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# Participant Handbook

Sector
**Electronics**

Sub-Sector
**Industrial Electronics**

Occupation
**Manufacturing**

Reference ID - **ELE/Q7302, Version 1.0**
**NSQF Level 3**

# Wireman – Control Panel

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"Skilling is building a better India. If we have to move India towards development then Skill Development should be our mission."

**Shri Narendra Modi**
Prime Minister of India

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# Certificate

**COMPLIANCE TO**

**QUALIFICATION PACK - NATIONAL OCCUPATIONAL STANDARDS**

is hereby issued by the

ELECTRONICS SECTOR SKILL COUNCIL OF INDIA

for

**SKILLING CONTENT : PARTICIPANT HANDBOOK**

Complying to National Occupational Standards of

Job Role/ Qualification Pack: **"- Wireman – Control Panel "** QP No. **"ELE/Q7302, NSQF Level 3"**

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Authorised Signatory
(Electronics Sector Skill Council)

## Acknowledgements

The need for having a standard curriculum for the Job Role based Qualification Packs under the National Skills Qualification Framework was felt necessary for achieving a uniform skill based training manual in the form of a participant handbook.

I would like to take the opportunity to thank everyone who contributed in developing this handbook for the QP Wireman-Control Panel.

The handbook is the result of tireless pursuit to develop an effective tool for imparting the Skill Based training in the most effective manner.

I would like to thank the team of KontentEdge for their support to develop the content, the SME and the team at the ESSCI along with the industry partners for the tireless effort in bringing the handbook in the current format.

CEO

Electronics Sector Skills Council of India

## About this Book

This Participant Handbook is designed to enable training for the specific Qualification Pack (QP). Each National Occupational (NOS) is covered across Unit/s.

Key Learning Objectives for the specific NOS mark the beginning of the Unit/s for that NOS.

- Define control panel
- Identify the various components of a control panel
- Define fundamentals of electricity
- Explain basic concepts of automation and electromechanical control system
- Use wiring diagrams and identify wire specifications
- Explain earthing principles and methods
- Identify basic wiring of the circuit components
- List the general procedures for wiring a control panel
- Identify how to wire an electrical control panel
- Describe electromechanical assemblies
- List wiring instructions and guidelines for the assemblies
- Describe the panel assembly process
- Identify the labelling methods for the assemblies
- Identify the hazards associated with an assembly process
- Describe cabling and identify different cable handling strategies
- Define colour coding of cables
- List general guidelines for electrical work
- Identify electrical codes and standards
- Identify the work requirements
- Manage work as per given responsibility
- Report as per schedule and maintain proper documentations
- Follow the health and safety norms and identify ways to improve the work process
- Identify the right way to interact with supervisors and colleagues
- Identify soft skills required for doing the job

The symbols used in this book are described below.

## Symbols Used


Key Learning Outcomes


Steps


Role Play


Tips


Notes


Unit Objectives


Activity


Practical


E-Content


Time

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# 1. Fundamentals of Wiring a Control Panel



ELE/N7302

## Key Learning Outcomes

**At the end of this module, you will be able to:**

- Define control panel
- Identify the various components of a control panel
- Identify the cables used in a control panel
- Define fundamentals of electricity
- Explain basic concepts of automation and electromechanical control system
- List the tools and equipment used for a control panel

# UNIT 1.1: Introduction to Control Panel

## Unit Objectives

**At the end of this unit, you will be able to:**

- Define control panel

## 1.1.1 What is a Control Panel?

Control panel is a cabinet containing electrical and electronic components to control the lighting system, motion and sensor system in industrial sector. It has an internal interface and may have a user interface.

An internal interface of a control panel will have the following components:

- Supply to connect the power source
- Programmable analog and digital inputs to connect the sensors
- Connectors for the outputs
- Cables for carrying current
- Circuit breakers to protect the circuit
- Connector switch

The following figure represents an internal interface of a control panel:

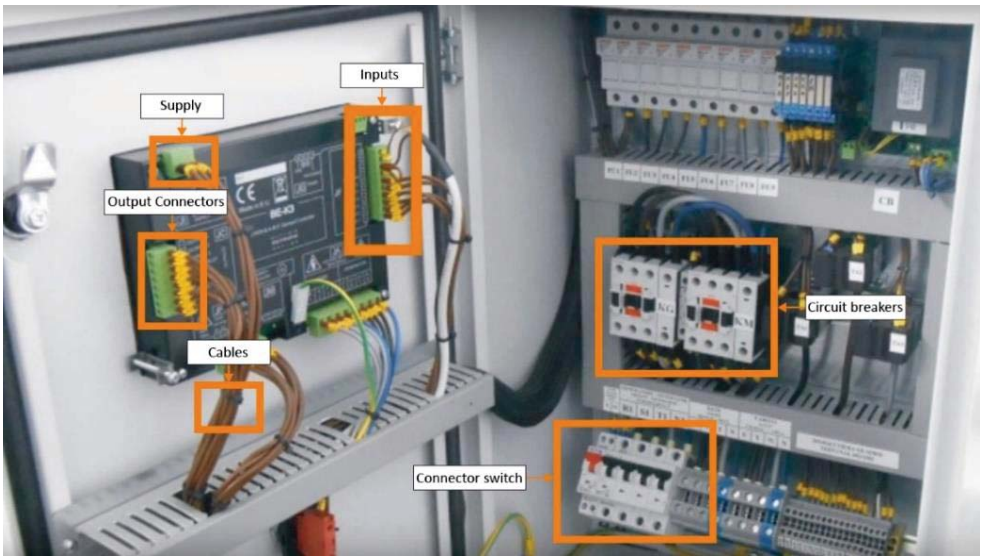



*Fig. 1.1.1: Internal interface of control panel*

Similarly, a typical user interface of a control panel has a graphic display to indicate functions performed by the system. It will have control push buttons to start or stop the system and mode push button to change the mode of operation or arrow push buttons to navigate the

control on the control panel. It has an alarm panel to raise an alarm internally for a function to stop or may be for a user intervention. It will also have light-emitting diode (LED) indicators to show the status of circuit breakers and presence of mains and/or to show the running status of the system. The following figure represents a user interface of a control panel:

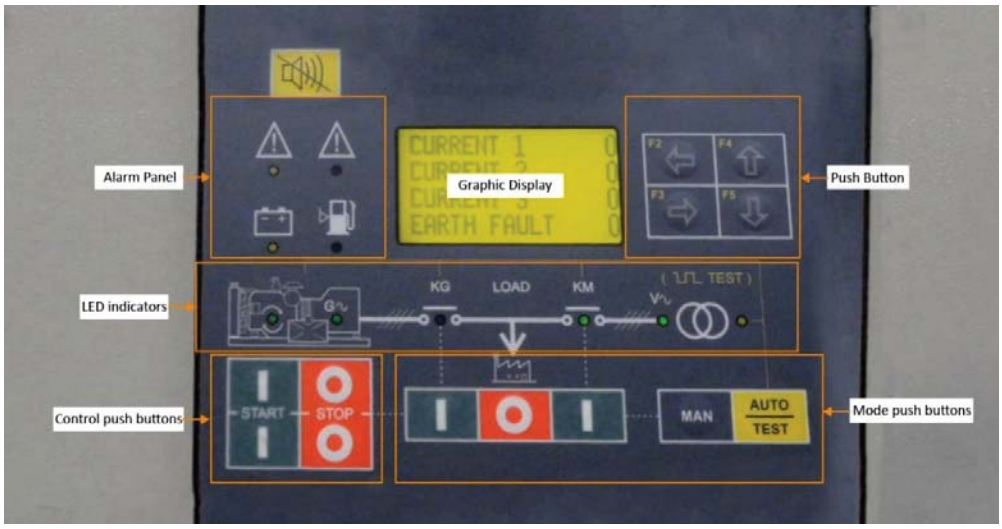



*Fig. 1.1.2: User interface of control panel*

Based on a wiring diagram provided by a design engineer, a wireman wires the control panel for its appropriate functioning.

## 1.1.2 Examples of a Control Panel

Variable speed drive (VSD) is an example of a control panel. A VSD is a large electric motor used for industrial purpose. The speed of the motor can be adjusted with the help of an external controller. VSDs are used in controlling the process and this helps in saving energy in those plants which use powerful electric motors. A VSD and the control panel of a VSD is shown in the following figures:

*Fig. 1.1.3: Variable Speed Drive*

*Fig. 1.1.4: VSD control panel*

Another example of a control panel is an elevator controller. An elevator controller is a system that controls the elevators, either manually or automatically. The motion of an elevator system

is controlled by a stepper motor. The system consists of a pulley that helps to move the lift in upward or downward direction. The indication of the position of the lift cabinet is provided by the limit switches. The limit switches act as a sensor.

A control panel of an elevator control system is shown in the following figures:

*Fig. 1.1.5: Elevator control*

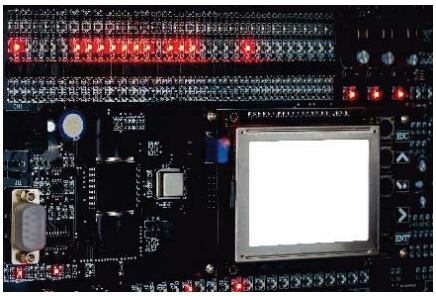


*Fig. 1.1.6: Elevator control panel*

# UNIT 1.2: Components of Control Panel

## Unit Objectives

**At the end of this unit, you will be able to:**

- Identify the various components of a control panel
- Identify the cables used in a control panel

## 1.2.1 Types of Components of a Control Panel

A control panel involves simple to complex circuitry. There are several components which build a control panel. The following figure represents different types of components of a control panel:

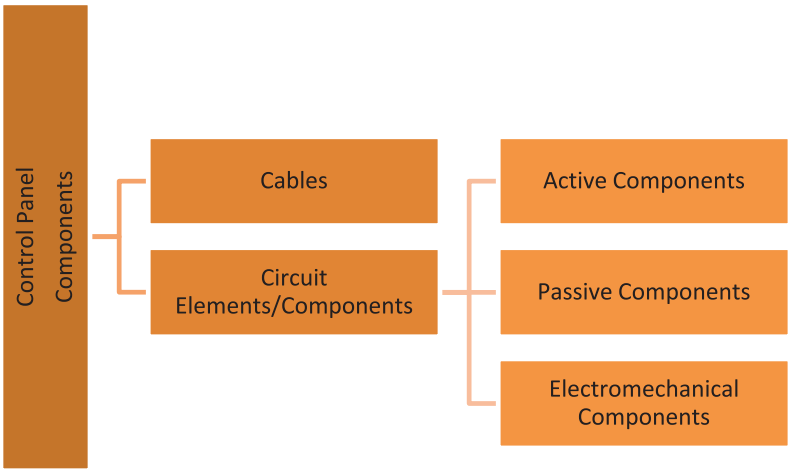



*Fig. 1.2.1: Types of components of a control panel*

### Cables

When two or more wires run side by side, twisted or bonded together to form one component or assembly, this component/assembly is called a cable. They are used to carry electric current or electric signals from one device to another. They are used in electronic devices for power and signal circuits. Cables are also used for bulk transmission of alternating and direct current power using high voltage power cables. They are used in building wiring for power and control circuits and lighting. Wires are braided or twisted together inside a cable to produce larger and more flexible wires. The following figure shows a typical cable:

*Fig. 1.2.2: Cable*

## Tips

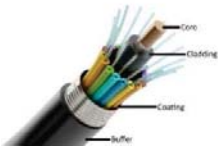
Cables can be organized securely by using cable trays, raceways, trunking, cable ties and so on.

### Cables used in a Control Panel

Many different types of cables are available nowadays and they have a wide range of application, from transmission to heavy industrial use. The following table lists some of the cables with their description and uses:

| Cable Type | Image | Description |
|---|---|---|
| **Coaxial/Heliax cable** |  | Has a thin conducting wire inside a tubular conducting shield, which is protected by a tubular insulating jacket.<br>Used to connect video equipment and carry television signals. |
| **Direct-buried cable (DBC)** |  | Are coaxial or bunched fibre optic cables consisting of a heavy metal centre with multiple layers of banded metal sheathing, shock-absorbing gel, weighty rubber coverings and waterproof wrapped impervious thread-fortified tape.<br>Used for transmission or communication requirements because of their high tolerance to temperature changes and moisture. |
| **Non-metallic sheathed cables (NM cables)** |  | Have a flexible jacket made of plastic with two to four wires and a bare wire for the purpose of grounding.<br>Used in damp areas such as gardens, open-to-air lamps, pumps and so on. |
| **Metallic sheathed /Armoured/BX cable** | | Consists of three plain stranded copper wires for current, grounding and neutral wire. |

| Cable Type | Image | Description |
|---|---|---|
| |  | These wires are insulated with cross-linked polyethylene, PVC bedding and a black PVC sheathing.<br>Used in mains electricity supply or big appliances. |
| **Multicore/ Multiconductor cable** |  | Consists of more than one conductor and each conductor is insulated separately. As an extra security measure an outer insulation layer is also provided.<br>Used at homes, as it is easy to use and well-insulated. |
| **Paired cables** |  | Consists of two conductors which are separately insulated.<br>Used in DC and low-frequency AC applications. |
| **Portable cord** |  | Is made of thermoset or thermoplastic with multiple conductors and is used for making temporary electrical power connections.<br>Used in operating motors in small and large tools, power extensions, home appliances, and machinery |
| **Ribbon cables** |  | Contains many conducting wires, fixed on a flat plane and running parallel to each other. They appear like flat ribbons and are flexible.<br>Used in low voltage applications, such as computers and peripherals. |
| **Twinax/Twinaxial cables** | | Similar to the coaxial cable except that it has two inner conductors |

| Cable Type | Image | Description |
|---|---|---|
| |  | instead of one.<br>Used in differential signalling applications with very-short-range and high-speed. |
| **Twin-lead cables** |  | Are flat multistranded copper cables with two conductor useful for transmitting radio frequency signals<br>Used in applications such as TV and radio. |
| **Twisted-pair cables** |  | Have two conductors that are twisted together to cancel out the electromagnetic interference that may come from external sources. This type of cable is almost the same as a paired cable. The difference is in the two twined inner wires which are insulated unlike the paired cable.<br>Used for transmission of data over networks such as, LAN. |
| **Optical fibre cable** |  | Contains one or more optical fibres for carrying light. The optical fibres are coated with plastic layers and secured in a protective tube.<br>Used for long distance communication. |
| **Optical fibre cable (Single Mode)** |  | Has small sized dimetral core and permits a single mode of light to propagate through it. As a result, it reduces the number of light reflections when the light passes through the centre. This decreases the attenuation and enables the signal to travel further.<br>Used for a long-distance coverage with a very high bandwidth requirement. |

| Cable Type | Image | Description |
|---|---|---|
| **Optical fibre cable (Multi Mode)** |  | Has big dimetral core and permits several modes of light to propagate through it. The number of light reflections formed when the light passes through the centre are more. This enables larger quantity of data to pass through at a given time. The strength of the signal decreases over long distances because of the increased dispersion and attenuation.<br>Used for backbone applications in buildings because of the reliability and high capacity. |

## Tips

- Single cable is a thin strand that is simply known as wire.
- Twisted pair cable may be shielded or unshielded.
- Communication cables are copper conductors.
- Coaxial cable, twisted pair and multicore cables are used as communication cables.
- Copper wire is used in telecommunications, electronics circuitry, power generation, power transmission, power distribution and so on.

## Circuit Elements/Components

A control panel circuit consist of a number of components that may be electrical, electronic, mechanical and so on. The following figure represents various types of circuit elements or components that are used in a control panel:

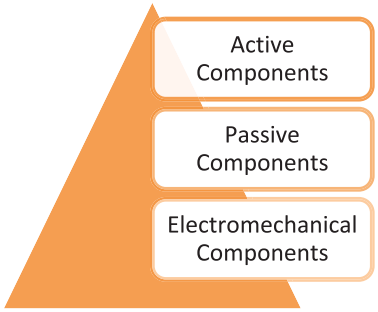



*Fig. 1.2.3: Circuit elements*

## Active Components

Active components depends on a source of energy to perform their functions. These components can amplify current and can produce a power gain. The following figure represents types of active components:

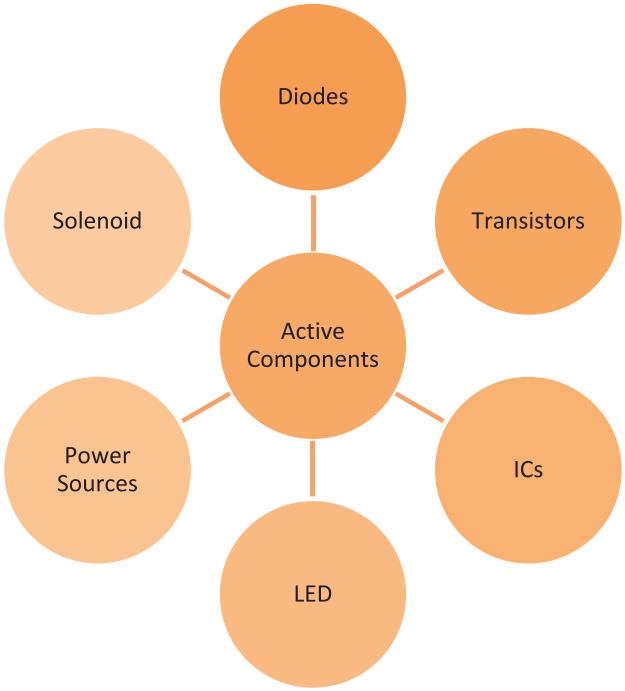



*Fig. 1.2.4: Active components*

**Diode**

A diode is a specialized electronic component with two terminals known as the anode and the cathode. It has asymmetric conductance, which means that it conducts mainly in one direction. It has very less resistance, ideally zero, to the flow of current in one direction whereas it has high resistance, ideally infinite, in the other direction. Diodes are usually made up of semiconductor materials such as germanium, silicon or selenium. The following figure shows diodes:

*Fig. 1.2.5: Diodes*

**Transistors**

A transistor is an electronic device, made up of semiconductor material. Usually, it has at least three terminals to connect to an external circuit. It is utilized to amplify or switch electrical power and electronic signals. The following figure shows a transistor:

*Fig. 1.2.6: Transistor*

**Integrated Circuit (IC)**

An IC, also known as a microchip, is a semiconductor wafer on which a number of small resistors, capacitors and transistors are fabricated. It can work as an oscillator, an amplifier, a timer, a counter, a microprocessor or as computer memory. The following figure shows an integrated circuit:

*Fig. 1.2.7: Integrated Circuit (IC)*

**Light Emitting Diode (LED)**

An LED is a p-n junction diode which gives out light when it is activated. It is a two-lead semiconductor source of light. Energy is released as photons when a suitable voltage is applied to the leads. The following figure shows an LED:

*Fig. 1.2.8: Light Emitting Diode (LED)*

**Power Sources**

A power source is a source which provides power to a circuit. Generally, power source is a generator or a battery. The following figure shows a battery:

*Fig. 1.2.9: A battery*

**Solenoid**

A solenoid is an insulated or enamelled wire coil wrapped around a cylindrical solid core. The solid core may be of iron, steel or powdered iron. Solenoids can be used as electromagnets and

inductors in the electronic circuits. The following figure shows a solenoid:

*Fig. 1.2.10: Solenoid*

## Passive Components

Passive components are those components which do not require any power source to perform their specific functions. These components are not capable of controlling current.

The following figure represents different passive components in a circuit:

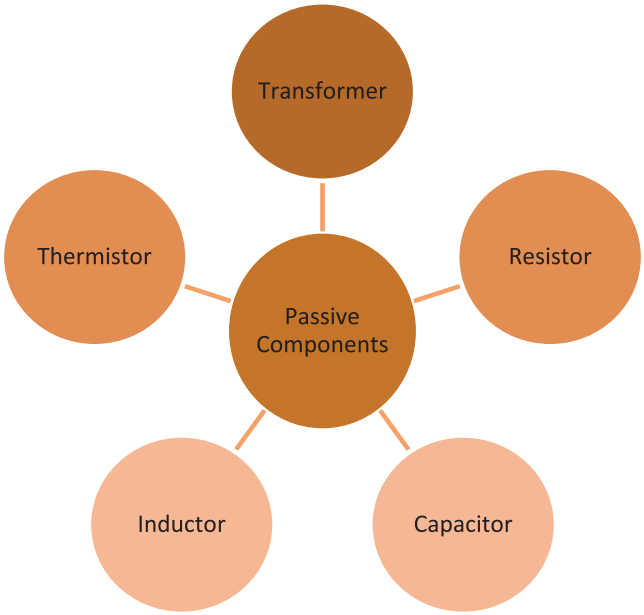



*Fig. 1.2.11: Passive components*

**Transformer**

A transformer consists of a metal core with coils of wire around it. It is a device used to convert alternating voltages (AC) to the required values by decreasing or increasing the alternating voltages in an electronic or electric system. The following figure shows a transformer:

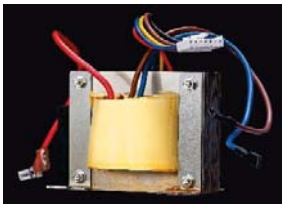


*Fig. 1.2.12: Transformer*

**Resistors**

A resistor is a component in an electronic circuit which is built to resist or limit the flow of current in that circuit. It may be a small carbon device or big wire-wound power resistor. Its size varies in length from 5mm up to 300mm. The following figure show resistors:

*Fig. 1.2.13: Resistors*

**Capacitors**

A capacitor is a device which is made up of one or more pairs of conductors and an insulator separating them. It is used to store electric charge. The following figure show capacitors:

*Fig. 1.2.14: Capacitors*

**Inductors**

An inductor consist of a coil or a wire loop. This component is used to store energy in form of magnetic field. The more the turns in the coil, the more will be the inductance. The following figure show inductors:

*Fig. 1.2.15: Inductors*

**Thermistors**

A thermistor is a kind of resistor which is sensitive to temperature as compared to other resistors. They are extensively used as inrush current limiter, temperature sensors, self-regulating heating elements and self-resetting overcurrent protectors. The following figure shows a thermistor:


*Fig. 1.2.16: A thermistor*