SURFACE VEHICLE STANDARD

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(R) Standardized Symbols for Electrical Circuit Diagrams

RATIONALE

Industry adoption of this symbol convention will aid in the understanding of electrical circuits by engineers, OEM suppliers, service technicians and the industry generally. Standardization will mitigate misinterpretation within the industry.

This surface vehicle standard applies to medium and heavy-duty commercial vehicles.

The benefits of standardization are:

- The symbols can be used universally.
- Communication of electrical information is enhanced.
- The symbols are supported by text annotations for identification and operating notes.
- The symbols can display clearly on electronic display monitors and can be printed legibly.

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1. SCOPE

This SAE Recommended Practice identifies graphic symbols used in electrical circuit diagrams. The symbols aid troubleshooting electrical systems.

2. REFERENCES

Additional standards available for reference:

International Electrotechnical Commission (IEC) 60617-Graphical Symbols for Diagrams

American National Standards Institute (ANSI) Y32.2

3. DEFINITIONS

3.1 CLEAN GROUND

A low impedance ground point isolated to reduce transient noise from the electrical circuit.

3.2 ELECTRICAL CIRCUIT

An electrical circuit includes all of the components and connecting cables, starting from the electrical energy source, going through the functional component(s) and the return route.

3.3 ELECTRICAL CIRCUIT DIAGRAM

A drawing using standardized symbols to depict the relationship and interconnections of components and conductors of an electrical circuit.

3.4 FUNCTIONAL NAME

A name of a component or device that describes the action or purpose of the component or device.

3.4.1 Example -- GROUND

An electrical conductor with a relative zero potential used as the return for an electrical circuit(s).

3.5 SEPARABLE

Used to describe a terminal or connector which can be separated, disjoined or disconnected.

3.6 SYMBOL

The graphic depiction of a device.

3.7 SYMBOL CHARACTER

A fundamental element used to construct a symbol.

4. DESCRIPTION OF SYMBOLS AND SYMBOL CONSTRUCTION

This document uses a building-block approach to construct symbols. Fundamental symbol characters are assembled to form symbols that depict physical components. Components are shown installed on a fully operable machine in a quiescent state: engine and key off, shifter in neutral, and engine cold. The following example shows how symbol characters can be combined to depict an actual vehicle device.

EXAMPLE: A single-pole relay or contactor consists of three main elements, a separate symbol character can depict each (see Figure 1):

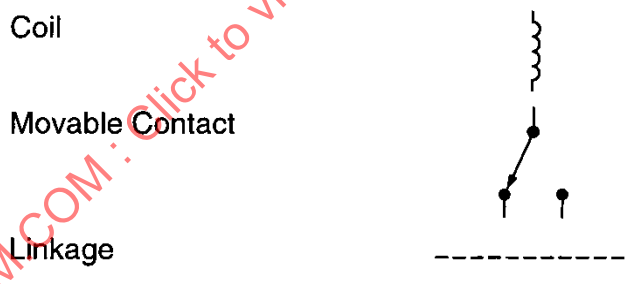


FIGURE 1 - FUNDAMENTAL SYMBOL CHARACTERS ASSEMBLED TO FORM SYMBOLS THAT DEPICTS A PHYSICAL COMPONENT

Symbols and symbol characters can be positioned and oriented in the attitude that best conveys circuit information. The symbol characters are usually positioned in a cause-and-effect sequence (left-to-right or top-to-bottom) to convey functional inter-relationships (see Figure 2):

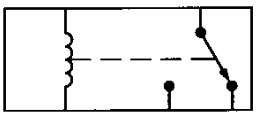


FIGURE 2 - ORIENTATION OF SYMBOL CHARACTERS

A relay for vehicle applications is protected by an integral enclosure, which is graphically depicted by a rectangular box symbol character. Adding the enclosure symbol character results in the following symbol (see Figure 3):

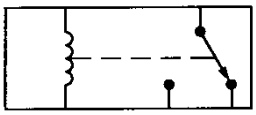


FIGURE 3 - ENCLOSURE WITH SYMBOL CHARACTERS

A vehicle relay includes terminals for connection to related circuit wiring. Symbol characters can be added to depict plug-in or threaded terminals. An enhanced relay symbol results (see Figure 4):

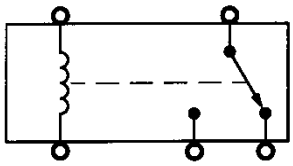


FIGURE 4 - SYMBOL CHARACTER WITH TERMINALS

To depict a relay with an integral transient-suppression resistor, the resistor symbol character can be added, with the result (see Figure 5):

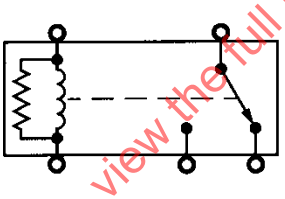


FIGURE 5 - SYMBOL CHARACTER WITH ADDITION OF INTEGRAL-TRANSIENT SUPPRESSION RESISTOR

5. SYMBOL LABELS

Symbols may include labels to depict identification information, including:

Functional Name
Rating
Terminal markings
Operating notes

If the actual vehicle uses symbols to identify devices or terminals, those identifying symbols should be included with the device symbol on the electrical circuit diagram.

For example, labels for a relay can be depicted as follows (see Figure 6):

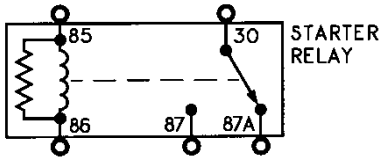


FIGURE 6 - SYMBOL CHARACTER WITH TERMINAL IDENTIFICATION

6. DIMENSIONS AND PROPORTIONS

Consistent symbol proportions insure consistent recognition and interpretation by technicians. This document depicts symbol characters and symbols to a uniform scale. The symbol characters should retain the same size when used to construct a symbol and electrical circuit diagrams. If size must be altered, change all symbols by the same scale to retain their proportions and relative sizes.

Spacing between symbols should be based on a grid. As examples, the grid could be 6 mm, 7 mm, 8 mm, or the standard used by a manufacturer.

7. LIST OF SYMBOLS IN ALPHABETICAL CATEGORIES

7.1 Symbol Characters

7.1.1 Capacitive Devices

See Figure 7.

Name	Symbol Character	Notes
Capacitor: Non-Polarized		
Capacitor: Polarized		

FIGURE 7 - CAPACITIVE DEVICES

7.1.2 Conductors

See Figure 8.

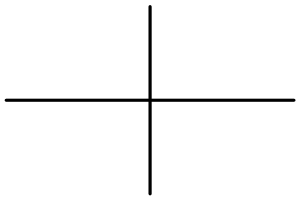
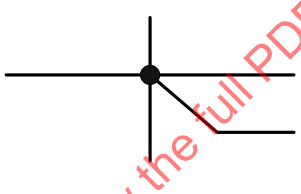
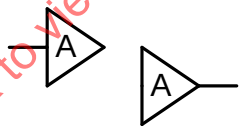
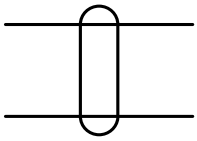
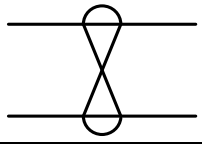
Name	Symbol Character	Notes
Conductor: Path Shown Completely		
Conductor: Path Shown Incomplete		Depicts conductor with one or more splices or connections not shown
Conductors: Crossing (not connected)		Avoid depicting crossing conductors that could be mistaken for connections
Conductors: Connected		Avoid depicting connections that could be mistaken for crossing conductors (applicable only to electrical conductors)
Conductor: Continued on Same Diagram		Use annotations to link ends within same diagram
Conductor: Continued on a Separate Diagram		Use annotation (optional) to identify title of diagram where conductor continues
Conductor: Fiber Optic		Data transmission or illumination transmission
Conductor: Shielded		
Conductor: Shielded Twisted Pair		

FIGURE 8 - CONDUCTORS

7.1.3 Connections

See Figure 9.

Name	Symbol Character	Notes
Female Terminal (Separable)		Terminal label optional
Male Terminal (Separable)		Terminal label options
Mechanical Linkage		
Rotation-Flexible Conductor		Sometimes named “clockspring” in steering wheel airbag applications
Screw Terminal		
Slip Ring and Brush		
Splice		Splice diameter to be depicted three (3) times width of conductor (minimum)

FIGURE 9 - CONNECTIONS

7.1.4 Enclosures

See Figure 10.

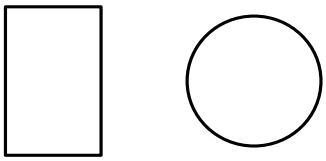
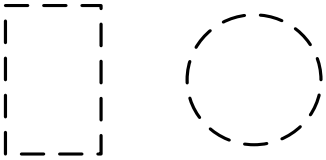
Name	Symbol Character	Notes
Component		Circular enclosure often used for gauges, etc.
Component: Incomplete or Reference		Circular enclosure often used for gauges, etc.

FIGURE 10 - ENCLOSURES

7.1.5 Grounds

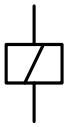
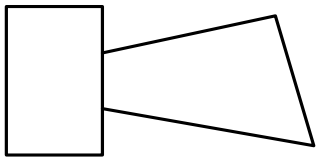
See Figure 11.

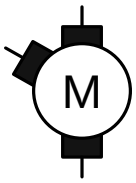
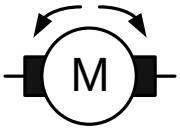
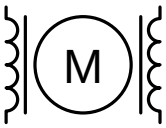
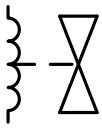
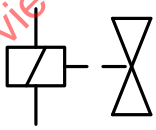
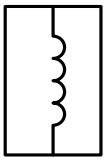
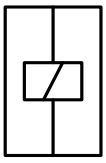
Name	Symbol Character	Notes
Ground: General Purpose		
Ground: Clean		Specific electronic ground connection. Isolated from high current and inductive loads

FIGURE 11 - GROUNDS

7.1.6 Inductive Devices

See Figures12.

Name	Symbol Character	Notes
Coil [Inductor] (Version 1)		Depict all coils in a diagram with the same symbol character version
Coil [Inductor] with core (Version 1)		
Coil (Version 2)		For Worldwide Applications Depict all coils in a diagram with the same symbol character version
Horn		
Motor, General		

Name	Symbol Character	Notes
Motor, Two-Speed		
Motor, Reversible		
Motor, Stepper		
Solenoid Valve (Version 1A)		Symbol character includes: • Fluid portion • Version 1 coil symbol character
Solenoid Valve (Version 2A)		For Worldwide applications. Symbol character includes: • Fluid portion • Version 2 coil symbol character
Solenoid Valve (Version 1B)		• Symbol character includes Version 1 coil symbol character
Solenoid Valve (Version 2B)		For Worldwide Applications. • Symbol character includes Version 2 coil symbol character • Symbol Character does not depict fluid portion

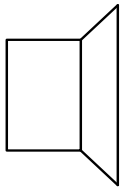
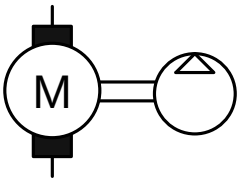
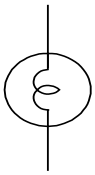
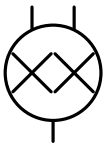
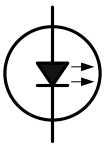
Name	Symbol Character	Notes
Speaker		
Pump		

FIGURE 12 - INDUCTIVE DEVICES

7.1.7 Lighting Devices

See Figure 13.

Name	Symbol Character	Notes
Bulb, Single Filament		Symbol character depicts incandescent technology
Bulb, Single Filament		Alternative
Bulb, Dual Filament		Symbols character depicts incandescent technology
Lamp, LED		Symbol character depicts: • Single or multiple LED junctions • All related internal current-limiting circuitry within lamp

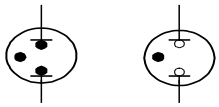
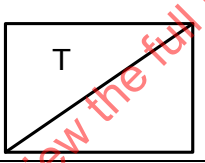
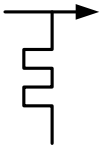
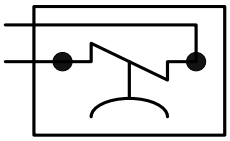
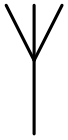
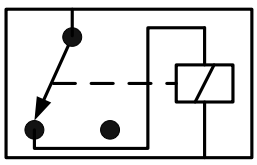
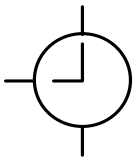
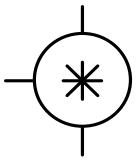
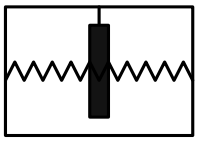
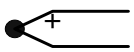
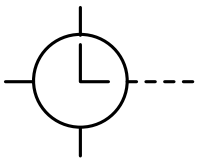
Lamp, Flashing		
Bulb, Fluorescent		

FIGURE 13 - LIGHTING DEVICES

7.1.8 Miscellaneous Electronic Devices

See Figures14.

Name	Symbol Character	Notes
Sensing Device		
Pressure Sensing Device		
Thermal Sensing Device		
Magnetic Sensing Device		
Antenna		
Buzzer		For Worldwide Applications. Symbol depicts electro-mechanical technology

Name	Symbol Character	Notes
Clock (Analog or Digital display)		Symbol character depicts clock with 3 leads: • Some clocks use different quantities of leads • Depict with actual number of leads involved
Gauge		Symbol character depicts gauge with 3 leads: • Some gauges use different quantities of leads • Depict with actual number of leads involved • Label gauge to identify where parameter is sensed, if applicable (ex: Coolant)
Oxygen Sensor		
Piezoelectric Cell		
Probe: Liquid Level		Symbol character depicts conductive technology
Thermocouple		
Timer (Electronic or Mechanical)		• Symbol character depicts timer with 3 leads: • Some timers use different quantities of leads

Name	Symbol Character	Notes
		• Depict with actual number of leads involved • Operates an output device

FIGURE 14 - MISCELLANEOUS ELECTRONIC DEVICES

7.1.9 Protection Devices

See Figure 15.

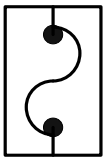
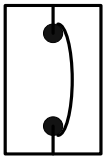
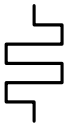
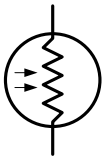
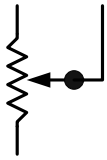
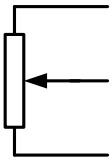
Name	Symbol Character	Notes
Fuse		Symbol character depicts plug-in construction
Circuit Breaker		• Symbol character depicts plug-in construction • Operating details (Type 1, 2, or 3) not to be depicted graphically

FIGURE 15 - PROTECTION DEVICES

7.1.10 Resistance Devices

See Figure 16.

Name	Symbol Character	Notes
Heater Element		
Photoresistor		
Potentiometer		
Potentiometer		Alternative

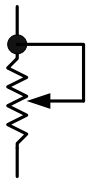
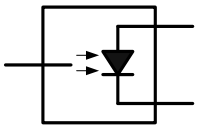
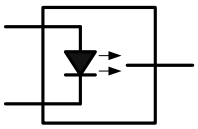
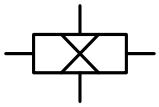
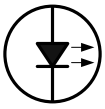
Name	Symbol Character	Notes
Resistor: Fixed		
Resistor: Variable (Version 1)		
Resistor: Variable (Version 2)		

FIGURE 16 - RESISTANCE DEVICES

7.1.11 Semiconductor Devices

See Figure 17.

Name	Symbol Character	Notes
Diode		General purpose
Fiber Optic Receiver		
Fiber Optic Transmitter		
Hall Effect Device		
LED (Light Emitting Diode)		Symbol character includes: • Multiple junctions • Current-control circuitry

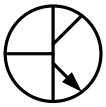
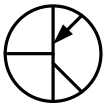
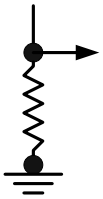
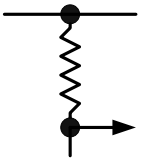
Photodiode		
Transistor: NPN		
Transistor: PNP		
Zener Diode		
Zener Diode: Dual		

FIGURE 17 - SEMICONDUCTOR DEVICES

7.1.12 Simplified Inputs and Outputs

See Figure 18.

Name	Symbol Character	Notes
Input: Power		• Label with source name (optional)
Input: Pulled-Down		• Label with signal name (optional)
Input: Pulled-Up		• Label with pull-up voltage and signal name (optional)

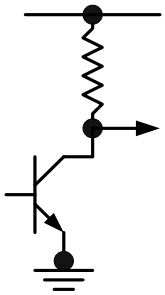
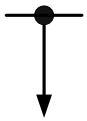
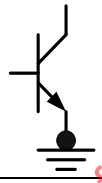
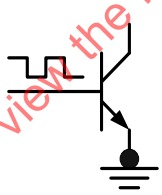
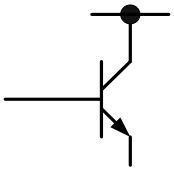
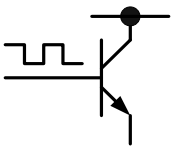
Name	Symbol Character	Notes
Data Line		• Label with data line name (optional)
Output: Reference Voltage		• Label with source voltage (optional)
Output: Sinking		• Label with output name (optional)
Output: Sinking (pulsed signal)		• Label with output name (optional)
Output: Sourcing		• Label with output name (optional)
Output : Sourcing (pulsed signal)		• Label with output name (optional)
Signal: Pulsed		

FIGURE 18 - SIMPLIFIED INPUTS AND OUTPUTS

7.1.13 Switches

See Figure 19.

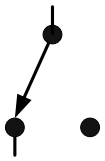
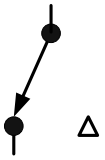
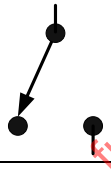
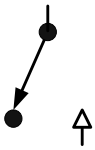
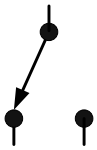
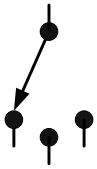
Name	Symbol Character	Notes
Contact: Closed (General Purpose)		Symbol character depicts single pole switch with a maintained contact
Contact: Closed (Momentary)		Symbol character depicts single pole switch with a momentary open position
Contact: Open (General Purpose)		Symbol character depicts single pole switch with a maintained contact
Contact: Open (High Current)		Symbol character depicts a single pole contact
Contact: Open (Momentary)		Triangular open contact signifies a manually-actuated momentary position
Contact: Momentary Position		Shape signifies a switch position that can be momentarily manually-actuated
Switch: Double-Throw		Symbol character depicts a single pole
Switch: Multi-Position		Symbol character depicts a single pole 3-position switch

FIGURE 19 - SWITCHES

7.2 Symbol Examples

Examples of symbols constructed from several symbol characters:

7.2.1 Capacitive Device Examples

See Figure 20.

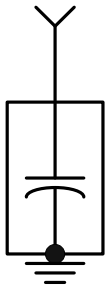
Name	Symbol Character	Notes
Capacitor: By-Pass		Example includes: • Female terminal • Pigtail lead • Case ground

FIGURE 20 - CAPACITIVE DEVICE EXAMPLES

7.2.2 Ground Examples

See Figure 21.

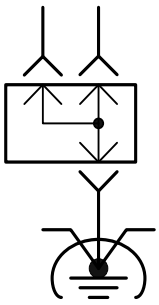
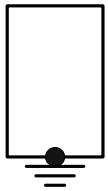
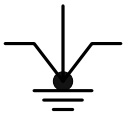
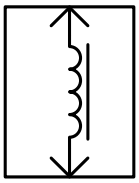
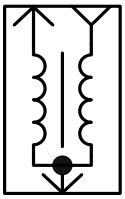
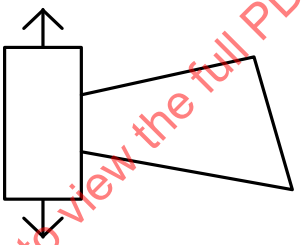
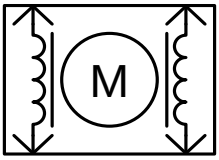
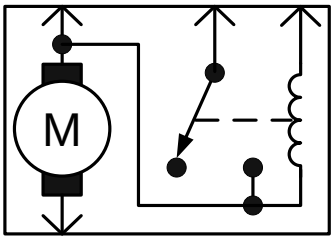
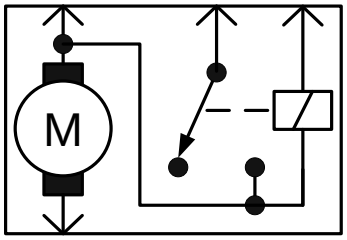
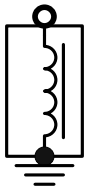
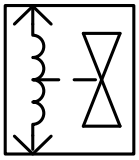
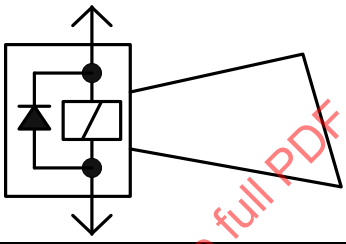
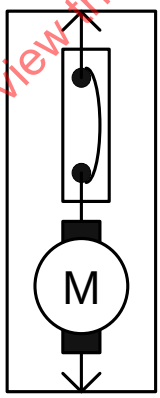
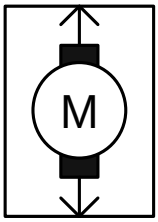
Name	Symbol Character	Notes
Ground: Clean, With Wires		Example includes: • 2 wires connected through a junction connector to a clean ground point • 2 additional wires connected to the clean ground point
Ground: Enclosure		
Ground: General Purpose, With Wires		Example includes 3 wires connected to a general purpose ground point

FIGURE 21 - GROUND EXAMPLES

7.2.3 Inductive Device Examples

See Figures22.

Name	Symbol Character	Notes
Coil: With Integral Terminals		Example includes: • Core • Version 1 coil symbol character
Coil: Ignition		Example includes: • Single-ended secondary • Version 1 coil symbol character
Horn: with Pigtail Terminals		
Motor: Stepper (with Integral Terminals)		
Motor: Windshield Wiper (Version 1)		Example includes: • Integral terminals • Integral relay • Version 1 coil symbol character
Motor: Windshield Wiper (Version 2)		For Worldwide Applications Example includes: • Integral terminals • Integral relay • Version 2 coil symbol character

Name	Symbol Character	Notes
Solenoid: with Case Ground and Threaded Terminal		Example includes Version 1 coil symbol character
Solenoid Valve: Complete		Example includes: • Integral terminals • Version 1A Solenoid Valve symbol character
Horn: with Suppression Diode		Example includes pigtail terminals
Motor: with Integral Circuit Breaker		Example includes integral terminals
Motor: with Integral Terminals		

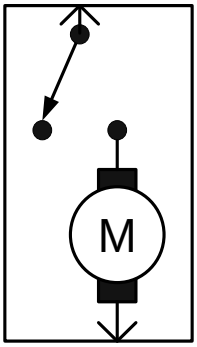
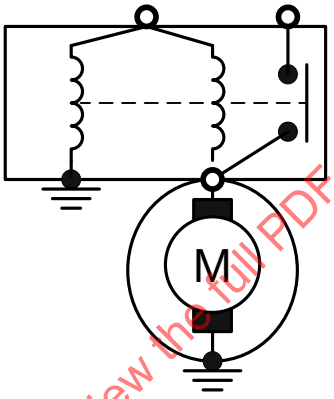
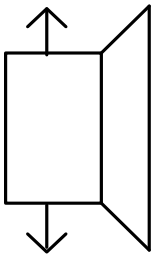
Name	Symbol Character	Notes
Motor: with Integral Switch		Example includes integral terminals
Motor: Starter (with Starter Solenoid)		Example includes: • Internal details • Threaded terminals • Version 1 coil symbol character • High current switch symbol character • Circular motor enclosure
Speaker: With Pigtail Terminals		

FIGURE 22 - INDUCTIVE DEVICE EXAMPLES

7.2.4 Power Source Examples

See Figure 23.

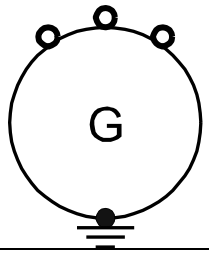
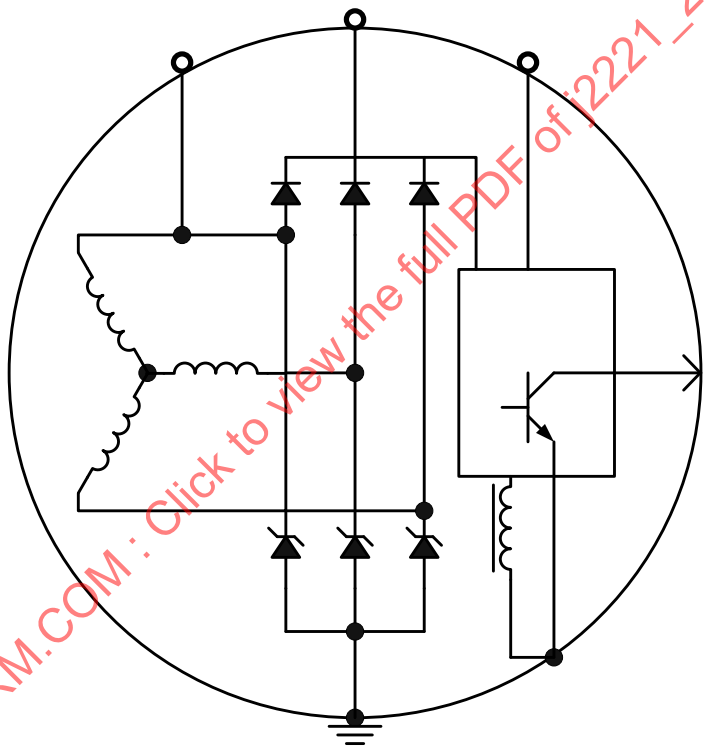
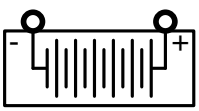
Name	Symbol Character	Notes
Alternator: Example 1		Label terminals accordingly (optional)
Alternator: Example 2		Example includes: • Internal details • Threaded power terminals • Integral signal terminal • Circular enclosure
Battery: Version 1		Example includes 6-cells (for nominal 12-volts)
Battery: Version 2		Version 1 rotated to accommodate diagram layout

FIGURE 23 - POWER SOURCE EXAMPLES

7.2.5 Protection Device Examples

See Figure 24.

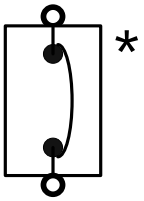
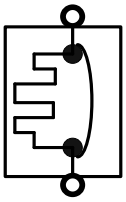
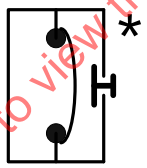
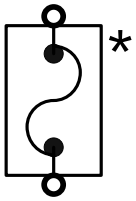
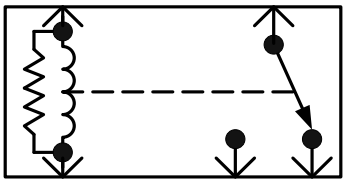
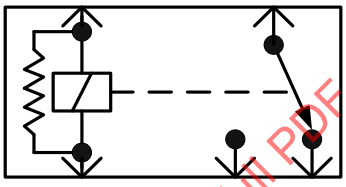
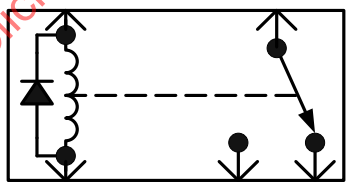
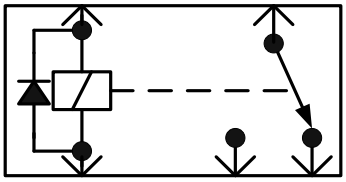
Name	Symbol Character	Notes
Circuit Breaker: With Threaded Terminals		For Worldwide Applications • Operating details (Type 1, 2, 3) not depicted graphically
Circuit Breaker: Type 2		Example includes: • Heater element to maintain high-resistance circuit until self-reset after power removal • Plug-in construction
Circuit Breaker: Type 3		Example includes: • Manual reset • Plug-in construction
Fuse: With Threaded Terminals		

FIGURE 24 - PROTECTION DEVICE EXAMPLES

7.2.6 Relay Examples

See Figures25.

Name	Symbol Character	Notes
Relay: With Suppression Resistor (Version 1)		Example includes: • Threaded terminals • Version 1 coil symbol character (depict all relay coils alike in a diagram)
Relay: With Suppression Resistor (Version 2)		For Worldwide Applications Example includes: • Threaded terminals • Version 2 coil symbol character (depict all relay coils alike in a diagram)
Relay: With Suppression Diode (Version 1)		Example includes: • Threaded terminals • Version 1 coil symbol character (depict all relay coils alike in a diagram)
Relay: With Suppression Diode (Version 2)		For Worldwide Applications Example includes: • Threaded terminals • Version 2 coil symbol character (depict all relay coils alike in a diagram)