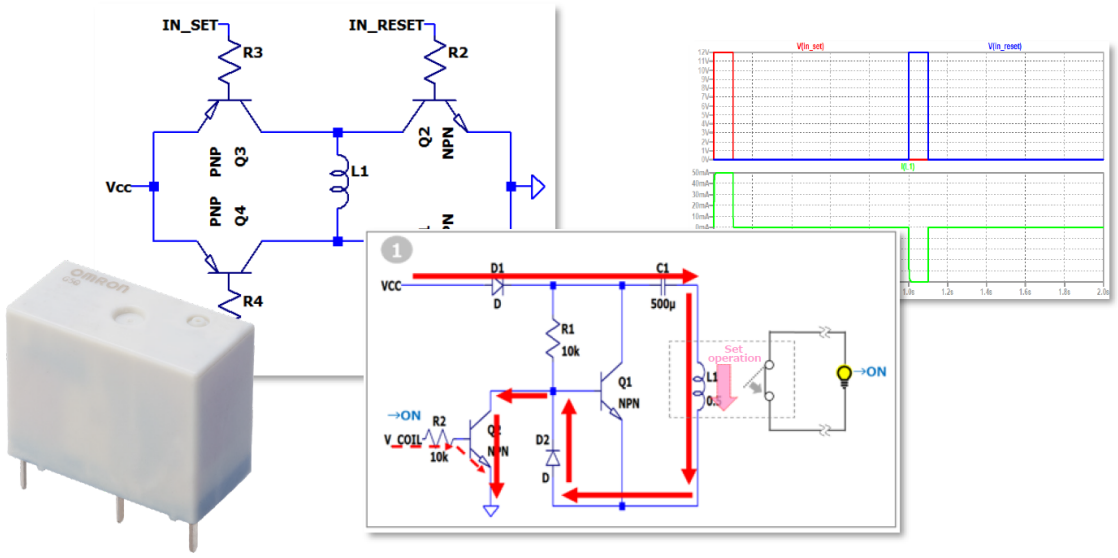
OMRON

Application Note

Low Power Consumption Drive Circuit Examples and Design Concepts for Making Full Use of Relays



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[Cautionary Notes]

- This document is intended only as a reference material for effective use of relays and does not guarantee the operation of the relays on your actual equipment.
- When utilizing the contents of this document, please carefully read the catalogs, specifications, etc. for the relevant relay and evaluate it on your actual equipment to confirm the specifications, performance, and safety.

A. Latching Relays: Low Power Consumption Drive Circuit Examples and Design Concepts

a. Single-winding Coil

A single-winding coil latching relay is equipped with only one coil and can switch between SET and RESET modes by changing the polarity of the current flowing through the coil. Therefore, it can be said that a single-winding coil is relatively more difficult to configure into a circuit than a double-winding coil. This section introduces the following three circuit examples:

- Example of an H-bridge circuit composed of transistors (positive and negative circuit)
- Example of an H-bridge circuit using a 2c type relay (positive and negative circuit)*
- Example of a circuit that drives a single-winding latching relay with only a simple coil signal ON/OFF (automatic recovery circuit example)

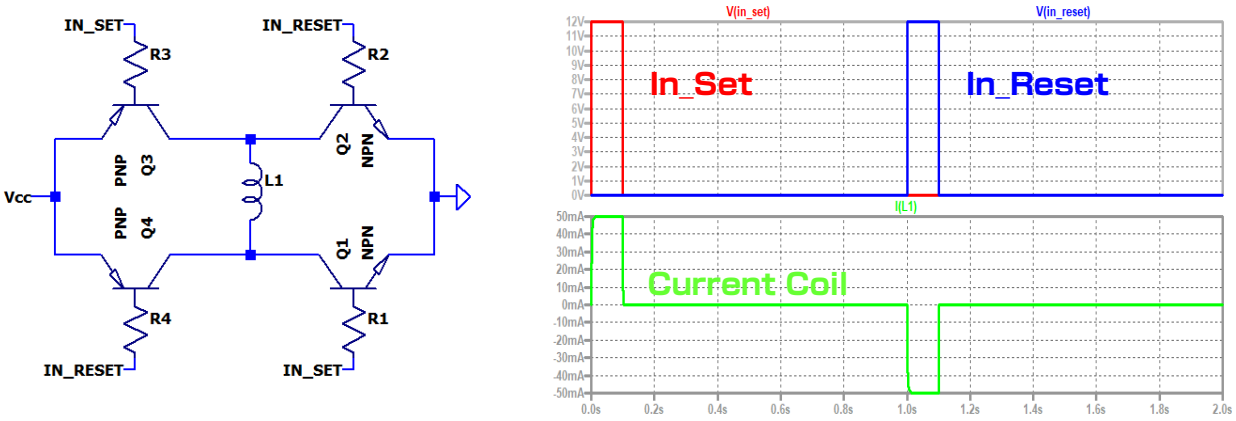
* Although there are cases where an IC that configures an H-bridge with a single chip is used instead of a 2c type relay, this section introduces the case where a 2c type relay is used.

The following are examples of each circuit and the concepts behind their design.

a-1. An H-bridge Circuit Composed of Transistors

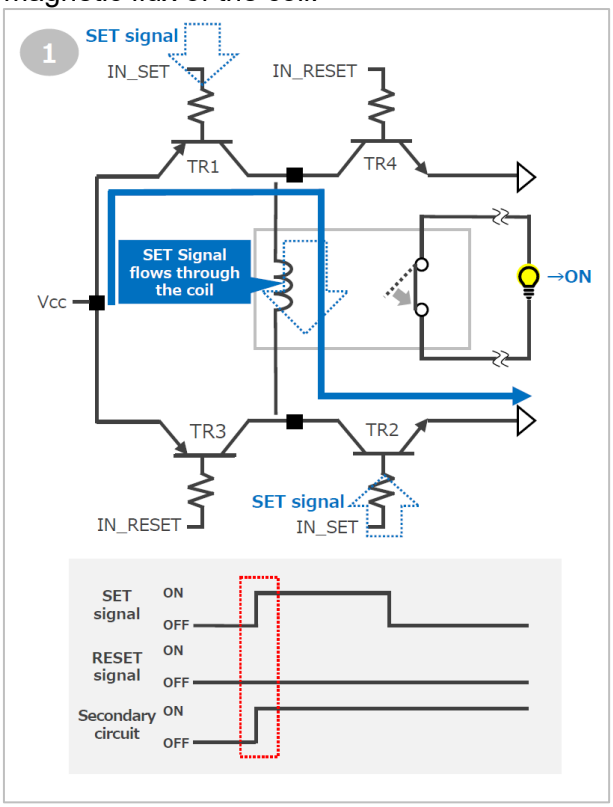
This circuit is composed of four transistors. Please refer to the circuit example and current/voltage waveform example below.

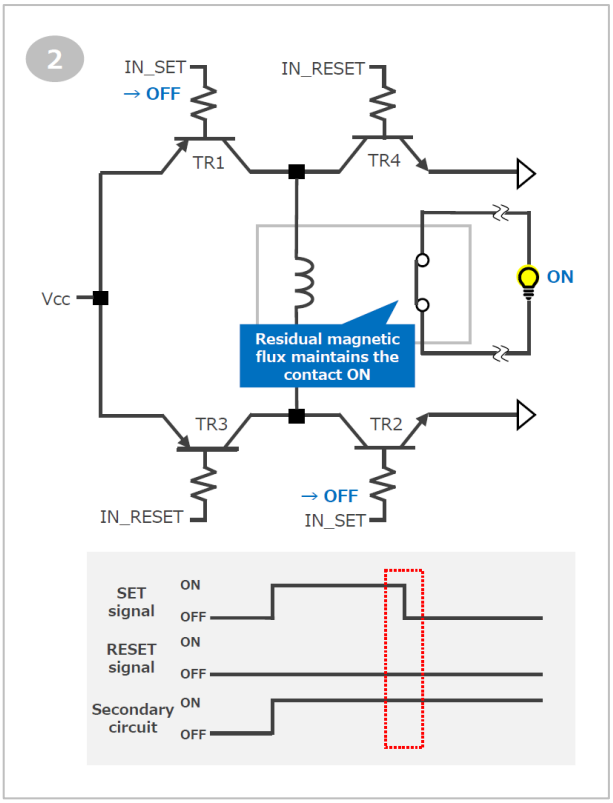
Fig. 1: An H-bridge circuit composed of transistors and example of current/voltage waveforms



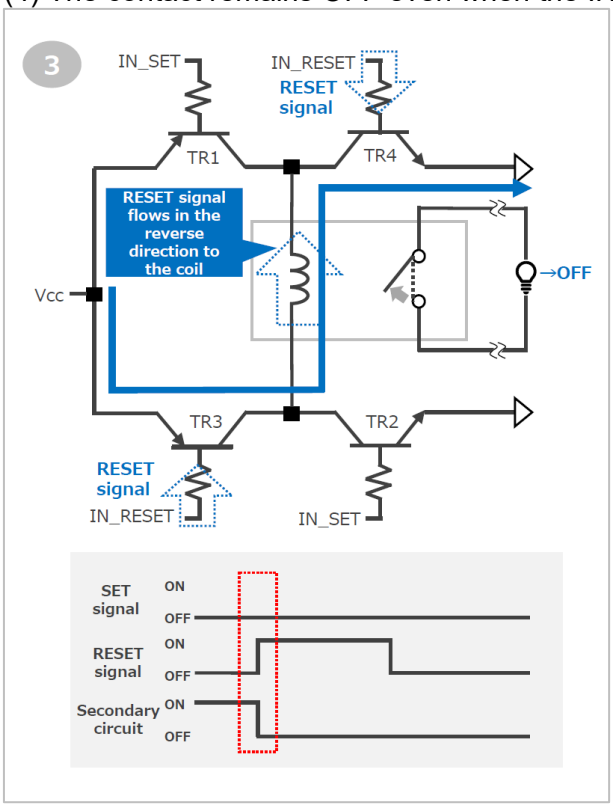
When designing a circuit, it is necessary to design it so that the current can flow in the reverse polarity.
On the next page, let's see how the current flows during SET and RESET respectively.

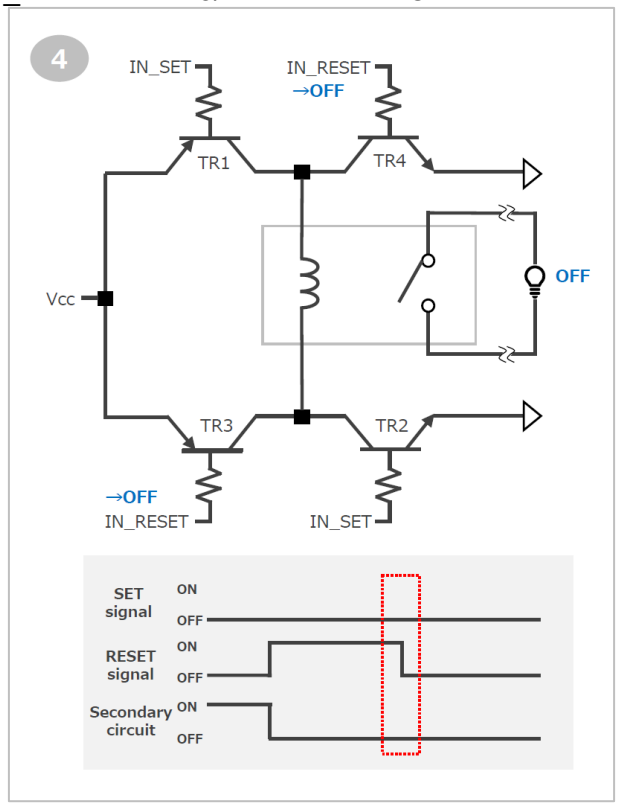
<During SET>
(1) When the IN_SET of TR1/TR2 is turned ON, a normal polarity current is applied to the relay coil through the path of TR1 → relay coil → TR2 to turn the contact ON.
(2) The contact remains ON even when the IN_SET of TR1/TR2 is turned OFF, due to the residual magnetic flux of the coil.





<During RESET>
(3) When the IN_RESET of TR3/TR4 is turned ON, a reverse polarity current is applied to the relay coil through the path of TR3 → relay coil → TR4 to turn the contact OFF.
(4) The contact remains OFF even when the IN_RESET of TR3/TR4 is turned OFF.

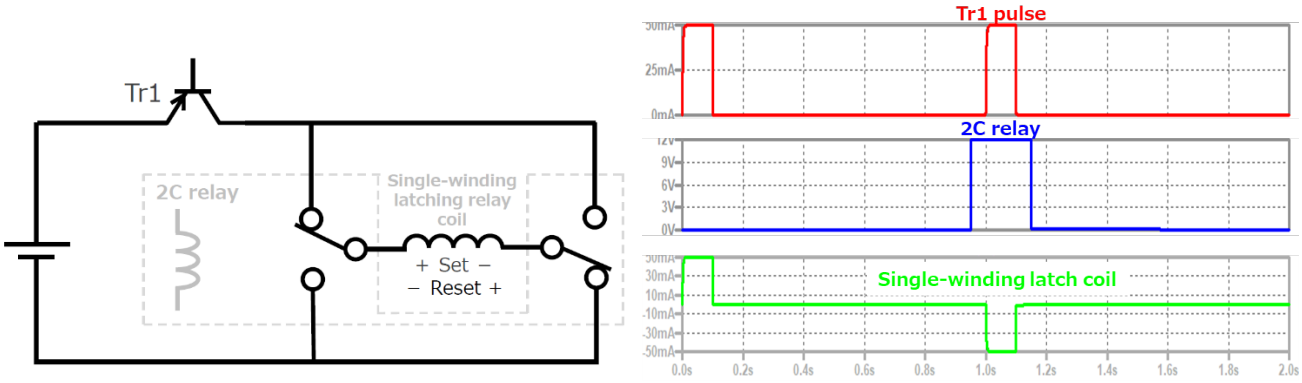




a-2. An H-bridge Drive Circuit Using a 2c Type Relay

This section introduces an H-bridge circuit (positive and negative circuit) using a 2c type relay. Please refer to the circuit example and current/voltage waveform example below.

Fig. 2: An H-bridge circuit using a 2c type relay and example of current/voltage waveforms



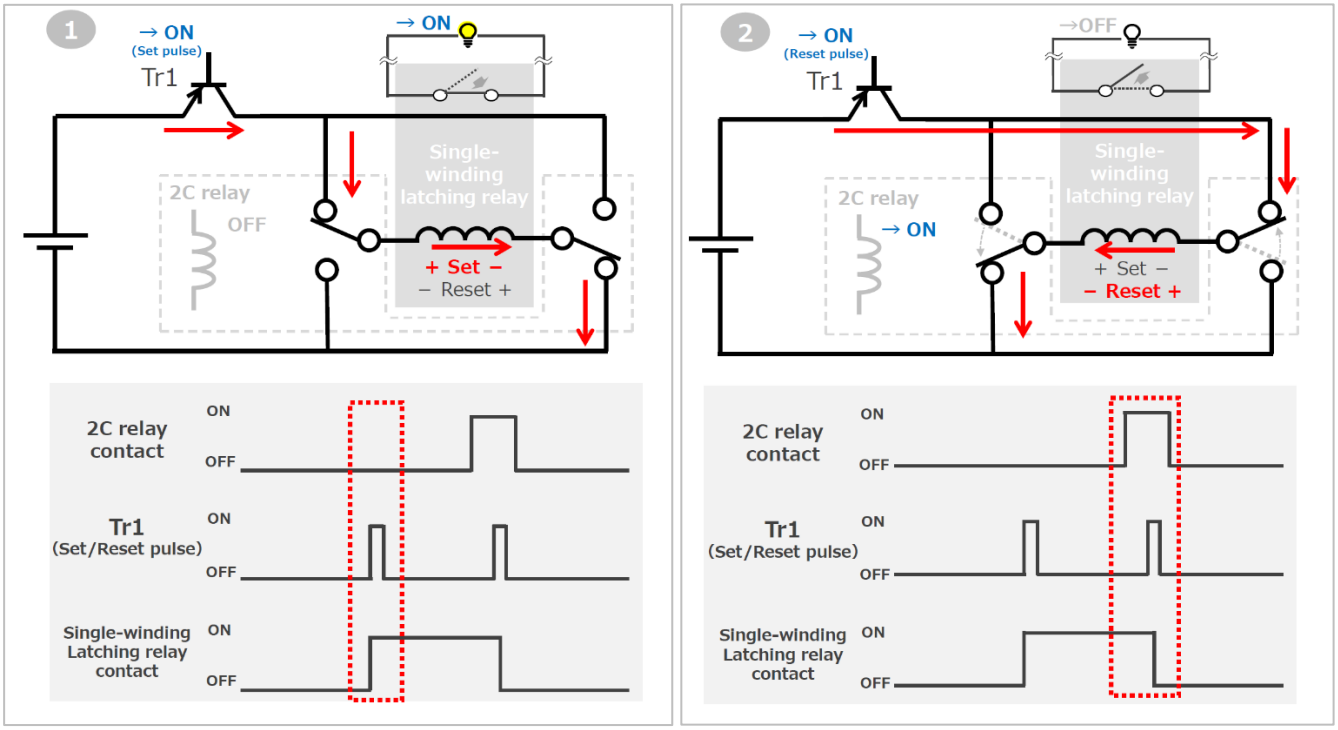
This is a method of switching SET/RESET by switching the path of the current flowing through the coil of the latching relay by turning the 2c type relay ON/OFF, and then applying the actual current flow using a transistor. The flow of each current is shown below.

<During SET>

(1) When Tr1 is turned ON with the 2C relay OFF, a set pulse is generated, and the single-winding latching relay is turned ON.

<During RESET>

(2) When Tr1 is turned ON with the 2C type relay ON, a reset pulse is generated, and the single-winding latching relay is turned OFF.

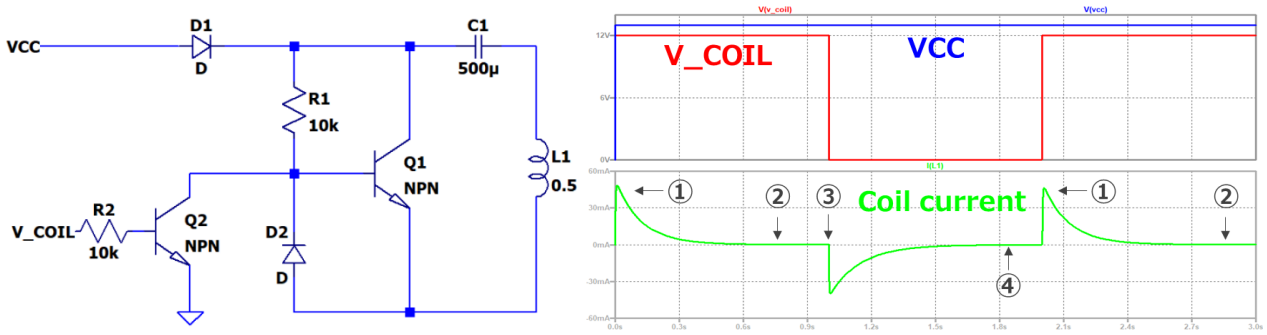


a-3. Single-winding Latching Relay with Only a Simple Coil Signal ON/OFF (Automatic Recovery Circuit Example)

This section introduces a circuit that controls a single-winding latching relay by means of a coil signal ON/OFF, like a single-stable relay. Due to the characteristics of latching relays, even if power is lost due to a power outage or other reasons while the relay is set, it will not automatically return to the reset state (because the reset signal does not flow through the coil). Therefore, in equipment that is designed to start power in the reset state, unexpected problems may occur due to startup power flowing through the relay in the set state.

The following is an example of a circuit that controls a single-winding latching relay using only a simple coil signal ON/OFF, without sending a set signal ON/OFF or reset signal ON/OFF. The use of capacitor charging/discharging enables automatic recovery (reset operation without a reset signal) during OFF, which is effective as a preventive measure against the aforementioned problems.

Fig. 3: Drive circuit using a capacitor and current/voltage waveforms

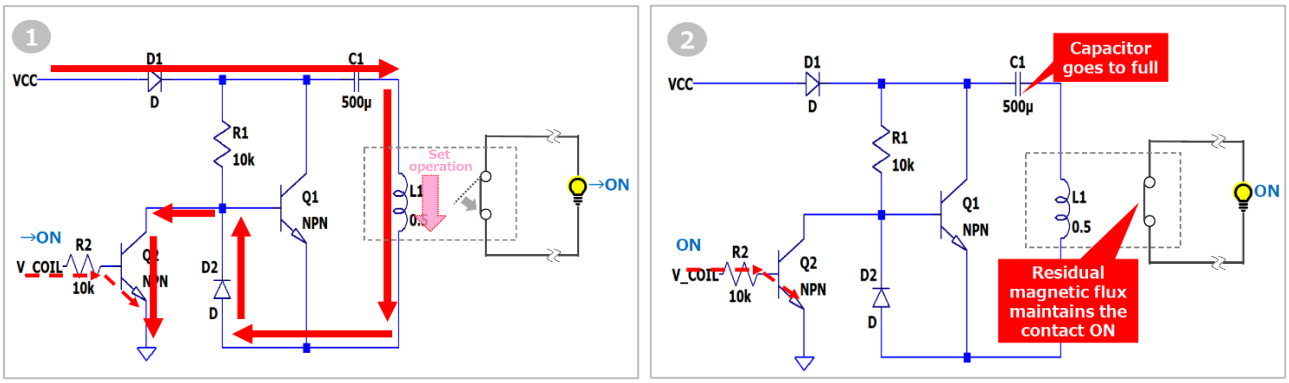


The current flows as follows. Please refer to the current waveforms (1) to (4) shown above for the current flow.

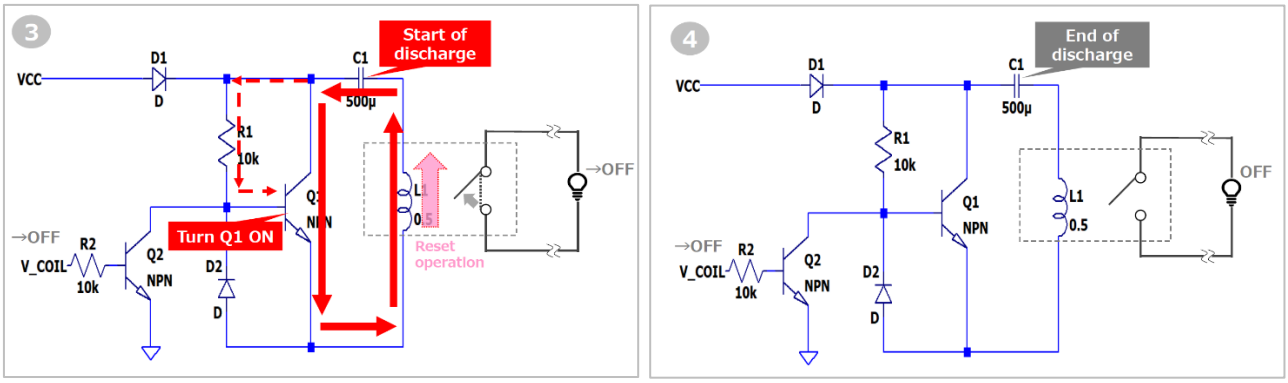
<During SET>

(1) When the V_COIL is turned ON, a set signal flows to the relay coil, thereby turning the contact ON.

(2) When the capacitor (C1) is full, the coil current stops flowing, but the residual magnetic flux keeps the contact ON.



<During RESET>
(3) When the V_COIL is turned OFF, the discharge of C1 turns Q1 ON and a RESET signal flows to the relay coil, thereby turning the contact OFF.
(4) When C1 finishes discharging, current will no longer flow. (The contact remains OFF)

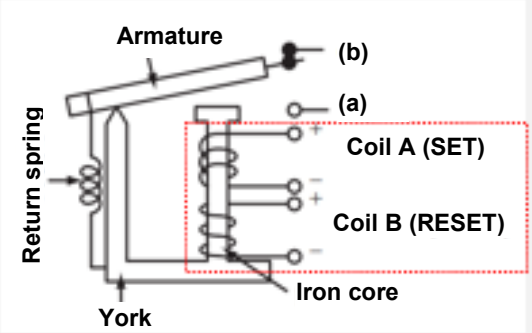


b. Double-winding Coil

b-1. Double-winding Latching Relay

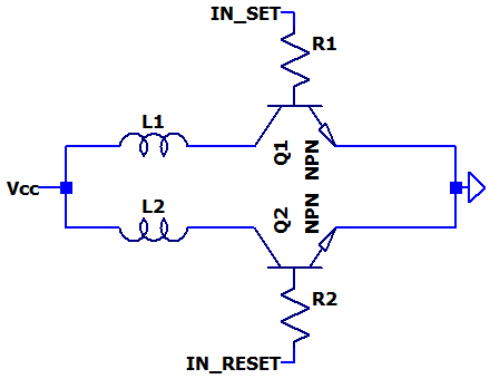
In the case of a double-winding coil latching relay, the coil for SET and the coil for RESET are each mounted in one relay. (Figure 4)
Therefore, by designing the circuit so that signals can be input to the respective coils during SET and RESET, the SET/RESET mode is switched. (See Figure 5 for a circuit example and waveforms)
Unlike a latching relay with a single winding coil, ON/OFF switching is possible simply by applying a signal (voltage) to each of the SET and RESET coils, so the design difficulty is relatively low. Please make your selection based on your circuit design philosophy and total cost.

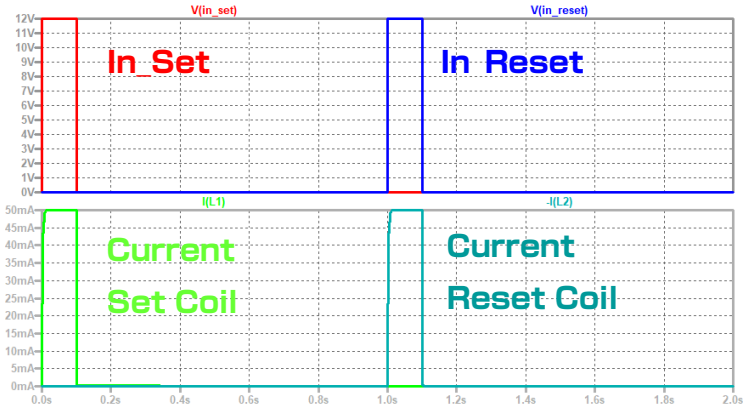
Fig. 4: Simplified internal structure of a double-winding latching relay



Two wires are wound around one iron core to realize a coil for SET and a coil for RESET.

Fig. 5: Drive circuit using a double-winding latching relay and current/voltage waveforms





Point!

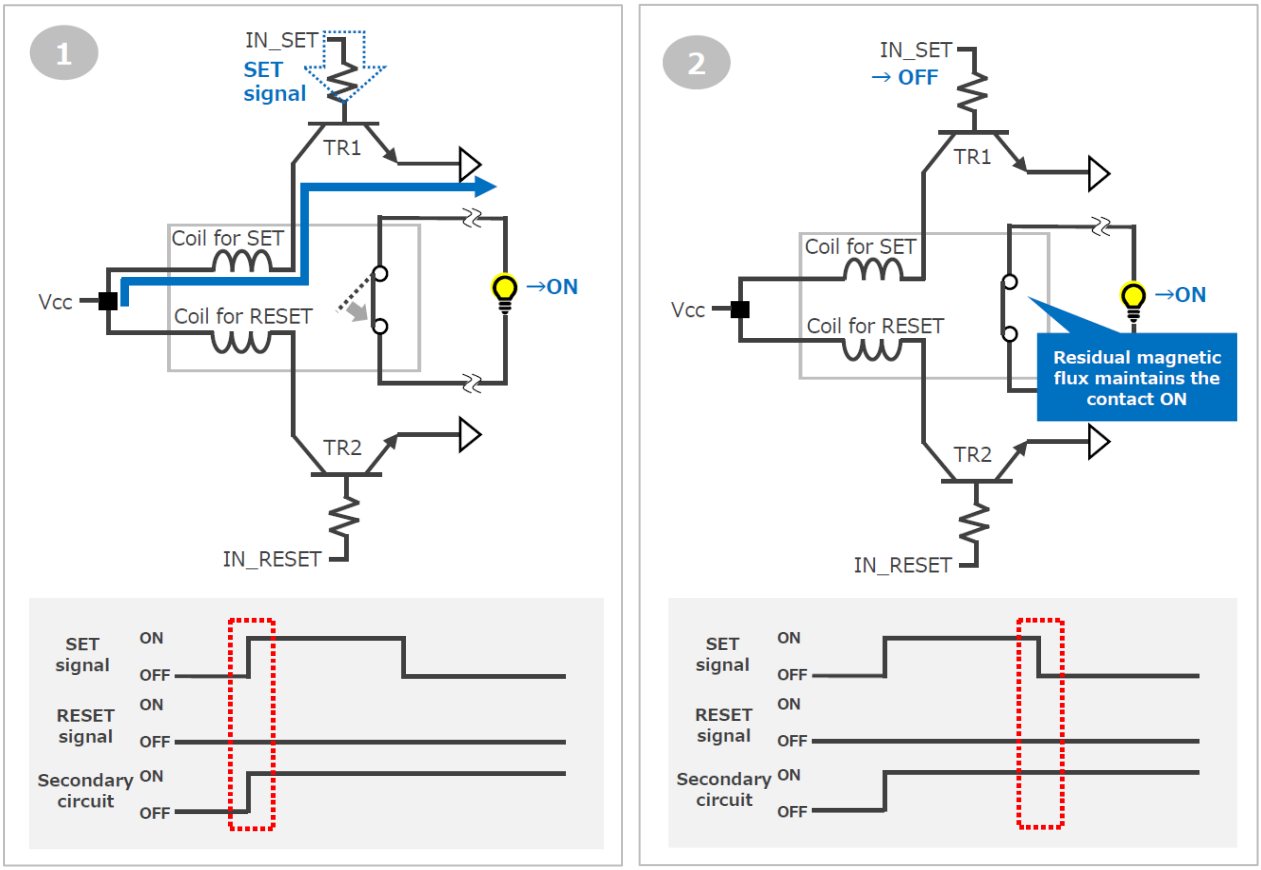
Latching relay: Differences in circuit design between single-winding coil and double-winding coil

	Advantage	Disadvantage
Single-winding coil	The aforementioned circuit controlled only by the coil signal ON/OFF (see section a-3.) is easy to configure.	The circuit tends to become complicated because of the need to switch the direction of the current in the coil.
Double-winding coil	The circuit is simple and easy to configure because it can be turned ON and OFF simply by adding signals to SET and RESET, respectively.	The unit cost of parts tends to become comparatively high.

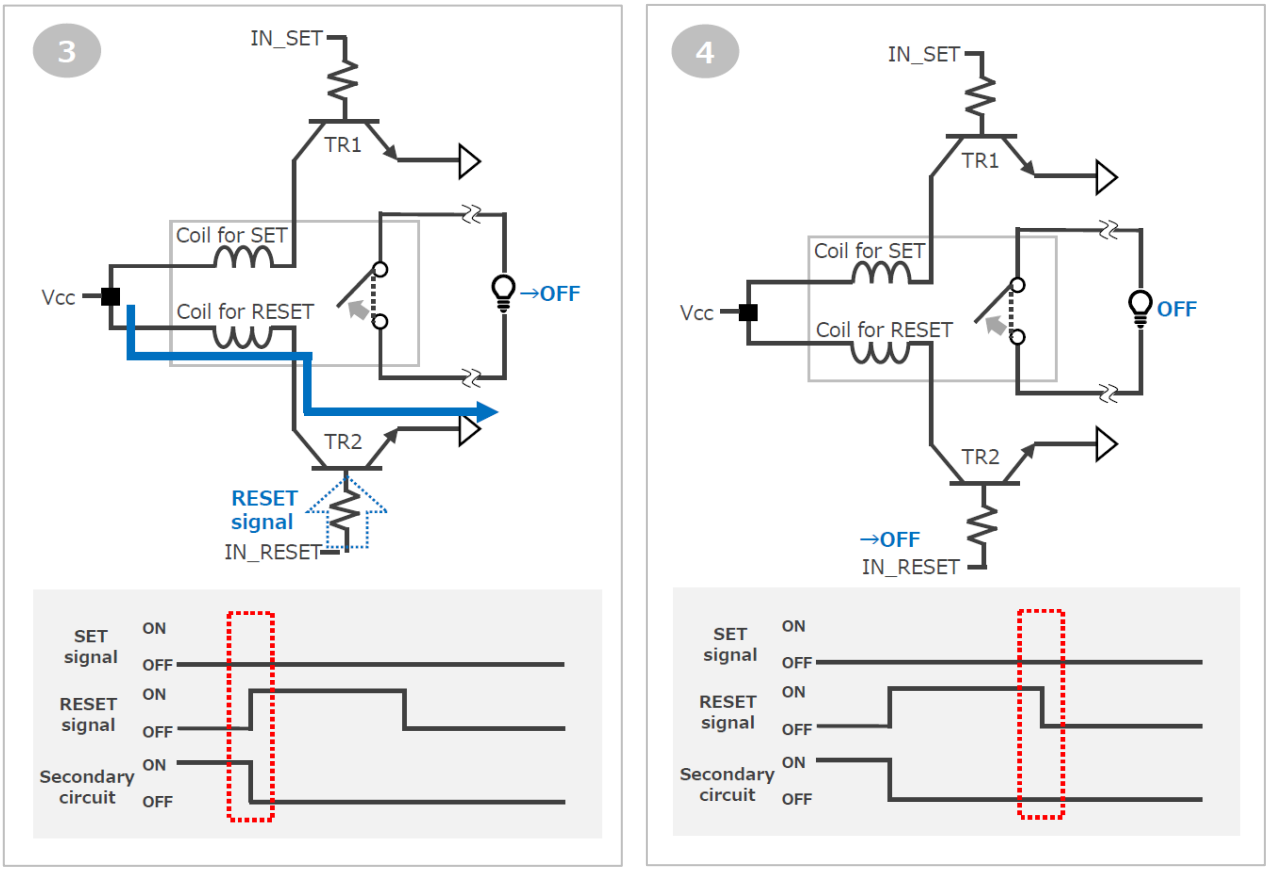
Note: Basically, there is no difference in the mounting area for a single relay.

Now let's see how the current flows during SET and RESET in a double-winding latching relay.

<During SET>
(1) When the IN_SET of TR1 is turned ON, current flows through the coil for SET of the relay.
(2) Even when the IN_SET of TR1 is turned OFF, the residual magnetic flux of the coil keeps the contact in the ON state.



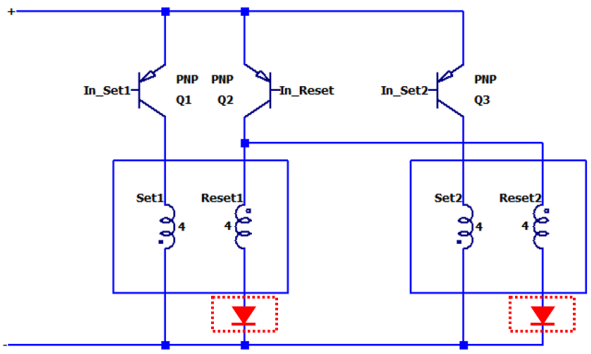
<During RESET>
(3) When the IN_RESET of TR2 is turned ON, current flows through the coil for RESET of the relay, turning the contact OFF.
(4) When the IN_RESET of TR2 is turned OFF, the non-energized state (the contact is also OFF) is maintained.



b-2. When Using Multiple Units in Parallel

We hope you now have a better understanding of basic circuit examples and concepts.
When connecting double-winding latching relays in parallel, there are two coils that share an iron core, which may cause unintended malfunctions due to electromagnetic induction.
Refer to the circuit example from “2-2-20 Using Latching Relays” here and be sure to connect a diode in series with the coil.

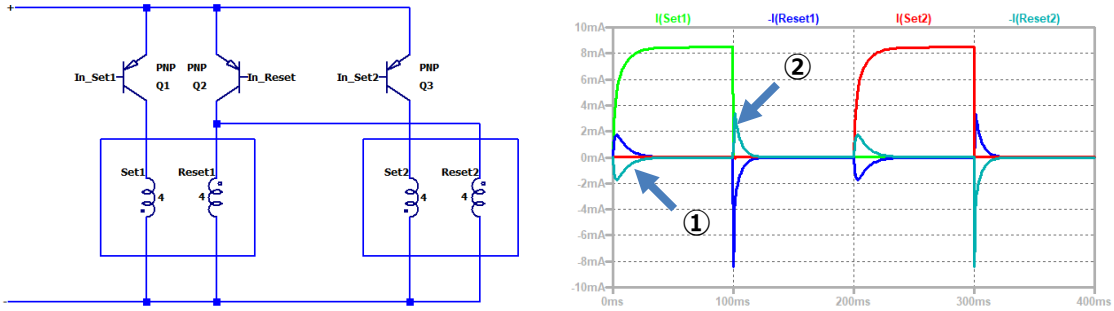
Fig. 6: Example of reset coil parallel connection circuit and diode installation location



(For details, refer to “2-2-20 Using Latching Relays (4) Circuit design for DC input” here)

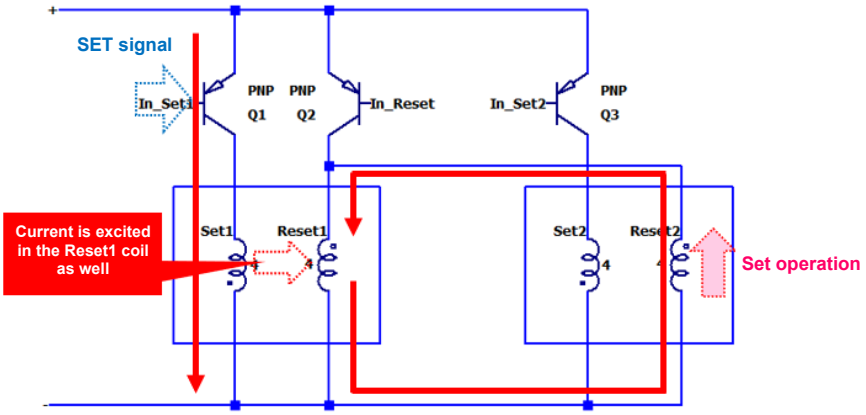
Why is it necessary to install diodes?
It is easier to understand the mechanism if you organize the information based on the current waveform and the way the current flows in the absence of diodes (Figures 7, 8, and 9).

Fig. 7: Example of circuit and current waveform without diodes



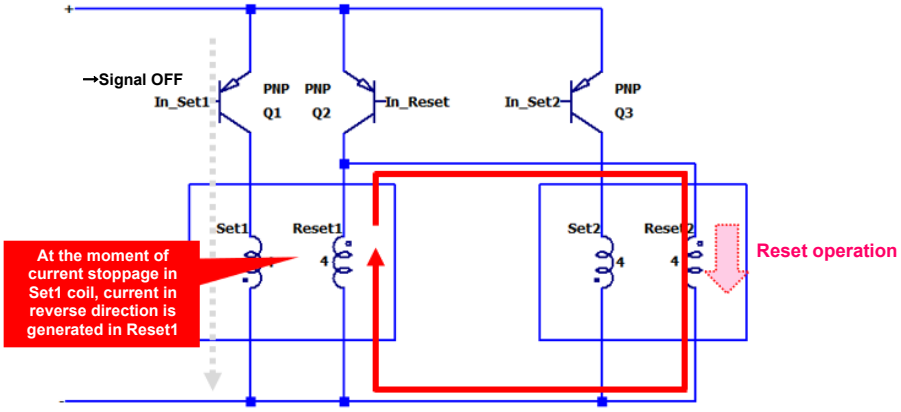
(1) When current flows through the Set1 coil, an induced current is generated in Reset1, and backward current (on the set action side) flows through Reset2. The current flow at this time is shown in Figure 8.

Fig. 8: Current flow when a signal is input to Set1



(2) When current to the Set1 coil stops, backward current flows through Reset1, and forward current (on the side of the reset action) flows through Reset2. The current flow at this time is shown in Figure 9.

Fig. 9: Current flow when a signal is input to Set1



As mentioned above, you can see that the current in one set coil causes the other relay to set and reset.

A double-winding coil is two pairs of coils that share an iron core, which is similar to the structure of a transformer. Therefore, when current is applied to one coil, current is excited in the other coil as well, which can cause unexpected problems.
In order to have a single switch set or reset multiple latching relays, care must be taken to prevent current flow-round by properly installing diodes, thereby preventing unexpected behavior.

c. Precautions for Handling Latching Relays

In addition to the items described in this article, there are other items that should be noted for optimal use of latching relays. For example, if the relay is placed too close to the magnet, it may affect the latching coil, which may cause problems. (Precautions for general purpose relays: See section 3-6)
Please refer to the following URL for precautions regarding relays in general, not just latching relays.

Precautions for general purpose relays
https://www.ia.omron.com/product/cautions/36/safety_precautions.html

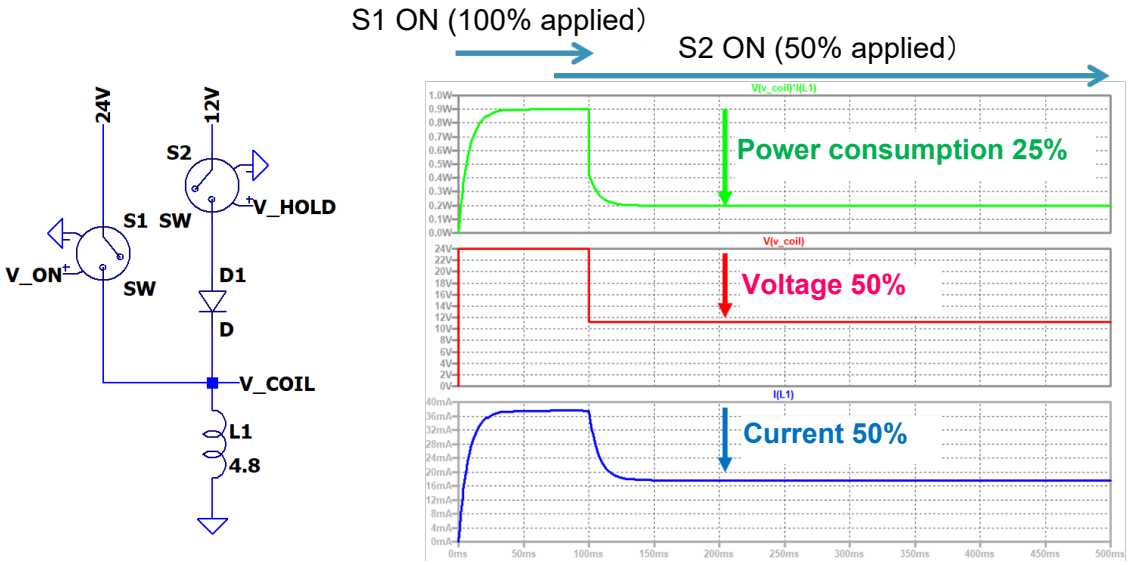
B. Single Stable Relay: Low Power Consumption Drive Circuit Example and Design Concept

When using a single-stable relay to reduce the power consumption of the drive circuit, it is common to control the reduction of the voltage applied to the coil after relay operation. It is also called low holding voltage control because the coil voltage is held in a reduced state.
Another approach would be to use a PWM drive to reduce coil power consumption. The required drive current can be reduced because the coil is held by pulse drive. Please refer to the following for each.

a. Low Holding Voltage Control Circuit and Design Concept

Based on the drive circuit example and waveforms (Figure 10), let's check how much power consumption can be reduced.

Fig. 10: Example of switch type circuit and waveforms

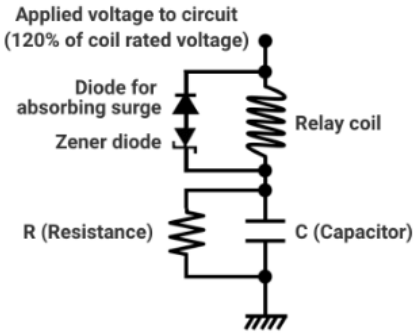


<Concept of coil power consumption>

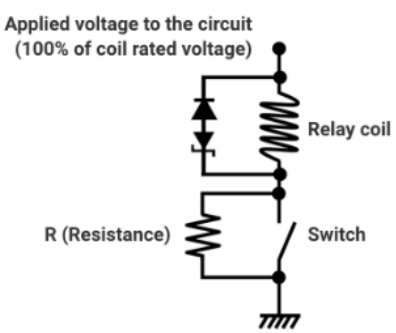
- 100% voltage is applied to the coil while S1 is ON.
- After S2 turns ON, S1 turns OFF, and the voltage applied to the coil becomes 50%.
- Since the voltage and current are each at 50%, power consumption is reduced to 25%, and power consumption can be reduced by as much as 75%.

There are various circuit examples for low holding voltage control. Please refer to the following.

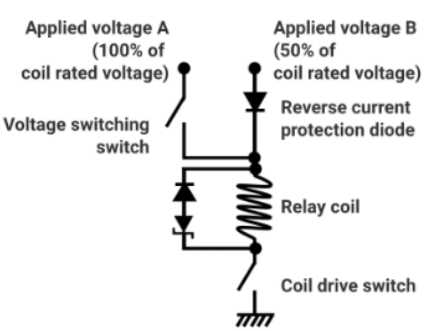
CR method



Switch method (1)



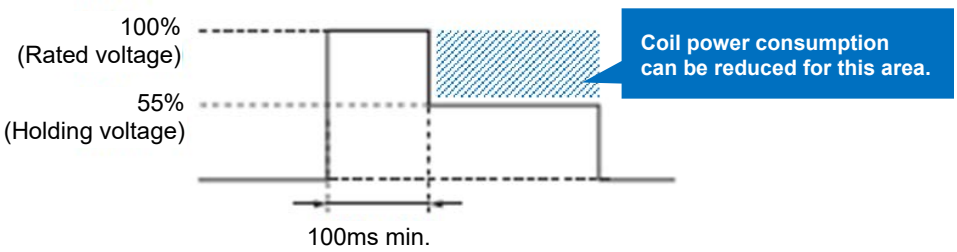
Switch method (2)



* For more information, please refer to "03. What types of holding voltage application circuits are recommended?" in the High-Capacity Power Relay Technical Support.

Control conditions at holding voltage differ depending on each product.
Please check the items listed in the data sheet before use. The following is an example for G2RL.

(Example for G2RL)
1. Apply rated voltage (100%) to the relay coil for at least 100 ms.
2. Then reduce the voltage to the holding voltage (at least 55% of the rated voltage).



	Applied coil voltage	Coil resistance*	Power consumption
Rated voltage	100%	62.5Ω (5 VDC) 360Ω (12 VDC) 1,440Ω (24 VDC)	Approx. 400 mW
Holding voltage	55%		Approx. 120 mW

* The coil resistance were measured at a coil temperature of 23°C with tolerances of ± 10%.

b. PWM Control Circuit and Design Concept

PWM control is a method of controlling electric power by rapidly repeating ON and OFF using semiconductors. The longer the voltage OFF time, the more power consumption can be reduced. Let's check the drive circuit example and waveforms. (Figure 9)

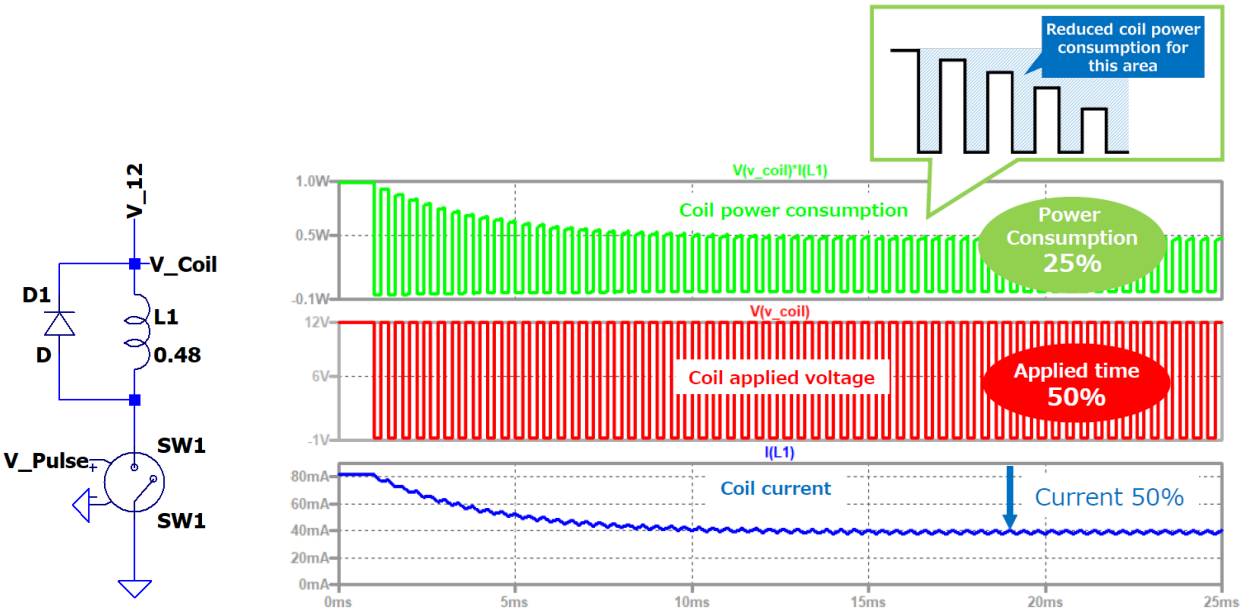


Fig. 9: PWM control circuit and waveform example

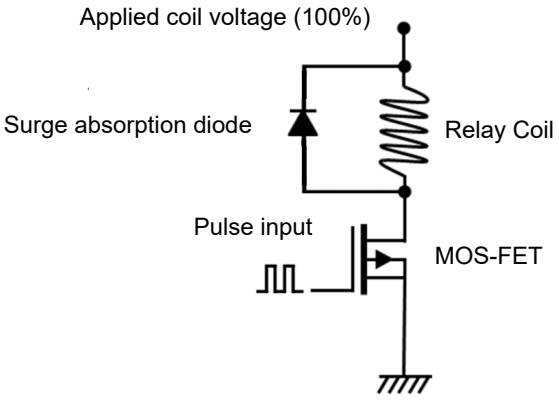
<Concept of coil power consumption (at 50% duty)>

・The voltage applied to the coil is 100% and the time it is applied is 50%.

・The coil current is gradually reduced to approximately 50% (from 80 mA to 40 mA).

・Since the application time is reduced to 50% and the electric power during application is also reduced to 50%, the power consumption is reduced to 25%, making it possible to save energy by as much as 75%.

Please refer to the following for an example of a general PWM control circuit.



Note: For high-capacity relays, it is recommended to configure a circuit with Zener diodes and switching devices.

*For more information, please refer to "03. What types of holding voltage application circuits are recommended?" in the High-Capacity Power Relay Technical Support.

C. Contact Us

If you have any questions about this article or need assistance on how to use relays effectively, please contact us.

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D. Related Contents

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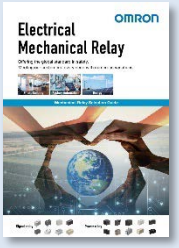
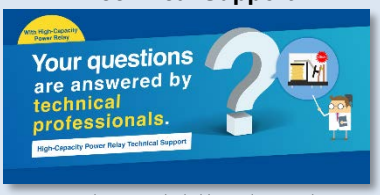


MOS FET Relay Selection Guide

High-Capacity Power Relay Technical Support

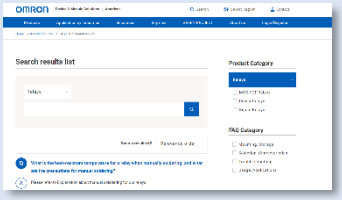


Reverse voltage in coils, holding voltage application circuits, the effects of magnetic fields, recommended conditions for PCB flow soldering, cautions for series/parallel connection, etc.

Basic Knowledge of Relays

Basic Knowledge of MOS FET Relays

Relay-related FAQs



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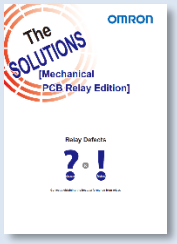

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