



AEROSPACE RECOMMENDED PRACTICE

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Selection and Application of Electro-Mechanical Relays for Proper Performance

RATIONALE

To update industry reference documents as needed and make minor editorial and clarifications to the ARP text.

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1. SCOPE

- 1.1 This SAE Aerospace Recommended Practice (ARP) provides information to guide in the selection of electromechanical relays to be used in electrical/electronic circuits for application in aerospace, ground, and shipboard systems to achieve proper performance.
- 1.2 Relays intended for use in aerospace industry and military applications are substantially different from those produced for industrial applications.

Most industrial relays are designed so that the user can convert contact sets from NO to NC (and vice versa); add and replace auxiliary contact sets; change or replace coils; use coils on systems up to 600 V 50 to 60 Hz and expect relays to last for many operations.

Typically, aerospace relays are designed to be nonrepairable with fixed contact configurations and generally for systems not exceeding 200 V and 400 Hz. These relays are generally for 28 V DC, and 115 V AC 400 Hz applications. The applicable system requirements are typically in accordance with MIL-STD-704 and RTCA-DO-160 (Radio Technical Commission for Aeronautics).

These relays are high-performance, low volume and low mass types, when compared to industrial types, and have little margin to tolerate an application or selection error.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 ECA Publications

Available from ECA, 2500 Wilson Boulevard, Arlington, VA 22201, Tel: 703-907-8024, www.ihs.com/products/eia-standards.html

Engineers' Relay Handbook

2.1.2 IEEE Publications

Available from IEEE Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE 315-1975

2.2 Definitions

2.2.1 Terms

For a list of common terms used in the rating and design application of relays, refer to the ECA Engineers' Relay Handbook. For relay definitions and terminology, refer to ANSI C83.16.

3. APPLICATION INFORMATION

3.1 General

This section contains general guideline information to assist the application engineer or circuit designer in choosing the appropriate relay.

3.2 Relay Selection and Application

CAUTION: The use of any coil voltage other than the rated coil voltage may compromise the operation of the relay. Choosing the proper relay depends primarily on matching the relay to the load, power supply, and environment. Selection should be limited to items that meet the following requirements.

CAUTION: When latching relays are employed in a circuit, the latch and reset coils should not be pulsed simultaneously. Coils should not be pulsed with less than the nominal voltage and the pulse width should be at least three times the specified operating time of the relay.

- a. Contacts must be rated for the load. Current rating, type of load (resistive, lamp, motor, inductive, and so forth), impedance range, voltage rating, DC or AC, frequency, single phase or polyphase, load balance, and type of switching or transfer should all be considered. Each of the following switching and transfer functions places a different requirement on the relay contacts and must be considered when selecting a relay with the proper contact rating:
 1. On-off switching - DC, AC (single phase or polyphase)
 2. Motor reversing (AC or DC)
 3. Transferring load between phases of same source
 4. Transferring load between unsynchronized AC sources
- b. Power supply characteristics must be taken into account. Voltage regulation, variations in frequency, ripples and spikes, as well as steady state conditions, should be included. If more than one power supply is involved, not only must each be suitable but any interaction between them also should be investigated.
- c. When selecting a relay for an application, the coil (or coils) should be rated to insure proper operation under all anticipated conditions.
- d. Consideration of the environmental conditions anticipated throughout the service life, as well as those expected during storage and transportation before installing the relays in the equipment, is mandatory. Electrical parameters, environmental factors, mechanical stresses, and proper relay application are among the categories which must be investigated.
- e. The circuit in which the relay is used, the interlocking feature employed, the wiring harness, and the associated components should all be investigated to assure suitability.
- f. Plug-in relays, if used, should be types that "lock" to their sockets and are specifically intended for use with a specified relay. Relays designed to be soldered are not typically suitable for use in sockets.
- g. Care should be exercised in handling, lead forming, and lead cutting of hermetically sealed relays, since extremely close cover-to-frame spacing and fragile glass seals make these types of relays susceptible to physical damage, if not handled properly. Leads should be supported near glass and shear type cutters, not side cutters, used.

- h. When it is required to provide "safe" isolation of the relay circuit in the OFF condition, and eliminate an electrical shock hazard, an electromechanical switching device should be placed between the positive terminal of the power source and the relay coil.

Proper transistor control of the relay coil requires a stable reference voltage. For example, this can be done by connecting the plus side of the coil to the positive side of the power source, the minus side of the relay coil to the collector of an NPN transistor, the emitter of the transistor to the grounded side of the power source, and the transistor base to the control voltage; for example, MIL-PRF-28776/1.

Any switching device controlling the relay coil circuit must be capable of withstanding, without damage, the sum of the maximum coil circuit voltage and the peak value of transient voltage that results when the coil field collapses. For example, a switch controlling a relay coil that is fed by a 28 VDC line and subjected to a transient voltage suppressed to 42 V must be capable of withstanding $28\text{ V} + 42\text{ V}$, i.e., 70 V surges without damage.

- i. In selecting solid state electronic switching devices to control relay coil circuits, care must be used in selecting a solid state device with a leakage current (in the "off" state) that is sufficiently low to guarantee that the relay will drop out.
- j. Control of the relay coil circuit by other than step-function switching may invalidate published relay performance properties such as pickup and dropout voltages (latch/reset) and pickup, dropout (latch/reset) times, and bounce times.

3.2.1 On-Off Load Control

On-off control of loads is a typical relay function. Where practical, one side of every load, including relay coils, should be connected to a common line (the grounded conductor of their power supply). All contacts will be on the hot side with respect to the loads. No contact shall be connected to ground. The switching should be done on the hot side of a circuit to prevent electrical shock, to decrease the possibility of circuit malfunction, and to reduce the number of contacts. Figures 1A, 1B, 1C, 1D, 1E, 1F, and 1G illustrate the problems that can be avoided by proper circuit design.

- a. Figure 1A is an example of a control problem resulting from not connecting all loads to the same common terminal. With three relays in series across the line, each has approximately one-third voltage available to it continuously. In addition to the power drain, the relays will be sensitive to temperature, vibration, and mechanical shock causing spurious operation. Relay K1 is energized when switch A is closed. Relay K3 is energized when switch B is closed. Relay K2 is energized when switch A and switch B are both closed. If switch A is closed and then reopened, relay K1 may remain in the energized mode due to the back circuit through coils K1, K2, and K3. Similarly, relay K3 may stay energized when switch B is opened. This uncertainty is corrected by the circuit of Figure 1B, in which all voltage is removed from the relay coils to be deenergized.
- b. Figure 1C - The opening ground lead does not open both relays; it places both in series.
- c. Figure 1E - Two relays in parallel will interact on dropout; if one relay is much larger, the smaller relay may false cycle. Transient protection on either relay coil will suppress both, whether or not desired. With two relay coils in parallel, if one has an internal series diode and the other is not suppressed, the diode may break down from the coil transients on dropout.
- d. Figure 1G - A common example of poor practice is motor dynamic braking with form C contacts. Contacts may handle run current but often fail to interrupt inrush and cause a line-to-ground fault through the switch. It is improper circuit design to have both line and ground on the stationary contacts.

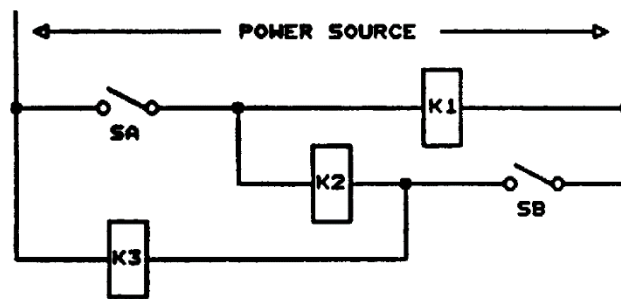


Figure 1A - Improper circuit design

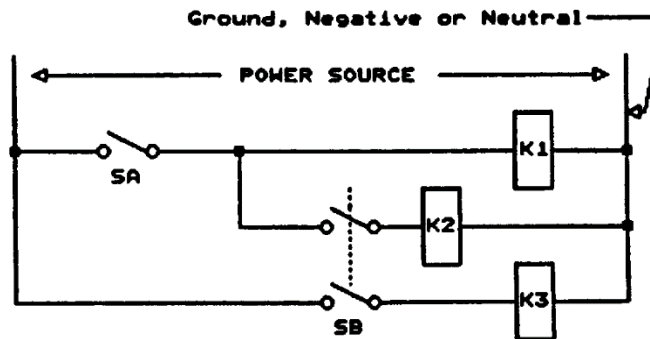


Figure 1B - Properly designed circuit

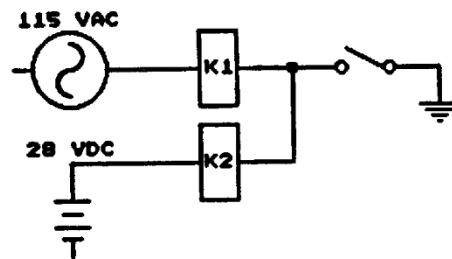


Figure 1C - Improper circuit design

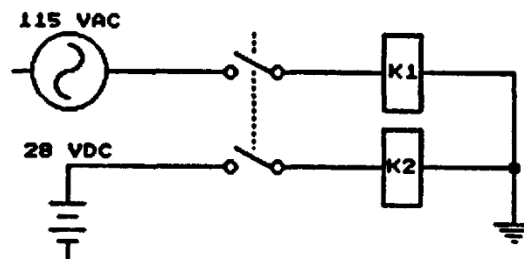


Figure 1D - Properly designed circuit

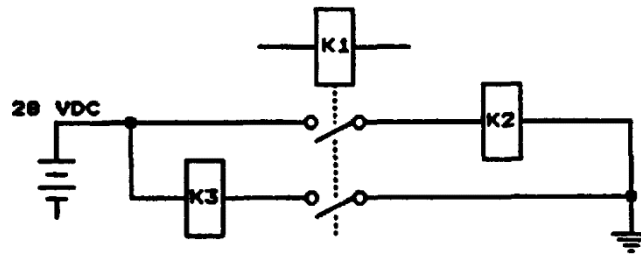


Figure 1E - Not recommended relay open ground

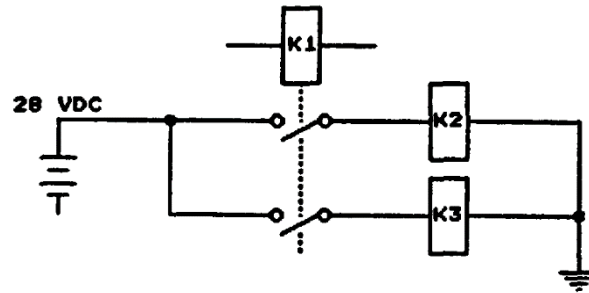


Figure 1F - Preferred design, two controlled with no adverse interaction on dropout

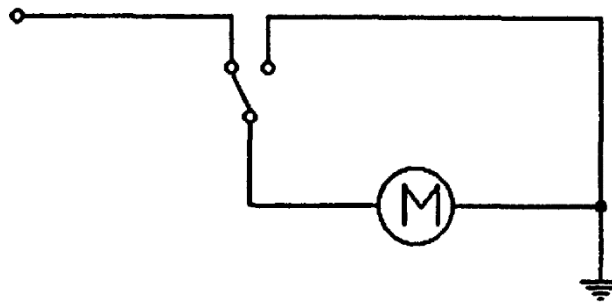


Figure 1G - Improper motor braking

3.2.2 Transfer Operation

Relays used in transfer operations are subject to greater electrical stresses than relays used for on-off load control. Typical transfer applications are those in which relays are used to reverse motors, reverse load polarity, or connect alternate power supplies to a load. Form C contact configurations are particularly susceptible to failure in transfer modes. Fast operation of a transfer contact can short circuit a power supply by making contact at one voltage before ionization from a previous voltage has decayed.

- Operate time, release time, contact air gap, spacing between contact poles, type of load, and power supply characteristics are factors that must be considered. Some manufacturers offer relays with form C contacts, properly derated, for transfer applications. Because of the uncertainties which arise, even with the best designed circuits, users should be aware of the possibility of failures. The reason may be no more sophisticated than overvoltage applied to the coil, resulting in abnormally fast pickup. Mechanical interlocking alone may not protect form C contacts used for transfer operations.

Figure 2A illustrates polarity reversal of a load by form C contacts. If a contact arc persists for the operate or release time of the relay, the power supply is short circuited. The circuit shown in Figure 2B is preferred.