thin circuit board based on e.g. FR-4, laminated on aluminum sheet metal, commonly 0.8, 1, 1.5, 2 or 3 mm thick. The thicker laminates sometimes also come with thicker copper metallization.
- Flexible substrates - can be a standalone copper-clad foil or can be laminated to a thin stiffener, e.g. 50-130 µm
  - Kapton or UPILEX, a polyimide foil. Used for flexible printed circuits, in this form common in small form-factor consumer electronics or for flexible interconnects. Resistant to high temperatures.
  - Pyralux, a polyimide-fluoropolymer composite foil. Copper layer can delaminate during soldering.

Less-often encountered materials:

- FR-1, like FR-2, typically specified to 105 °C, some grades rated to 130 °C. Room-temperature punchable. Similar to cardboard. Poor moisture resistance. Low arc resistance.
- FR-3, cotton paper impregnated with epoxy. Typically rated to 105 °C.
- FR-5, woven fiberglass and epoxy, high strength at higher temperatures, typically specified to 170 °C.
- FR-6, matte glass and polyester
- G-10, woven glass and epoxy - high insulation resistance, low moisture absorption, very high bond strength. Typically rated to 130 °C.
- G-11, woven glass and epoxy - high resistance to solvents, high flexural strength retention at high temperatures. Typically rated to 170 °C.

- CEM-1, cotton paper and epoxy
- CEM-2, cotton paper and epoxy
- CEM-3, non-woven glass and epoxy
- CEM-4, woven glass and epoxy
- CEM-5, woven glass and polyester
- PTFE, ("Teflon") - expensive, low dielectric loss, for high frequency applications, very low moisture absorption (0.01%), mechanically soft. Difficult to laminate, rarely used in multilayer applications.
- PTFE, ceramic filled - expensive, low dielectric loss, for high frequency applications. Varying ceramics/PTFE ratio allows adjusting dielectric constant and thermal expansion.
- RF-35, fiberglass-reinforced ceramics-filled PTFE. Relatively less expensive, good mechanical properties, good high-frequency properties.
- Alumina, a ceramic. Hard, brittle, very expensive, very high performance, good thermal conductivity.
- Polyimide, a high-temperature polymer. Expensive, high-performance. Higher water absorption (0.4%). Can be used from cryogenic temperatures to over 260 °C.

Copper thickness

Copper thickness of PCBs can be specified directly or as the weight of copper per area (in ounce per square foot) which is easier to measure. One ounce per square foot is 1.344 mils or 34 micrometers thickness. *Heavy copper* is a layer exceeding three ounces of copper per ft^2, or approximately 0.0042 inches (4.2 mils, 105 μm) thick. Heavy copper layers are used for high current or to help dissipate heat. On the common FR-4 substrates, 1 oz copper per ft^2 (35 μm) is the most common thickness; 2 oz (70 μm) and 0.5 oz (18 μm) thickness is often an option. Less common are 12 and 105 μm, 9 μm is sometimes available on some substrates. Flexible substrates typically have thinner metalization. Metal-core boards for high power devices commonly use thicker copper; 35 μm is usual but also 140 and 400 μm can be encountered.

Design

A board designed in 1967; the sweeping curves in the traces are evidence of freehand design using adhesive tape

Initially PCBs were designed manually by creating a photomask on a clear mylar sheet, usually at two or four times the true size. Starting from the schematic diagram the component pin pads were laid out on the mylar and then traces were routed to connect the pads. Rub-on dry transfers of common component footprints increased efficiency. Traces were made with self-adhesive tape. Pre-printed non-reproducing grids on the mylar assisted in layout. The finished photomask was photolithographically reproduced onto a photoresist coating on the blank copper-clad boards. Modern PCBs are designed with dedicated layout software, generally in the following steps:

1. Schematic capture through an electronic design automation (*EDA*) tool.
2. Card dimensions and template are decided based on required circuitry and case of the PCB.
3. The positions of the components and heat sinks are determined.

4. Layer stack of the PCB is decided, with one to tens of layers depending on complexity. Ground and power planes are decided. A power plane is the counterpart to a ground plane and behaves as an AC signal ground while providing DC power to the circuits mounted on the PCB. Signal interconnections are traced on signal planes. Signal planes can be on the outer as well as inner layers. For optimal EMI performance high frequency signals are routed in internal layers between power or ground planes.
5. Line impedance is determined using dielectric layer thickness, routing copper thickness and trace-width. Trace separation is also taken into account in case of differential signals. Microstrip, stripline or dual stripline can be used to route signals.
6. Components are placed. Thermal considerations and geometry are taken into account. Vias and lands are marked.
7. Signal traces are routed. Electronic design automation tools usually create clearances and connections in power and ground planes automatically.
8. Gerber files are generated for manufacturing.

TEXT 22 SURFACE TENSION

We are familiar with the surface tension of water as a force that retains the cold water in globules on a greasy plate. The adhesive force that tends to spread the liquid on the solid is, in this case, less than the cohesive force. Washing with warm water and using a detergent reduces the surface tension and the water wets the greasy plate and flows out into a thin layer. It happens if the adhesive force is stronger than the cohesive force. The cohesive force of tin/lead solder is even higher than that of water and also draws the solder into spheres, as it tends to minimize the surface area (a sphere has the smallest surface of any geometric configuration with equal volume in order to satisfy the requirements of the lowest state of energy). Flux acts similarly as the detergent does with the greasy plate. Further, surface tension is highly dependent on any contamination on the surface, as well as, on temperature. Only if the adhesion energy becomes much stronger than the surface energy (cohesive force), ideal wetting will occur.

Creation of an Inter-metallic Compound

The intermolecular bond of copper and tin forms crystalline grains whose shape and size is determined by the duration and intensity of the temperature while soldering. Less thermal application results in fine crystalline structures, which results in excellent solder joints having an optimum strength. Longer reaction times, provided by either longer time or higher temperature or both, result in coarse crystalline structures having less shear strength because of being more gritty and brittle. With copper as the base metal and tin/lead as solder alloy, lead does not form any inter-metallic compound with copper. However, tin penetrates into copper and the intermolecular bond of tin and copper forms the inter metallic compounds Cu3Sn and Cu6Sn5 at the interface of solder and the metal being joined. This is shown in Figure 13.1a. The inter-metallic layer (*n*-phase plus *e*-phase) must be every thin. In laser soldering, the intermetallic layer has a thickness of the order of 0.1 mm. In wave soldering and manual soldering, the thicknesses of the intermolecular bond of excellent solder joints mostly exceed 0.5 mm. Since the shear strength of the solder joint decreases with an increase in the thickness of the inter-metallic layer, the attempt is always made to keep the thickness less than 1 mm. This can be achieved by keeping the soldering time as short as possible. The layer thickness of the inter-metallic compound depends on the temperature and time taken to form the joint. Ideally a soldered connection should be made at approximate 220 °C for two seconds. The chemical diffusion reaction between copper and tin will produce under these conditions the optimal amount, 0.5 m, of the inter-metallic bonding material Cu3Sn and Cu6Sn5. Insufficient intermetallic bond, as seen in a cold solder joint or a joint that has not been raised to the proper temperature, can result in a shearing at this interface. In contrary, too much inter-metallic, as seen in a joint that has been overheated or is held too long at temperature, can result in a drastic weakening of the tensile strength of the joint

The Wetting Angle

The ability of a surface to be wetted by solder can, to some extent, be assessed by the shape of the meniscus formed when a drop of solder is placed on the hot, fluxed surface, approximately 35 °C above the eutectic point of the solder. If the meniscus has a noticeable undercut edge, like a water drop on a greasy plate or even if it tends to form balls, the metal is not at all solderable. The solderability is good only when the meniscus draws out to a fine angle of less than 30°.

Soldering Variables

The important variables of soldering are: temperature, time, tarnish-free surface, right flux and right solder. These variables are important to all the soldering techniques and should be always kept in mind. For achieving good results the golden rule is "Applying the right temperature to the solder as well as to the lands/terminations to be soldered for the correct time on a clean surface by using the right flux and proper solder will provide excellent joint looking bright and shiny".

Temperature and Time Taken for Soldering

The temperature and the time of heat application determine the thickness of the inter-metallic compound.

Because of the brittleness of the inter-metallic layer, a too thick layer may cause solder cracking under conditions of thermal or mechanical stress. Beside, the larger thickness of the inter-metallic compound, excess of heat and its longer application may also destroy heat-sensitive components as well as the board. The aim is to keep the temperature low and the time of the highest heat application as short as possible. For surface mounted components, the shear strength is very critical. Due to the different thermal expansion coefficients of the board and components, temperature changes lead to different changes in length and the creation of shear forces especially for larger components. The temperature for soldering depends on the melting point of solder and its application. For each metal and solder combination, there is a critical temperature below which wetting does not occur or take place to a very small extent. As a rule of thumb, the temperature in re-flow soldering processes should be 30° to 50° and in wave soldering 45° to 60° above the melting point of the solder. A good starting point in manual soldering is a temperature setting of 85° above the melting point of the solder. The application of heat should be homogeneous since the solder always tends to flow towards the higher temperature.

Tarnish-free Surface

The solder will wet the metal only when the metal to be soldered is free from any tarnish. Although the surfaces to be soldered may look clean, there is always a thin film of oxide covering it. The outer layer of the metal attracts water and various gases get physically bound and below it, they may be chemically bound with oxides, sulphides and carbonates. For a good solder bond, all dirt, grease and surface oxides must be removed before and with the help of flux during the soldering process.

Application of Right Flux and Proper Solder

Fluxes should remove the tarnish from base metals and prevent them from reforming oxides while soldering. The effectiveness of the flux in removing oxide is called "activity" which depends on the activators that are used. A highly active flux will remove oxides. However, the corrosiveness of acids desirable to remove the reaction layer of the tarnish may damage the electronic components. Even mild acids, if not removed, leave a residue that continues to corrode after the soldering process is complete, leading to future failure. The selection of the flux depends on the soldering process chosen, the metal being soldered and on the cleanness of the metal. The plastic range of a solder varies, depending upon the ratio of the metals forming the solder alloy, e.g. tin to lead. The 63/37 ratio, known as eutectic solder has practically no plastic range, and melts almost instantly at 183 °C and therefore is usually recommended. Besides, the purity of solder is very important. The presence of more than 0.5 per cent of contaminants within common soft solders may not give the required quality.

TEXT 23 TYPES OF ELECTRICAL CABLE

by Natasha Gilani

An electrical cable, or power cable, is used to transmit electrical power. Electrical cables provide connection and allow power stations, wired computer networks, televisions, telephones and other electricity-powered devices to work. There are many types of electrical cables that differ in configuration, size and performance.

Components of Electrical Cables

All electrical cables consist of at least two conducting wires and an outer protective jacket. For medium to high power cables that carry high voltages, the conducting wires within the outer protective jacket may individually be enclosed in insulating sheaths. Electrical conductors are commonly made of copper. Synthetic polymers make the outer jacket and protective, insulating material.

Coaxial Cable

A coaxial electrical cable has a copper-plated core, surrounded by a dielectric insulator. A woven shield of copper surrounds the insulating layer, which is finally wound by an outmost plastic sheath. Coaxial cables differ in size, performance, flexibility, power handling capabilities and cost. They are used to connect home audio and video equipment, television networks and components of a local area network. Hard line, leaky cable, RG/6, twin-axial, biaxial and semi-rigid are types of coaxial cables.

Ribbon Cable

A ribbon electrical cable (also called multi-wire planar electrical cable or flat twin cables) is made up of multiple insulated wires running parallel to each other. These parallel wires allow the simultaneous transmission of multiple signals of data. According to "Optical Communications Essentials," a typical ribbon cable consists of four to 12 wires. It is commonly used to interconnect network devices. Ribbon cables also connect the motherboard with other core CPU (central processing unit) components in computers.

Twisted Pair Cable

A twisted pair electrical cable consists of pairs of insulated copper wires (that are color coded), which are twisted around each other. The diameter of each wire ranges from 0.4 to 0.8 mm, and the number of pairs vary in different types of twisted pair cables. The greater the number of pairs, the higher the resistance of the cable will be to external noise and cross-talk. Twisted pair cables are easy to install, flexible and inexpensive. They are used for telephone cabling and to wire local area networks.

Shielded Cable

A shielded electrical cable is made of one or more insulated wires that are collectively enclosed by an aluminum Mylar foil or woven braid shielding. The shielding prevents the cable from external radio and power frequency interference, allowing the signal transmission to proceed smoothly. High-voltage power cables are commonly shielded.

TEXT 24 THE BASICS OF WIRING HARNESSES FOR INDUSTRIAL ENGINES

Technosoft Engineering, Jan 19, 2018

Acting as the central nervous system to many vehicle electronics designs, wiring harnesses for engines and rotating machines are used in the transmission of signals or electrical power. As applications become increasingly complex, innovation in the design and manufacturing process becomes even more critical. Bound tightly together, these harnesses provide advantages over loose wires and cables. Commonly used in automobiles, marine vessels and off-highway vehicles, they act as an efficient space saver. If the wires in these vehicles were stretched out, they would be over several miles long fully extended. Binding the cables with the use of a wiring harness, they are better protected from adverse effects caused by vibrations, moisture and abrasions. Biding the wires also decreases the risk of the wires short-circuiting.

The creation of electrical harness has traditionally been planned through a combination of desktop documentation and 2D drawings. The size of the harness segments was typically derived from actual physical measurements of a prototype. These techniques for the development of the electrical harness are labor intensive and highly inaccurate. But harness development in 3D CAD has been a demanding and formidable task that is prone to error, and typically still requires separate documentation for electrical interconnect information.

Wiring harnesses also make installation easier. By eliminating the need to install multiple wires, the installation process can be easily standardized and the time it takes for installation decreases dramatically.

Designed according to both geometric and electrical requirements, wiring harnesses can be fully customized. Wires are first cut to the specified length using a special machine. The ends of the wires are then stripped to expose the metal, or core, of the wires. The core of the wire is then fitted for any required terminals or connector housings. According to the design specifications, the cables are then assembled and bound together. A protective sleeve made of pipe or conduit is then fitted if necessary.

Generally, these harnesses are manufactured by hand due to the many different processes involved. This includes, routing the wires through sleeves and fastening strands with tape, clamps or cable ties. While these processes are difficult to automate, experienced manufacturers can offer high-quality, handmade wiring harnesses that are still cost efficient. See **2D wiring harness routing** for more.

Depending on the final use and environment in which the wiring harness will operate, a different harness maybe needed. There are many ***types of harnesses***.

· **Open Bundles**: The wires are attached to connectors, terminal lugs, and are then tied into bundles with multiple breakouts by means of plastic tie wraps or waxed lacing twine.

· **Closed Bundles**: Wires are bundled with a covering, such as pulled-on braided tubing, braided-on Nomex or nylon, or in some cases, metal braid.

· **Waterproof Harnesses:** The legs are covered with tubing, such as neoprene. The junctions between the legs and back shells of the connectors are over molded with a material such as urethane or rubber compounds. In some cases, PVC tubing and molding are used.

CONTROL QUESTIONS BY THEMES:

Types of Electrical Cable, The Basics of Wiring Harnesses for Industrial Engines, Requirements of Solder Pastes, Printed circuit board. Materials (Part 1), Printed circuit board. Design (Part 2), Surface Tension

THE SCHEME FOR THE QUESTIONS ANSWERS:

1) **TEXT 1.** Выпишите из текста 5 ключевых предложений, характеризующих типы кабеля.

Переведите следующее предложение. Что не так в этом предложении? Найдите его в тексте. Если надо, скорректируйте его. Обоснуйте свой ответ.

A woven shield of silver surrounds the insulating layer spot, which is finally wound by an outmost plastic sheath. Coaxial cables differ in circuits board, performance, flexibility, power handling capabilities and cost.

2) **TEXT 2.** Выпишите из текста только *технические данные*. Почему вы решили, что выбранные вами предложения технические? Обоснуйте свой ответ (3-4 предложения).
3) **TEXT 3.** В 7 предложениях перескажите текст на англ. яз.

Переведите выделенное слово, замените его синонимом. Поясните суть следующего предложения своими словами на англ. яз.:

It is wiped across the stencil or screen with ***a squeegee****, which pushes the paste through the openings, depositing it on the lands at the right places.*

4) **TEXT 4.** Укажите главную идею текста (выпишете предложения, где выражается суть).

Переведите данное ниже предложение. Два слова стоят не на своих местах. Меняют ли они смысл всего предложения? Исправьте, если считаете, что меняют.

Woven are cheaper, but the high dielectric constant of glass may not be reinforcements favorable for many higher-frequency applications. The nonhomogeneous spatially structure also introduces local variations in electrical parameters, due to different resin/glass ratio at different areas of the weave pattern.;

5) **TEXT 5.** Как можно проверить плату? В 5 предложениях на англ. яз. опишите процесс.
6) **TEXT 6.** Выпишите 5 важных терминов текста, без которых было бы невозможно понять смысл текста. Почему вы так решили? Обоснуйте свой выбор (1-2 предложения в обосновании)

Переведите словосочетание - *eutectic solder*. Это термин, два слова, образующие термин, или просто слова, передающие значение? Обоснуйте ваш ответ на англ. яз.

Переведите **выделенные** слова **отдельно**, потом в **контексте**. Объясните своими (английскими) словами **смысл описанного процесса**.

A highly active flux will ***remove*** *oxides. However, the corrosiveness of acids desirable to remove the reaction layer of the tarnish may damage the electronic components. Even* ***mild acids****, if not removed, leave a* ***residue*** *that continues to corrode after the soldering process is complete, leading* ***to future failure.***

APPENDIX

TEXT 1. Types of Electrical Cable

An electrical cable, or power cable, is used to transmit electrical power. Electrical cables provide connection and allow power stations, wired computer networks, televisions, telephones and other electricity-powered devices to work. There are many types of electrical cables that differ in configuration, size and performance.

Components of Electrical Cables All electrical cables consist of at least two conducting wires and an outer protective jacket. For medium to high power cables that carry high voltages, the conducting wires within the outer protective jacket may individually be enclosed in insulating sheaths. Electrical conductors are commonly made of copper. Synthetic polymers make the outer jacket and protective, insulating material.

Coaxial Cable A coaxial electrical cable has a copper-plated core, surrounded by a dielectric insulator. A woven shield of copper surrounds the insulating layer, which is finally wound by an outmost plastic sheath. Coaxial cables differ in size, performance, flexibility, power handling capabilities and cost. They are used to connect home audio and video equipment, television networks and components of a local area network. Hard line, leaky cable, RG/6, twin-axial, biaxial and semi-rigid are types of coaxial cables.

Ribbon Cable A ribbon electrical cable (also called multi-wire planar electrical cable or flat twin cables) is made up of multiple insulated wires running parallel to each other. These parallel wires allow the simultaneous transmission of multiple signals of data. According to "Optical Communications Essentials," a typical ribbon cable consists of four to 12 wires. It is commonly used to interconnect network devices. Ribbon cables also connect the motherboard with other core CPU (central processing unit) components in computers.

Twisted Pair Cable A twisted pair electrical cable consists of pairs of insulated copper wires (that are color coded), which are twisted around each other. The diameter of each wire ranges from 0.4 to 0.8 mm, and the number of pairs vary in different types of twisted pair cables. The greater the number of pairs, the higher the resistance of the cable will be to external noise and cross-talk. Twisted pair cables are easy to install, flexible and inexpensive. They are used for telephone cabling and to wire local area networks.

Shielded Cable A shielded electrical cable is made of one or more insulated wires that are collectively enclosed by an aluminum Mylar foil or woven braid shielding. The shielding prevents the cable from external radio and power frequency interference, allowing the signal transmission to proceed smoothly. High-voltage power cables are commonly shielded.

TEXT 2. The Basics of Wiring Harnesses for Industrial Engines

Acting as the central nervous system to many vehicle electronics designs, wiring harnesses for engines and rotating machines are used in the transmission of signals or electrical power. As applications become increasingly complex, innovation in the design and manufacturing process becomes even more critical. Bound tightly together, these harnesses provide advantages over loose wires and cables. Commonly used in automobiles, marine vessels and off-highway vehicles, they act as an efficient space saver. If the wires in these vehicles were stretched out, they would be over several miles long fully extended. Binding the cables with the use of a wiring harness, they are better protected from adverse effects caused by vibrations, moisture and abrasions. Biding the wires also decreases the risk of the wires short-circuiting.

The creation of electrical harness has traditionally been planned through a combination of desktop documentation and 2D drawings. The size of the harness segments was typically derived from actual physical measurements of a prototype. These techniques for the development of the electrical harness are labor intensive and highly inaccurate. But harness development in 3D CAD has been a demanding and formidable task that is prone to error, and typically still requires separate documentation for electrical interconnect information.

Wiring harnesses also make installation easier. By eliminating the need to install multiple wires, the installation process can be easily standardized and the time it takes for installation decreases dramatically.

Designed according to both geometric and electrical requirements, wiring harnesses can be fully customized. Wires are first cut to the specified length using a special machine. The ends of the wires are then stripped to expose the metal, or core, of the wires. The core of the wire is then fitted for any required terminals or connector housings. According to the design specifications, the cables are then assembled and bound together. A protective sleeve made of pipe or conduit is then fitted if necessary.

Generally, these harnesses are manufactured by hand due to the many different processes involved. This includes, routing the wires through sleeves and fastening strands with tape, clamps or cable ties. While these processes are difficult to automate, experienced manufacturers can offer high-quality, handmade wiring harnesses that are still cost efficient. See **2D wiring harness routing** for more.

Depending on the final use and environment in which the wiring harness will operate, a different harness maybe needed. There are many ***types of harnesses***.

· **Open Bundles**: The wires are attached to connectors, terminal lugs, and are then tied into bundles with multiple breakouts by means of plastic tie wraps or waxed lacing twine.

· **Closed Bundles**: Wires are bundled with a covering, such as pulled-on braided tubing, braided-on Nomex or nylon, or in some cases, metal braid.

· **Waterproof Harnesses:** The legs are covered with tubing, such as neoprene. The junctions between the legs and back shells of the connectors are over molded with a material such as urethane or rubber compounds. In some cases, PVC tubing and molding are used.

TEXT 3. Requirements of Solder Pastes

Solder pastes must meet the following requirements: The individual powder particles of the solder alloy should have a homogeneous distribution of the metal within the paste as well as a fair equality of shape and surface roughness of the individual powder particles. It should develop an adhesive action in order to hold the components in place until the reflow operation has been finished. It must not tend to solder balling; if they become detached on the substrate, they may cause short circuits. It has to maintain its shape during curing and reflow and must remain on the pads, not leaking to unsolderable parts of the PCB. It must have sufficient activity as the solder paste is sometimes in contact with the parts for several hours.

Solder Paste Application

The reflow soldering process starts mostly with the application of solder paste to the specific areas of the circuit board where the components will be attached. Solder paste printing is commonly applied by stencil or screen-printing. It is wiped across the stencil or screen with a squeegee, which pushes the paste through the openings, depositing it on the lands at the right places. With solder paste printing, the entire amount of solder is deposited on the PCB in one operational step. Solder paste application with dispenser is generally used for laboratory applications because of its flexibility. With a dispenser, the solder paste can be applied not only in form of dots, but also in stripes, which may be more useful and accurate in certain cases.

Handling of Solder Paste

Solder paste ages and changes with temperature, humidity and light. The following precautions may be taken while handling solder paste, keeping in view the recommendations of the paste supplier; Store solder paste in a clean, cool, dry and dark location. Before opening refrigerated solder paste, keep it for 24 hours at room temperature to avoid water condensation. Do not mix old and new pastes since the fluxes and thinners will evaporate at different rates. Stir solder paste at least 30 seconds before applying to the stencil/screen. Use only clean and inert tools (Such as made of stainless steel, Teflon, Polyethylene). Apply to the stencil/screen the amount of paste just required for printing.

TEXT 4. Printed circuit board. Materials (Part 1)

Key substrate parameters

The circuit board substrates are usually dielectric composite materials. The composites contain a matrix (usually an epoxy resin) and a reinforcement (usually a woven, sometimes nonwoven, glass fibers, sometimes even paper), and in some cases a filler is added to the resin (e.g. ceramics; titanate ceramics can be used to increase the dielectric constant). The reinforcement type defines two major classes of materials: woven and non-woven. Woven reinforcements are cheaper, but the high dielectric constant of glass may not be favorable for many higher-frequency applications. The spatially nonhomogeneous structure also introduces local variations in electrical parameters, due to different resin/glass ratio at different areas of the weave pattern. Nonwoven reinforcements, or materials with low or no reinforcement, are more expensive but more suitable for some RF/analog applications.

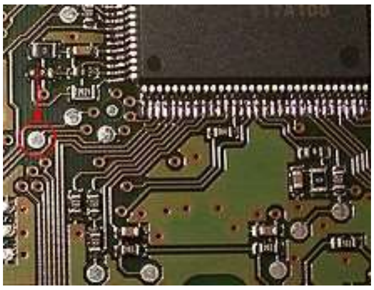
The substrates are characterized by several key parameters, chiefly thermomechanical (glass transition temperature, tensile strength, shear strength, thermal expansion), electrical (dielectric constant, loss tangent, dielectric breakdown voltage, leakage current, tracking resistance...), and others (e.g. moisture absorption). At the glass transition temperature the resin in the composite softens and significantly increases thermal expansion; exceeding T_g then exerts mechanical overload on the board components - e.g. the joints and the vias. Below T_g the thermal expansion of the resin roughly matches copper and glass, above it gets significantly higher. As the reinforcement and copper confine the board along the plane, virtually all volume expansion projects to the thickness and stresses the plated-through holes. Repeated soldering or other exposition to higher temperatures can cause failure of the plating, especially with thicker boards; thick boards therefore require a matrix with a high T_g. The materials used determine the substrate's dielectric constant. This constant is also dependent on frequency, usually decreasing with frequency. As this constant determines the signal propagation speed, frequency dependence introduces phase distortion in wideband applications; as flat a dielectric constant vs frequency characteristic as is achievable is important here. The impedance of transmission lines decreases with frequency, therefore faster edges of signals reflect more than slower ones. *Dielectric breakdown voltage determines* the maximum voltage gradient the material can be subjected to before suffering a breakdown (conduction, or arcing, through the dielectric). Tracking resistance determines how the material resists high voltage electrical discharges creeping over the board surface.

Loss tangent determines how much of the electromagnetic energy from the signals in the conductors is absorbed in the board material. This factor is important for high frequencies. Low-loss materials are more expensive. Choosing unnecessarily low-loss material is a common engineering error in high-frequency digital design; it increases the cost of the boards without a corresponding benefit. Signal degradation by loss tangent and dielectric constant can be easily assessed by an eye pattern. Moisture absorption occurs when the material is exposed to high humidity or water. Both the resin and the reinforcement may absorb water; water also may be soaked by capillary forces through voids in the materials and along the reinforcement. Epoxies of the FR-4 materials aren't too susceptible, with absorption of only 0.15%. Teflon has very low absorption of 0.01%. Polyimides and cyanate esters, on the other side, suffer from high water absorption. Absorbed water can lead to significant degradation of key parameters; it impairs tracking resistance, breakdown voltage, and dielectric parameters. Relative dielectric constant of water is about 73, compared to about 4 for common circuit board materials. Absorbed moisture can also vaporize on heating, as during soldering, and cause cracking and delamination, the same effect responsible for "popcorning" damage on wet packaging of electronic parts. Careful baking of the substrates may be required to dry them prior to soldering.

TEXT 5. Printed circuit board. Design (Part 2)

Assembly

PCB with test connection pads



In assembly the bare board is populated (or "stuffed") with electronic components to form a functional *printed circuit assembly* (PCA), sometimes called a "printed circuit board assembly" (PCBA). In through-hole technology, the component leads are inserted in holes surrounded by conductive *pads*; the holes keep the components in place. In surface-mount technology (SMT), the component is placed on the PCB so that the pins line up with the conductive *pads*or *lands* on the surfaces of the PCB; solder paste, which was previously applied to the pads, holds the components in place temporarily; if surface-mount components are applied to both sides of the board, the bottom-side components are glued to the board. In both through hole and surface mount, the components are then soldered; once cooled and solidified, the solder holds the components in place permanently and electrically connects them to the board. There are a variety of soldering techniques used to attach components to a PCB. High volume production is usually done with a "Pick and place machine" or SMT placement machine and bulk wave soldering or reflow ovens, but skilled technicians are able to hand-solder very tiny parts (for instance 0201 packages which are 0.02 in. by 0.01 in.) under a microscope, using tweezers and a fine-tip soldering iron, for small volume prototypes. Some SMT parts cannot be soldered by hand, such as BGA packages. All through-hole components can be hand soldered, making them favored for prototyping where size, weight, and the use of the exact components that would be used in high volume production are not concerns. Often, through-hole and surface-mount construction must be combined in a single assembly because some required components are available only in surface-mount packages, while others are available only in through-hole packages. Or, even if all components are available in through-hole packages, it might be desired to take advantage of the size, weight, and cost reductions obtainable by using some available surface-mount devices. Another reason to use both methods is that through-hole mounting can provide needed strength for components likely to endure physical stress (such as connectors that are frequently mated and demated or that connect to cables expected to impart substantial stress to the PCB-and-connector interface), while components that are expected to go untouched will take up less space using surface-mount techniques. *For further comparison, see the SMT page.* After the board has been populated it may be tested in a variety of ways:

- While the power is off, visual inspection, automated optical inspection. JEDEC guidelines for PCB component placement, soldering, and inspection are commonly used to maintain quality control in this stage of PCB manufacturing.
- While the power is off, analog signature analysis, power-off testing.
- While the power is on, in-circuit test, where physical measurements (for example, voltage) can be done.
- While the power is on, functional test, just checking if the PCB does what it had been designed to do.

To facilitate these tests, PCBs may be designed with extra pads to make temporary connections. Sometimes these pads must be isolated with resistors. The in-circuit test may also exercise boundary scan test features of some components. In-circuit test systems may also be used to program nonvolatile memory components on the board. In boundary scan testing, test circuits integrated into various ICs on the board form temporary connections between the PCB traces to test that the ICs are mounted correctly. Boundary scan testing requires that all the ICs to be tested use a standard test configuration procedure, the most common one being the Joint Test Action Group (JTAG) standard. The JTAG test architecture provides a means to test interconnects between integrated circuits on a board without using physical test probes, by using circuitry in the ICs to employ the IC pins themselves as test probes. JTAG tool vendors provide various types of stimuli and sophisticated algorithms, not only to detect the failing nets, but also to isolate the faults to specific nets, devices, and pins. When boards fail the test, technicians may desolder and replace failed components, a task known as *rework*.

TEXT 6. Surface Tension

We are familiar with the surface tension of water as a force that retains the cold water in globules on a greasy plate. The adhesive force that tends to spread the liquid on the solid is, in this case, less than the cohesive force. Washing with warm water and using a detergent reduces the surface tension and the water wets the greasy plate and flows out into a thin layer. It happens if the adhesive force is stronger than the cohesive force. The cohesive force of tin/lead solder is even higher than that of water and also draws the solder into spheres, as it tends to minimize the surface area (a sphere has the smallest surface of any geometric configuration with equal volume in order to satisfy the requirements of the lowest state of energy). Flux acts similarly as the detergent does with the greasy plate. Further, surface tension is highly dependent on any contamination on the surface, as well as, on temperature. Only if the adhesion energy becomes much stronger than the surface energy (cohesive force), ideal wetting will occur.

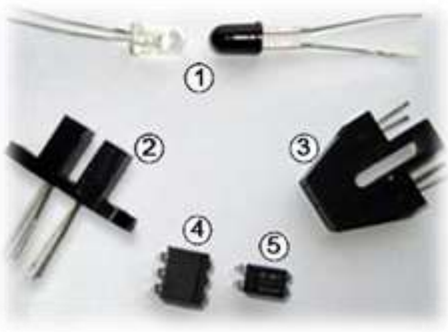
Tarnish-free Surface

The solder will wet the metal only when the metal to be soldered is free from any tarnish. Although the surfaces to be soldered may look clean, there is always a thin film of oxide covering it. The outer layer of the metal attracts water and various gases get physically bound and below it, they may be chemically bound with oxides, sulphides and carbonates. For a good solder bond, all dirt, grease and surface oxides must be removed before and with the help of flux during the soldering process.

Application of Right Flux and Proper Solder

Fluxes should remove the tarnish from base metals and prevent them from reforming oxides while soldering. The effectiveness of the flux in removing oxide is called “activity” which depends on the activators that are used. A highly active flux will remove oxides. However, the corrosiveness of acids desirable to remove the reaction layer of the tarnish may damage the electronic components. Even mild acids, if not removed, leave a residue that continues to corrode after the soldering process is complete, leading to future failure. The selection of the flux depends on the soldering process chosen, the metal being soldered and on the cleanness of the metal. The plastic range of a solder varies, depending upon the ratio of the metals forming the solder alloy, e.g. tin to lead. The 63/37 ratio, known as eutectic solder has practically no plastic range, and melts almost instantly at 183 °C and therefore is usually recommended. Besides, the purity of solder is very important. The presence of more than 0.5 per cent of contaminants within common soft solders may not give the required quality.

СПИСОК ИСПОЛЬЗУЕМОЙ ЛИТЕРАТУРЫ



1. F. Raymond Dewey A Complete Guide to Data Sheets

2. Fabio Rocha Radio and TV Electronics

3. R. Khandpur Printed Circuit Boards Design, Fabrication Copyright © 2006 by The McGraw-Hill Companies, Inc.3. Steven W. Smith Digital Signal Processing, second edition Copyright © 1997-1999 by California Technical Publishing

4. Microprocessors. Microprocessor control, стр. 1-3, 23-26

5. Brian Elliott Electromechanical Devices and Components, Copyright © 2007 by The McGraw-Hill Companies

6. Joseph A. Eichmeier Manfred K. Thumm (Eds.) Vacuum Electronics Components and Devices © Springer-Verlag Berlin Heidelberg 2008

7. Balbir Kumar and Shail B. Jain ELECTRONIC DEVICES AND CIRCUITS, Second Edition© 2014 by PHI Learning Private Limited, Delhi

8. Tony Kuphaldt Lessons In Electric Circuits, Volume II – AC, Sixth Edition, 2007

9. ТЕКСТЫ ДЛЯ РЕФЕРИРОВАНИЯ ПО РАДИОТЕХНИКЕ И ЭЛЕКТРОНИКЕ (сборник текстов)

Интернет- ресурсы:

1. Learnabout Electronics- Semiconductors - http://www.learnabout-electronics.org/Semiconductors/thyristors_60.php
2. Learnabout Electronics- Semiconductors - http://www.learnabout-electronics.org/Semiconductors/opto_50.php
3. Learnabout Electronics- Semiconductors -http://www.learnabout-electronics.org/Semiconductors/thyristors_66.php
4. https://trendexmexico.com/tehnologii/106529-obschiy-princip-raboty-acp.html
5. https://encyclopedia2.thefreedictionary.com/Electrical+Installation+Work

6. https://en.wikipedia.org/wiki/Printed_circuit_board
7. http://www.electronicsandyou.com/blog/printed-circuit-board-design-diagram-and-assembly.html
8. https://en.wikipedia.org/wiki/Printed_circuit_board Design
9. https://en.wikipedia.org/wiki/Printed_circuit_board