Basic Information on Control Panel Design

Knowhow on Control Panel Design, from the Latest Information, Environmental Measures, Safety Standards, and Valuable Information.

Changes in the market require handling a wide variety of control panel issues. Control Panel Basics describes OMRON’s wealth of knowhow and information and provides easy-to-understand descriptions of the knowledge required to solve these issues through concrete examples.
## CONTENTS

<table>
<thead>
<tr>
<th>Design Efficiency</th>
<th>Control Panel Efficiency Starts with the Terminals</th>
<th>P.4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Change from Tightening Screws to Inserting Wires</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Application of Electrical Control CAD</td>
<td>P.6</td>
</tr>
<tr>
<td></td>
<td>Ways to Increase the Efficiency and Quality of Electrical Control Designs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Panel Assist Web</td>
<td>P.8</td>
</tr>
<tr>
<td></td>
<td>Useful Tool to Simplify and Accelerate Panel Designing</td>
<td></td>
</tr>
<tr>
<td>Environmental Measures</td>
<td>Heat Measures</td>
<td>P.10</td>
</tr>
<tr>
<td></td>
<td>Knowhow on Fan Selection and Installation to Prevent Device Failure Caused by Heat</td>
<td></td>
</tr>
<tr>
<td>Environmental Measures</td>
<td>High Humidity Measures</td>
<td>P.12</td>
</tr>
<tr>
<td></td>
<td>Measures against Short-circuits Caused by Condensation from High Humidity</td>
<td></td>
</tr>
<tr>
<td>Machine Precautions</td>
<td>Examples of and Measures to Prevent Motor Failures</td>
<td>P.14</td>
</tr>
<tr>
<td></td>
<td>Protective Measures in Advance to Minimize the Effects of Failures</td>
<td></td>
</tr>
<tr>
<td>Relay Selection:</td>
<td>Relay Selection:</td>
<td>P.16</td>
</tr>
<tr>
<td></td>
<td>“Better Too Big Than Too Small” Does Not Apply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Optimum Selection Techniques to Improve Relay Circuit Reliability</td>
<td></td>
</tr>
<tr>
<td>Standards</td>
<td>Types of UL Certification</td>
<td>P.18</td>
</tr>
<tr>
<td></td>
<td>Difference between UL Listed Components and UL Recognized Components</td>
<td></td>
</tr>
<tr>
<td>Control Panel Design Considering</td>
<td>Control Panel DesignConsidering</td>
<td>P.20</td>
</tr>
<tr>
<td></td>
<td>Electrical Safety Standards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Points on Panel Design for Conformance to IEC 60204-1</td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td>Saving Space in Control Panels with No Transformers</td>
<td>P.22</td>
</tr>
<tr>
<td></td>
<td>Eliminating Transformers for Control Panels</td>
<td></td>
</tr>
<tr>
<td>Color Universal Design</td>
<td>Color Universal Design</td>
<td>P.24</td>
</tr>
<tr>
<td></td>
<td>Color Designs That Are Easy to Use by Anyone</td>
<td></td>
</tr>
<tr>
<td>Display Innovations for On-panel Devices</td>
<td>Display Innovations for On-panel Devices</td>
<td>P.25</td>
</tr>
<tr>
<td></td>
<td>Increased Visibility with White Characters on Black Backgrounds</td>
<td></td>
</tr>
</tbody>
</table>
Control Panel Efficiency Starts with the Terminals

Change from Tightening Screws to Inserting Wires
You Can Increase Production Efficiency by Rethinking Wiring Work

Wiring Work
Wiring work is essential to manufacturing control panels, and it accounts for the majority of the lead time for control panel manufacturing. Therefore, if you can make wiring work easier and faster, you can dramatically shorten the manufacturing lead time for control panels.

Current Issues
Normally when people hear about wire connection methods, many of them tend to think about securing wires by tightening screws. And in reality, many of the control devices used in control panels use screw terminals, and such devices have become common. Also, screw terminals have a long track record, are the method most recognized by customers, and are therefore considered reliable. However, screw terminals require that you loosen the screw, attach the wire (crimp terminal), and then tighten the screw, which is a lot of work.

New Screwless Connections
Screwless connections, which have recently become common in Europe, eliminate the need to tighten screws to dramatically reduce the work required for wiring and they are gradually becoming popular in control panels around the world. The work of loosening and tightening screws has been replaced by merely inserting wires to complete wiring work, greatly reducing work time. First you need to learn about screwless connections and then experience how efficient this method is.

Push-in Terminals
Push-in terminals are one type of screwless terminal. Wiring is completed simply by inserting a wire with a crimped ferrule. The strength of a spring presses the ferrule against the terminal wall to connect the wire.

Mechanism
- Clamp spring
  - The pressure of the clamp spring holds the ferrule securely.
- Conductive fitting

Differences in Wiring Work

<table>
<thead>
<tr>
<th>Wiring</th>
<th>Screw terminals</th>
<th>Round terminals</th>
<th>Forked terminals</th>
<th>Push-in terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Loosen the screw.</td>
<td>(2) Remove the screw.</td>
<td>(3) Attach the terminal.</td>
<td>(4) Tighten the screw.</td>
<td></td>
</tr>
<tr>
<td>27 s *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 s *</td>
<td>Unnecessary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 s *</td>
<td>Insert.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Based on OMRON demonstration test results.

No Retightening Work
Note: Test conditions: IEC 60947-7-1
What Are Push-In Plus Terminal Blocks?

Push-In Plus Terminal Blocks were independently developed by OMRON for easy wire insertion and firm wire holding ability.

It’s as easy as inserting an earphone jack: No tools are required for wiring.

**Easy to Insert**
OMRON’s Push-In Plus terminal blocks are as easy as inserting to an earphone jack. This reduces the load on worker fingers.

**Work with Both Hands**
Optimized shape to hold the screwdriver was created by the resin parts and the spring. Work goes smoothly when connecting stranded wires directly to the terminal because it’s easier to aim at the desired terminal.

**Held Firmly in Place**
Even though less insertion force is required, the wires are held firmly in place. The advanced mechanism design technology and manufacturing technology produced a spring that ensures better workability and reliability.

**Wiring Possible with Stranded Wires**
You can insert wires with ferrules or you can also insert solid wires or stranded wires.

---

**Recommended Products with Push-In Plus Terminals**

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch Mode Power Supplies</td>
<td>Switch Mode Power Supplies S8VK-S</td>
</tr>
<tr>
<td>Uninterruptible Power Supply (UPS)</td>
<td>Uninterruptible Power Supply (UPS) S1BA</td>
</tr>
<tr>
<td>Solid-state Timers</td>
<td>Solid-state Timers H3Y(N)-B</td>
</tr>
<tr>
<td>Solid-state Timers</td>
<td>Solid-state Timers H3RN-B</td>
</tr>
<tr>
<td>Solid-state Timers</td>
<td>Solid-state Timers H3RN-B</td>
</tr>
<tr>
<td>Solid-state Timers</td>
<td>Solid-state Timers H3RN-B</td>
</tr>
<tr>
<td>I/O Relay Terminals</td>
<td>I/O Relay Terminals G7V</td>
</tr>
<tr>
<td>Digital Temperature Controllers</td>
<td>Digital Temperature Controllers ESCC-B/ESSEC-B</td>
</tr>
<tr>
<td>DIN Track Terminal Block</td>
<td>DIN Track Terminal Block XWST</td>
</tr>
<tr>
<td>Sockets for Relays with Forcibly Guided Contacts (for G7SA)</td>
<td>Sockets for Relays with Forcibly Guided Contacts (for G7SA) P7SA-PU</td>
</tr>
<tr>
<td>Common Sokets (for MY/H3YN-8)</td>
<td>Common Sokets (for MY/H3YN-8) P7F-P8A-L</td>
</tr>
<tr>
<td>Common Sokets (for G2R-5/H3RN-B/97L-B)</td>
<td>Common Sokets (for G2R-5/H3RN-B/97L-B) P2RF-FU</td>
</tr>
<tr>
<td>Slim I/O Relays G2RV-SR</td>
<td>Slim I/O Relays G2RV-SR</td>
</tr>
<tr>
<td>Slim I/O Relays G3RV-UR</td>
<td>Slim I/O Relays G3RV-UR</td>
</tr>
<tr>
<td>Solid-state Relays for Heaters G3PJ</td>
<td>Solid-state Relays for Heaters G3PJ</td>
</tr>
<tr>
<td>Pushbutton Switches Push-In Plus Terminal Block Series A22N-P/A30N-P/A22N-P</td>
<td>Pushbutton Switches Push-In Plus Terminal Block Series A22N-P/A30N-P/A22N-P</td>
</tr>
</tbody>
</table>

---

*Information for Push-In Plus terminal blocks and Screw terminal blocks is based on OMRON’s actual measurement value data for the XW2R.*
Application of Electrical Control CAD

Electrical Control CAD Significantly Increases the Efficiency and Quality of Electrical Control Designs

What Is an Electrical Control CAD?
Electrical control CAD is specialized software to design circuit diagrams (elementary wiring diagrams), cable production diagrams, and control panel layout diagrams. Specialized electrical CAD previously existed, but CAD that unifies management of design data have recently received a lot of attention.

The use of high-quality electrical control CAD libraries is important to maximizing the functionality of electrical control CAD.

Realtime Information Linkage between Diagrams *

Central Database

Circuit Designs

Control Panel Design

Specifications Coordination

Lists

Conceptual Considerations

Cable and Harness Design

* This illustration is based on the functionality of the E3. series from Zuken Inc.

Partners for electrical control CAD:

Zuken Inc. E3.series

EPLAN

E3.series is a product name of Zuken Inc. for their Electrical and Control Cable Design Solution. EPLAN is a registered trademark of EPLAN Software & Service GmbH & Co. KG.
Benefits of Introducing Electrical Control CAD

Automatic Creation of Diagrams and Lists
The unified management of design information in a database makes it easy to automatically create diagrams, such as cable production diagrams, as well as many different types of lists.

### Reduced Design Work

<table>
<thead>
<tr>
<th>Current Situation</th>
<th>With the CAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checking specifications</td>
<td>Checking specifications</td>
</tr>
<tr>
<td>Collecting information on components</td>
<td>Collecting information on components</td>
</tr>
<tr>
<td>Circuit designing</td>
<td>Library registration</td>
</tr>
<tr>
<td>Cable designing</td>
<td>Circuit designing</td>
</tr>
<tr>
<td>Outputting BOM</td>
<td>Cable designing</td>
</tr>
<tr>
<td>Checking diagrams</td>
<td>Device listings</td>
</tr>
<tr>
<td>Releasing diagrams</td>
<td>Releasing diagrams</td>
</tr>
</tbody>
</table>

Reduction in Total Design Work by Up to **30% to 50%**
Reduction of **50% to 70%** for Cable Production Diagrams

Achieve Consistency between Diagrams in Realtime
The results of designing work (circuit diagrams, cable production diagrams, control panel layout diagrams, terminal block layout diagrams, connector lists, etc.) can be edited from any diagram and the changes will be reflected in all the related diagrams and lists in real time.
This helps eliminate entry mistakes and forgotten corrections to greatly increase design quality.

Higher Design Quality
By eliminating entry mistakes and forgotten corrections from diagrams, higher quality is achieved in diagram data and reworking after manufacturing is eliminated.

Flexible Panel Design, Including Wiring, Interference Checks, and Wire Processing
Simplified 3D designing allows you to consider interference checks and prohibited areas in designs.
Wire length measurement function allows wires to be prepared in advance.

Greater Manufacturing Efficiency
More efficient designing is accompanied by more efficiency in panel manufacturing preparations, assembly, and installation.

Note: The example of the results of CAD introduction on this page is based on the functionality of the E3 series from Zuken Inc.
Panel Assist Web

Simplify and Accelerate Panel Designing. Information to Solve Your Control Panel Manufacturing Issues

The Panel Assist Web is a new website for our customers that work with control panels. You can select products and search for documents. Or you can find solutions for the issues you face in control panel manufacturing and you can manage BOM. Use this website to more efficiently design control panels.

Take a Look Now!
www.ia.omron.com/solution/panel/

Easy Product Selection: No Registration Required

Find Information to Help Solve Issues
You can find information to help you solve control panel issues, such as downsizing or work reduction issues. (e.g., explanatory videos for Push-In Plus Terminal Blocks are available.)

Sample: Specifications Search

Easy Selection of In-panel Devices
You can greatly reduce model selection work. You can filter selection by model and then compare product specifications for easy selection.

Find Information without Getting Lost
Just the right products and documents will be recommended in response to operations. You can find the information you need quickly and select the optimum products.
Even More Convenient Functions with Member Registration (Free Registration)

Create BOM Easily
You can create and save BOM of OMRON and non-OMRON products. Convenient tools are provided for more-advanced designing.

BOM to Reduce Design Work
You can use the tool and various kinds of convenient functions starting from BOM.

Reduce Work with the Terminal Block Support Tool
The electrical specifications and applicable wires are automatically displayed for the selected devices. You can easily select the Terminal Blocks required to wire devices without wasting time.

Checking in Advance with Thermal Simulation Tool
Just input basic control panel information in addition to the selected device information to understand heat risks and thereby reduce the need of working later.

Replacement with the Latest Products
You can import an existing BOM to check product manufacturing status and stock status, and to replace products with the most suitable up-to-date products.

Download Documents as Soon as You Select Parts
You can download CAD data or catalogs in multiple languages.
The correct Fan must be selected to suppress temperature rise inside the panel.

If the temperature inside the panel increases, the lives of devices and parts inside the panel will be reduced and malfunctions could result. Particularly devices and parts that generate heat are greatly affected by heat. Panel cooling and Fan selection are extremely important to long-term usage of the panel and parts inside the panel.

Selecting Fans

1. Check the heating values of devices and the panel (kW).
   Check the heating value of each device located in the control panel and then find the total heating value. Generally speaking, the heating value indicates the power consumption, so you can assume that the power consumption equals the heating value.
   \[
   \text{Heating value (W)} = \frac{\text{Input power}}{\text{Efficiency}} - \frac{\text{Output power}}{} 
   \]

2. \(\Delta T\) of devices and panel: Allowable temperature rise (°C)
   \(\Delta T\) can be obtained by subtracting the device ambient temperature, \(T_1\) from the allowable internal temperature, \(T_2\).
   Note: As a guideline, you can make the calculation with a value of 10°C.
   \(\Delta T = 10°C\) (guideline)

3. Calculate \(Q\), the required flow rate (m³/min).
   \[
   Q = \frac{50 \times W}{\Delta T} \text{ m}^3/\text{min} 
   \]

4. Select the size of the required Fan based on the maximum flow rate.
   Normally, select a Fan with a maximum flow rate of 1.3 to 2 times the calculated required flow rate (\(Q\)). As the flow rate increases, noise increases. If the Fan is used in an environment where noise is a problem, select a Fan with a lower flow rate.

Selecting Options

- If fine foreign matter may enter the Fan, select a Filter.
- If slender objects such as fingers may enter the Fan, select a Finger Guard.

Note: Actually results may vary from calculations, so measurement and confirmation in the actual panel are required.

Calculation Example for a Control Panel with Two 100-W Power Supplies

Note: The SJXJ-N10024C (output voltage: 24 VDC, output current: 4.5 A, efficiency: 83% min.) is used for the 100-W Power Supplies.

First, the heating value (power consumption) is calculated.

- Heating value (W)
  \[
  \frac{24 \text{ (V)} \times 4.5 \text{ (A)}}{83 \text{ (%)}} - 24 \text{ (V)} \times 4.5 \text{ (A)} = 108 \text{ (W)} - 108 \text{ (W)} = 22.120\ldots \text{ (W)} 
  \]

Two Power Supplies are used, therefore,

- \(Q\): Required flow rate
  \[
  Q = \frac{50 \times W}{\Delta T} = 0.2 \text{ [m}^3/\text{min]} 
  \]

Maximum flow rate calculation: \(0 \times 2 = 0.2 \times 2 = 0.4 \text{ [m}^3/\text{min]}\)

Therefore, one R87F-A□A83H is required according to the maximum flow rate of the table on the right.

Note: This calculation example assumes that the control panel contains only two Power Supplies.
Airflow Direction and Inlet/Outlet Cooling Effect Differences

When the Heat-generating Portions Are Concentrated at One Location
- You can concentrate cooling on the heat-generating portions.
- The pressure inside the box increases, which reduces dust entry from other openings.

Advantages of Inlet Installation

When the Heat-generating Portions Are at Many Locations
- A wide area can be cooled.

Advantages of Outlet Installation

Reference Information:
The Fan airflow is in one direction, which is indicated on the top of the Fan.

Recommended Axial Fans

R87F AC Axial Fans

<table>
<thead>
<tr>
<th>Size [mm]</th>
<th>Flow rate [m³/min] at 50 Hz</th>
<th>Flow rate [m³/min] at 60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 × 120 × 138</td>
<td>0.6 (0.7)</td>
<td>0.8 (0.9)</td>
</tr>
<tr>
<td>120 × 120 × 125</td>
<td>0.9 (1)</td>
<td>1.9 (2.2)</td>
</tr>
<tr>
<td>92 × 92 × 125</td>
<td>0.8 (0.9)</td>
<td>1.9 (2.2)</td>
</tr>
<tr>
<td>80 × 80 × 138</td>
<td>0.9 (1)</td>
<td>1.9 (2.2)</td>
</tr>
<tr>
<td>80 × 80 × 125</td>
<td>0.8 (0.9)</td>
<td>1.9 (2.2)</td>
</tr>
</tbody>
</table>

Options

Plug with Cable

Finger Guard

Filters

Models

<table>
<thead>
<tr>
<th>Models</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plug with Cable *</td>
<td>R87F-PC(JT)</td>
</tr>
<tr>
<td>Finger Guards</td>
<td>R87F-FG</td>
</tr>
<tr>
<td>Filters</td>
<td>R87F-FL(S)</td>
</tr>
</tbody>
</table>

* Required for models with terminals (models ending with "P").

Search for OMRON R87F for details.
If a control panel is installed in a location with high humidity, measures against short-circuits are required.

Condensation will occur in the control panel as the result of a difference in the device temperature and external air temperature. This condensation may adhere to a PCB and if condensation and dust repeatedly collect on the PCB, short-circuits will occur.

**Examples of Short-circuits Caused by Condensation**

**Case 1:** Short-circuit from Water Drops Generated by Condensation  
**Case 2:** Short-circuit Caused by Repeated Condensation and Dust Collection

**Preventing Short-circuits with Products with Coated PCBs or Modifications**

PCBs can be coated to protect them against humidity and reduce the possibility of short-circuit accidents.

**Recommended Products with Coated PCBs**

Ask your OMRON representative for more information on coating.

<table>
<thead>
<tr>
<th>Switch Mode Power Supplies</th>
<th>Timers</th>
<th>Digital Temperature Controllers</th>
<th>Single-phase Power Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>S8VK-S</td>
<td>H3CR</td>
<td>E5□C/E5□C-B</td>
<td>G3PW</td>
</tr>
<tr>
<td>S8FS-G</td>
<td>H3DT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H3Y-B</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H5CX</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro PLCs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP1E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP1L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP1H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP1W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Search for OMRON with the model name.
Implementing Protective Measures for Failures of Important Devices

In general, when devices are used for a long period of time, they deteriorate over that time, and ultimately fail. To minimize the effects of device failure, we recommend that you implement protective measures in advance for important devices. This section discusses motors, which are important devices.

**Motors**

A motor converts electrical energy to mechanical energy. Due to its characteristics, a motor has both an electrical structure and a mechanical structure, and it fulfills very important roles.

There are various failure types that lead to motor failure. By detecting abnormal signals and using them to stop the motor, motor failure and damage to the motor’s load can be avoided. Major examples of motor failures and products that can be used to detect motor abnormalities are introduced on the right-hand page.

**One Point!**

Are just breakers and thermal relays insufficient as protective measures?

Not all types of motors and operation can be protected with just breakers and thermal relays.

Example:

Breakers can not detect phase loss.

General thermal relays can not detect phase loss during operation, so operation may not be stable.
Motor Failure Examples (Phenomena)

Phase-loss Errors
Example: Disconnection of a power line
- Failure to start
  - A motor does not start.
  - A motor cannot operate a load.
- Burning due to phase-loss operation
  - Forced startup causes a motor to burnout.
- Unstable operation
  - Stopping of operation when the load is heavy.
  - Intermittent starting and stopping, etc.

Causes
- Welded contacts inside a breaker
- Disconnection
  - Wheels rolling over or people stepping on lines
  - Cables bent too far, etc.
- Loose screws (contact failure in wiring)
- Phase loss inside a motor

Reversed-phase (Phase-sequence) Errors
Incorrect wiring causes reverse rotation of the motor.
- Incorrect wiring
  - Movable equipment
  - Incorrect phase on power line side
- Reverse rotation of motor will damage valves in pumps.
  - Non-return valves

Overloads
Caught foreign matter locks up the motor.

Current Leakage
Current leakage due to insulation deterioration
- Aged deterioration
- Deterioration due to water or oil intrusion

Recommended Protective Relays
- Detect Phase loss and Phase sequence
- Models added with transistor outputs for stable operation with PLC.
- Phase-sequence Phase-loss Relays
- K8DT-PH
Relay Selection:
“Better Too Big Than Too Small” Does Not Apply

Circuit Reliability will be Increased by Selecting a Suitable Relay for the Load.

With a computer or smartphone, you may want to select a hard disk or memory with extra capacity. In general, something larger often works well to substitute for something smaller, as in the saying “better too big than too small”. However, that does not work with relays. The structural conditions required in a control relay to carry a large current as opposed to a minute current are different, so a suitable relay must be selected. Selecting a suitable relay will help increase the reliability of the relay circuit. You need to understand relay characteristics and correctly select relays to increase the quality of control circuits.

Relay Selection Methods

Switching High-capacity Loads

An important thing that determines the contact breaking capacity is the size of the gap between contacts of the same pole. Double-break contacts (see right-hand page) with a wide gap are effective. An Ag alloy with high conductivity is generally used for the contact material. However, Ag alloys are not suitable to switch minute loads that do not generate arcs when switching because organic films easily forms on the contact surfaces.

Switching Minute Loads

To reduce the probability of contact failure, using bifurcated contacts (see right-hand page) with two contact points is more effective than using single contacts with one contact point. Also, the arcs that are generated when switching minute loads are small, so they do not remove oxide and other films. Therefore, Au or Au alloys that resist corrosion are used for the contact material. However, they are not suitable to switch large currents due to the smaller contacts and lower conductivity in comparison with Ag alloys.

Differences and Trends in Contact Materials

<table>
<thead>
<tr>
<th>Ag alloy</th>
<th>Au-clad Contacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>High conductivity</td>
<td>The contact surfaces are clad with Au, which has a high resistance to corrosion, to increase resistance to corrosion. The formation of a resistive film will be suppressed, and arcing will be also reduced to make these contacts effective for minute loads.</td>
</tr>
<tr>
<td>Resistance to corrosion</td>
<td>Low</td>
</tr>
</tbody>
</table>

Note: Au: Gold, Ag: Silver, Cu: Copper.
Differences in Contact Configuration and Application Examples

<table>
<thead>
<tr>
<th>Contact Configuration</th>
<th>Common Loads</th>
<th>Application Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Double-break contacts</strong></td>
<td>High-capacity loads&lt;br&gt;Guideline: Loads over 15 A&lt;br&gt;Note: For relays, 40 A for AC and 10 A for DC.</td>
<td>Switching compressors and heaters&lt;br&gt;Control applications for switching motors</td>
</tr>
<tr>
<td><strong>Single contacts</strong></td>
<td>General loads&lt;br&gt;Guideline: 0.05 to 15 A</td>
<td>General sequence circuits</td>
</tr>
<tr>
<td><strong>Bifurcated contacts</strong></td>
<td>Minute loads&lt;br&gt;Guideline: Less than 0.05 A</td>
<td>PLC inputs, signal applications, and self-holding circuits</td>
</tr>
<tr>
<td><strong>Crossbar Bifurcated Contacts</strong></td>
<td>Minute loads&lt;br&gt;Guideline: Less than 0.01 A</td>
<td>Alarm applications (Infrequent applications)</td>
</tr>
</tbody>
</table>

**Major Examples of Relay Models, Contact Configuration, and Contact Materials**

<table>
<thead>
<tr>
<th>Model</th>
<th>Contact configuration</th>
<th>Contact materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) MY</td>
<td>Single</td>
<td>2-pole: Ag alloy 3-pole: Ag alloy &lt;br&gt;Au cladding + Ag alloy</td>
</tr>
<tr>
<td>(2) MK</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(3) MM</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(4) MY(S)</td>
<td>Single</td>
<td>2-pole: Ag alloy 3-pole: Ag alloy &lt;br&gt;Au cladding + Ag alloy</td>
</tr>
<tr>
<td>(5) MK-S</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(6) MY4Z</td>
<td>Bifurcated</td>
<td>Ag alloy &lt;br&gt;Au cladding + Ag alloy</td>
</tr>
<tr>
<td>(7) MY4Z-CBG</td>
<td>Crossbar bifurcated</td>
<td>Ag alloy &lt;br&gt;Au cladding + Ag alloy</td>
</tr>
<tr>
<td>(8) MYQ</td>
<td>Bifurcated</td>
<td>Ag alloy &lt;br&gt;Au plating + Ag alloy</td>
</tr>
<tr>
<td>(9) MY4H</td>
<td>Bifurcated</td>
<td>Ag alloy &lt;br&gt;Au plating + Ag alloy</td>
</tr>
<tr>
<td>(10) MY2K</td>
<td>Single</td>
<td>Ag alloy &lt;br&gt;Au plating + Ag alloy</td>
</tr>
<tr>
<td>(11) G7N</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(12) MKX</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(13) MKK</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(14) MK-S(K)</td>
<td>Double break</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(15) MKX</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(16) G2RV-C-J-AP</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(17) G2PR-C-J-S</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(18) LY</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(19) G7J</td>
<td>Double break</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(20) G7Z</td>
<td>Double break</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(21) MMK</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(22) MMK</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(23) G2PR-C-J-AP</td>
<td>Single</td>
<td>Ag alloy &lt;br&gt;Au plating + Ag alloy</td>
</tr>
<tr>
<td>(24) G7T for input</td>
<td>Crossbar bifurcated</td>
<td>Ag alloy &lt;br&gt;Au plating + Ag alloy</td>
</tr>
<tr>
<td>(25) G7T for output</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(26) G2PRV-SIR</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(27) GMMBH-4BND</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(28) G4HB-4CB</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(29) G4HD-4F8</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(30) G7TVC-S1 Series</td>
<td>Single</td>
<td>Ag alloy &lt;br&gt;Au plating + Ag alloy</td>
</tr>
<tr>
<td>(31) G7TVC-SO Series</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
<tr>
<td>(32) G7TVC-SO Series</td>
<td>Single</td>
<td>Ag alloy</td>
</tr>
</tbody>
</table>

Note: Mainly Two-pole Relays are used in control circuits.

Note: Mainly One-pole Relays are used for I/O applications.
Types of UL Certification

There are UL Listing and UL Component Recognition for UL certification.

UL certification is required for control panels used in the USA.
Here we describe the difference between certification as a UL listed component (listing) and certification for a UL recognized component (R/C).

Actions Required for New or Revised Components Used in Control Panels for the USA

Industrial control panels used in the USA are required to comply with UL508A.
Of the components used in control panels that comply with UL 508A, there are differences in the requirements depending on the UL certification (UL listed components or UL recognized components).

Using UL Listed Components

Application to the UL is **not required.**
- New or upgraded components can be used at any time.
- If urgent changes to components become necessary for adjustments or to handle problems, they can be made immediately.

Changes are possible at any time.

Using UL Recognized Components

Application to the UL is **required.**
- These components must be registered. The documents and data required for registration must be prepared and an application must be made to the UL.
- The UL will check the certification conditions and process the changes, so time will be required to use new or upgraded components.

Component registration is required, which delays application.
In general, this certification applies to end products that are operated by general users, such as machine tools, robots, and other equipment that are directly controlled by an operator.

Because it is assumed that the equipment will be used by an operator or a general user, there are many restrictions and evaluation tests for designs and configuration components.

**UL Listing**

- In general, this certification applies to end products that are operated by general users, such as machine tools, robots, and other equipment that are directly controlled by an operator.
- Because it is assumed that the equipment will be used by an operator or a general user, there are many restrictions and evaluation tests for designs and configuration components.

**UL Component Recognition**

- This certification applies to components that are built into end products that do not function by themselves or have limited functionality (molded products, wires, PWB, and general-purpose Automation Systems).
- Components for which UL Listing is not required fall under UL Component Recognition.

There are also differences based on whether the component is directly connected to devices or equipment outside of the control panel.

**Example in Final Installation Site of Control Panel**

**Using UL Listed Components**

- Wiring is allowed.

**Using UL Recognized Components**

- Wiring is not allowed.

**Point !**

For People Who Want to Know More

**UL Listing**

- In general, this certification applies to end products that are operated by general users, such as machine tools, robots, and other equipment that are directly controlled by an operator.
- Because it is assumed that the equipment will be used by an operator or a general user, there are many restrictions and evaluation tests for designs and configuration components.

**UL Component Recognition**

- This certification applies to components that are built into end products that do not function by themselves or have limited functionality (molded products, wires, PWB, and general-purpose Automation Systems).
- Components for which UL Listing is not required fall under UL Component Recognition.

**Recommended UL Listed Components**

- **A Perfect Fit for Small Control Panels**
  - Coated PCBs for Better Resistance to Environment Connections for Easy Wiring
  - **Switch Mode Power Supplies**
    - (60-W, 120-W, 240-W, 480-W)
    - **S8VK-S**
      - Search for “OMRON S8VK-S” for details.

- **Reliable and Easy Operation-**
  - **Worldwide Power Supply**
    - Resistant in tough environments
    - Easy and fast installation
    - The most compact class on the market
    - **Switch Mode Power Supplies**
      - **S8VK-G**
        - Search for “OMRON S8VK-G” for details.

- **Worldwide 3-phase Power Supply**
  - Resistant in tough environments
  - Easy and fast installation
  - The most compact class on the market
  - **Switch Mode Power Supplies**
    - (120-W, 240-W, 480-W, and 960-W models)
    - **S8VK-T**
      - Search for “OMRON S8VK-T” for details.
The IEC 60204-1 electrical safety standards related to machine control panels must be considered.

The power supply breakers, device locations, and electric-shock prevention for control panel design are described from the viewpoint of safety standards.

**Power Supply Cutoff (Breaker) Devices**
- ON "|" and OFF "○" must be indicated.
- There must be an external operation means (e.g., handle).
- There must be a means to lock the device in the OFF position.
- There must be a suitable cutoff capacity. Etc.

**Device Locations**
(1) Power supply cutoff devices: 0.6 to 1.9 m, recommended max.: 1.7 m
(2) Manual operation devices: 0.6 m or higher
(3) Terminals: 0.2 m or higher
(4) Devices that must be approached for periodic maintenance or adjustments: 0.4 to 2.0 m

**Enclosure Degree of Protection: IP22 or Better**

**Electric Shock Prevention**
When Enclosure Is Opened:
- It must be possible to open the enclosure when charged sections are cut off.
- If the enclosure can be opened without cutting off a charged section, all charged sections must have IP2X or IPXXB protection.
  If a barrier is provided, a tool must be required to remove it or the charged section must be automatically cut off when it is removed.

**Additional Information**
IP2X: Protection against foreign objects with a diameter of 12.5 mm or larger (equivalent to a finger)
IPX2: Protection against vertically falling water drops when enclosure tilted up to 15°
IPPXXB: Protection against an approaching finger

**Reference Illustration**
(Numbers 1 to 4 correspond to items 1 to 4 under Device Locations.)
- The structure does not allow the panel door to be opened unless the power supply is cut off.
- If the door can be opened without cutting off the power supply, charged sections must be protected, e.g., with covers, so that they cannot be touched with fingers or similar objects.

Note: The values are the heights from the working surface.
Control Panel Component Colors

It is important to correctly understand the meaning of the colors of indicators, operation parts, and wires.

**Machine status indicated by indicator color**

<table>
<thead>
<tr>
<th>Color</th>
<th>Meaning</th>
<th>Description</th>
<th>Operator action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Emergency</td>
<td>Hazardous situation</td>
<td>Immediate action for the hazardous situation</td>
</tr>
<tr>
<td>Yellow</td>
<td>Caution</td>
<td>Abnormal situation</td>
<td>Monitoring and/or intervention</td>
</tr>
<tr>
<td>Green</td>
<td>Normal</td>
<td>Normal situation</td>
<td>No specific action required</td>
</tr>
<tr>
<td>Blue</td>
<td>Mandatory</td>
<td>Indication of situation</td>
<td>Required action required</td>
</tr>
<tr>
<td>White</td>
<td>Neutral</td>
<td>Other situations</td>
<td>Monitoring</td>
</tr>
</tbody>
</table>

**General meaning of operation device (operation part) color**

<table>
<thead>
<tr>
<th>Description</th>
<th>Application example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actuate in the event of a hazardous situation or emergency</td>
<td>Emergency stop</td>
</tr>
<tr>
<td>Actuate in the event of an abnormal condition</td>
<td>Intervention to suppress abnormal condition</td>
</tr>
<tr>
<td>Actuate to initiate normal conditions</td>
<td>Intervention to restart an interrupted automatic cycle</td>
</tr>
<tr>
<td>Actuate for a condition requiring mandatory action</td>
<td>White is the most suitable color for a device (operation part) for starting or turning ON something, but green is also acceptable.</td>
</tr>
</tbody>
</table>

**General rules**

<table>
<thead>
<tr>
<th>Human or environmental safety</th>
<th>Process status</th>
<th>Hazard</th>
<th>Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazards</td>
<td>Abnormality</td>
<td>Safe</td>
<td>Normal</td>
</tr>
<tr>
<td>Mandatory</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Color Requirements for Emergency Stop Switches**

- **Operation part:** Red
- **Background:** Yellow

**Wire Colors (IEC 60204-1)**

<table>
<thead>
<tr>
<th>Applicable conductor</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground (earth) circuit</td>
<td>Green-yellow spiral</td>
</tr>
<tr>
<td>Power neutral circuits</td>
<td>Light blue</td>
</tr>
<tr>
<td>Primary power circuits</td>
<td>Black</td>
</tr>
<tr>
<td>DC control circuits</td>
<td>Blue</td>
</tr>
<tr>
<td>AC control circuits</td>
<td>Red</td>
</tr>
<tr>
<td>Excepted circuits (e.g., interlock circuits)</td>
<td>Orange</td>
</tr>
</tbody>
</table>

**Recommended Operation Devices**

- **Pushbutton Switches A22N**
  - Globally applicable switches conceived for compactness, simplicity, and safety.
  - Search for OMRON A22N for details.

- **Emergency Stop Switches A22E**
  - Emergency Stop Switches That Conform to Various Standards
  - Search for OMRON A22E for details.
Saving Space in Control Panels with No Transformers

Eliminating Transformers for Control Circuits
(Using a Switch Mode Power Supply with a Transformer Conforming to IEC 61558-2-16)

IEC 60204-1 in the Machinery Directive specifies that, if AC power is supplied to a control circuit, a transformer must be used in the control circuit and the transformer must have separate (compound) windings.

IEC 61558-2-16 also states that a switch mode power supply that uses a transformer with separate (compound) windings satisfies the above condition. That means that a transformer in a control circuit can be eliminated by using this type of switch mode power supply.

The transformer can sometimes be eliminated.

Recommended Power Supplies

For 380 to 480 VAC
Worldwide 3-phase Power Supply Resistant in tough environments Easy and fast installation The most compact class on the market
Switch Mode Power Supplies (120-W, 240-W, 480-W, and 960-W models)
S8VK-T
Search for “OMRON S8VK-T” for details.

For 100 to 240 VAC
A Perfect Fit for Small Control Panels Coated PCBs for Better Resistance to Environment Connections for Easy Wiring
Switch Mode Power Supplies (60-W, 120-W, 240-W, 480-W)
S8VK-S
Search for “OMRON S8VK-S” for details.

For 100 to 240 VAC
Reliable and Easy Operation-Worldwide Power Supply Resistant in tough environments Easy and fast installation The most compact class on the market
S8VK-G
Search for “OMRON S8VK-G” for details.

One Point!
The industrial power supply voltage in the world is often 380 to 480 VAC.

<table>
<thead>
<tr>
<th>Area</th>
<th>Industrial power supply voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Three-phase, 460 or 480 V</td>
</tr>
<tr>
<td>Europe</td>
<td>Three-phase, 380, 400, or 415 V</td>
</tr>
<tr>
<td>Thailand</td>
<td>Three-phase, 380 V</td>
</tr>
<tr>
<td>China</td>
<td>Three-phase, 380 V</td>
</tr>
<tr>
<td>India</td>
<td>Three-phase, 400 or 415 V</td>
</tr>
<tr>
<td>Japan</td>
<td>Three-phase, 200 V</td>
</tr>
</tbody>
</table>
Adding Kindness to Manufacturing

What Is Color Universal Design?
Color universal design was developed to provide products, facilities, buildings, environments, services, and information to as many individuals as possible in consideration of people with color weakness.

Percentage of People with Color Weakness
In Japan, one man in 20 and one woman in 500, and over 3.2 million people across Japan are assumed to have color weakness. The percentage of people with color weakness is even higher in Europe and the United States, and it is 8% to 10% in the West and 2% to 4% in Africa among men. Over 200 million people are assumed to have color weakness in the world.

The Value of Color Universal Design
Designing for people with color weakness will benefit people with normal color vision because it will produce well-organized, easy-to-understand designs. Therefore, color universal design is valuable to all people. Pushbutton switches and other operation switches are used not only on production lines in factories, but in public facilities, transportation, other infrastructure applications, food machines, and medical equipment, as just a few examples. At a medical site, an operating mistake can end up in life-threatening accidents. In the infrastructure, fatal accidents, traffic accidents, fires, and other accidents can be the result of a single operating mistake. Let us build a kinder working environment by improving the social color environment to make it easier to use by people with various types of color vision.

Recommended Operation Devices

Conforms to Color Universal Design *

Push-button Switches (Push-in terminals)
A22N-P
Push-button Switches A22N

* The yellow-blue-white and red-blue-white color combinations conform to color universal design.
Increase Visibility by Using White Characters on Black Backgrounds

Control panels always include control amounts (e.g., temperatures or pressures). The control amounts are important parameters that affect workpiece quality, and displays of the control amounts are generally provided on the fronts of control panels. Although touch panels are becoming popular display methods for high-end models, the cost involved results in many control panels using controllers with displays.

Control panels are installed in various lighting environments, from well-lit to dimly-lit locations. You need on-panel devices with good visibility. The visibility of displays increases with the difference in the brightness of the colors used, so displays with a large difference in color brightness are easily recognized from a distance or in bright or dark locations.

If the background is black, white offers the largest difference in brightness, but the chromatic color yellow draws attention better.

Visibility of Various Colors on Black

Creating Panels with a Good Sense of Design and Good Visibility

By incorporating large display devices with white or yellow characters on a black background into panels, not only is visibility improved, but also panels with a high sense of design are made possible.

Also, control panels are not always viewed from directly in front of them, so viewing angles are also important.

Consider the visibility from an angle when you select components.

Recommended Controllers with Displays

- Large, white PV displays that are easy to read and provide better visibility.
- Easy to use from model selection to setup and operation.
- A complete range of I/O capacities, functions, and performance.
- Handles more applications.

Digital Temperature Controllers

E5□C/E5□C-Bseries

Search for “OMRON E5□C” for details.
OMRON Corporation      Industrial Automation Company
Kyoto, JAPAN
Contact:  www.ia.omron.com

OMRON ASIA PACIFIC PTE. LTD.
No. 438A Alexandra Road # 05-05/08 (Lobby 2),
Alexandra Technopark,
Singapore 119967
Tel: (65) 6835-3011/Fax: (65) 6835-2711

OMRON EUROPE B.V.
Wegalaan 67-69, 2132 JD Hoofddorp
The Netherlands
Tel: (31)2356-81-300/Fax: (31)2356-81-388

OMRON ELECTRONICS LLC
2895 Greenspoint Parkway, Suite 200
Hoffman Estates, IL 60169 U.S.A.
Tel: (1) 847-843-7900/Fax: (1) 847-843-7787

OMRON (CHINA) CO., LTD.
Room 2211, Bank of China Tower,
200 Yin Cheng Zhong Road,
PuDong New Area, Shanghai, 200120, China
Tel: (86) 21-5037-2222/Fax: (86) 21-5037-2200

Authorized Distributor: