Signal Training Bulletin

COMMITTEE G: Education & Training
Communication & Signal Section, AAR

C-4 Direct Current Relay Operating Characteristics

Approved January 1974

Definition:

(a) Operating Characteristics: As applied to a relay, the measure of the electrical values at which a relay operates (Drop-away, pick-up, working value, etc.)

(b) Drop-away (or release value): The electrical value at which the movable member of an electromagnetic device will move to its de-energized position.

(c) Pick-up: The electrical value which, when applied to an electromagnetic instrument, will cause the moving member to move to the position which will just close the front contacts or visually indicate its energized position.

(d) Working Value: The electrical value which, when applied to an electromagnetic instrument, will cause the moving member to move to its full energized position to provide maximum front contact pressure.

Symbol: None

Description: As defined above, the operating characteristics are the electrical values at which electrical apparatus operates. A label affixed to the inside of the transparent contact compartment contains the specific operating characteristics of a relay. Also shown is the relay serial number, coil resistance, initials of person who inspected relay and the date of inspection. A typical track relay label is illustrated in Figure 1.

DROP AWAY		PICK UP		WORKING		SER. L 270579
VOLTS	AMPS	VOLTS	AMPS	VOLTS	AMPS	OHMS 2
.108	.054	.206	.103	.206	.103	INSP. G.A.R. DATE 9/6/71
~~SLOW REL.~~ .... SEC. AT ...... V.		~~SLOW P.U.~~ .... SEC. AT ...... V.		ORDINARY ACT.		

Figure 1

Purpose and Application: Operating characteristics must be provided for each piece of electrical apparatus in order that design staff may properly select the power requirements and capacity of the circuit. Field personnel must also be aware of the importance of consulting the characteristics label to ensure that through circuit adjustments they do not exceed the electrical tolerance of the equipment or circuit.

As an example of application of the use of the operating characteristics, consider the conventional track circuit where the coil of the track relay receives its energy from a track battery. For track circuit adjustment, adjustable resistors are connected in series with the relay coil and battery. In one method of track circuit adjustment the signal employee is required to adjust the normal current flow through the relay coils to a value 50 percent above the relay working value. To do this, insert an ammeter in the coil circuit and adjust the resistor until the current reading is 50 percent greater than the value shown on the relay characteristic label.

If the circuit referred to in the preceding paragraph utilized a track relay with the characteristics shown in Figure 1, the signalman would note that the working current is 0.103 amp. He would calculate that 50 percent of 0.103 is approximately 0.052 amp and adjust the relay series resistor to provide 0.155 amp (0.103 + 0.052) through the relay coil.

General Information: Although signal construction and maintenance forces must consult the operating characteristics for relay identification and adjustments it is not normally part of their duties to test that relay operation does conform with the characteristics shown. Many railroads have field inspection forces who make periodic tests to determine if relay operating characteristics are within acceptable tolerances.

When relays are found defective they are replaced in kind and shopped. It is generally considered poor practice to repair relays in the field because of the possibility of foreign material entering the relay. Relay shops are equipped with precision instruments for accurate calibration in a relatively dust free environment.

All employees should be familiar with their company's policy for inspection, repair and replacement of relays.

Detailed Operation: When designing relays, the manufacturers attempt to keep the power requirements as low as practical, bearing in mind that dependable and safe operation must result.

The range in operating characteristics between relays is significant and necessary.

Two governing factors considered in establishing a relay's operating values are:

(a) The voltage of the circuit in which the relay will be used.

(b) The type of relay; i.e. neutral, slow release, biased, etc.

DROP AWAY		PICK UP		WORKING		SER. L270579
VOLTS	AMPS	VOLTS	AMPS	VOLTS	AMPS	OHMS 2
.108	.054	.206	.103	.206	.103	INSP. g.a.R. DATE 9/6/71
~~SLOW REL.~~ ....SEC. AT....V.		~~SLOW P.U.~~ ....SEC. AT....V.		ORDINARY ACT.		

Figure 2(a)

DROP AWAY		PICK UP		WORKING		SER. L262396
VOLTS	AMPS	VOLTS	AMPS	VOLTS	AMPS	OHMS 500
1.85	.0037	3.50	.0070	3.50	.0070	INSP. A.I.B DATE 6/1/72
~~SLOW REL.~~ ....SEC. AT....V.		~~SLOW P.U.~~ ....SEC. AT....V.		ORDINARY ACT.		

Figure 2(b)

DROP AWAY		PICK UP		WORKING		SER. L73226
VOLTS	AMPS	VOLTS	AMPS	VOLTS	AMPS	OHMS 250
2.70	.0108	5.95	.0238	6.55	.0262	INSP. B.P. DATE 4/6/72
SLOW REL. 1.8 SEC. AT 8.0 V.		~~SLOW P.U.~~ ....SEC. AT....V.		~~ORDINARY ACT.~~		

Figure 2(c)

NOTE: DC relays used in signaling are classified as track or line relays. Any relay which receives all or part of its operating current through the rails of the track is a track relay. A line relay does not receive any of its operating current through the rails of the track.

Three of the most commonly used relays have been selected for the discussion that follows. They are a neutral track relay, a neutral line relay and a slow release line relay. Typical characteristic labels for each are illustrated in Figure 2.

Note that the labels contain voltage and current levels for drop-away, pick-up and working values. Note also that the pick-up and working values are generally shown to be the same. By definition the pick-up value would be less than the working value; however, they are considered to be the same. This is because signal circuits are designed so that when the proper voltage is applied to the relay, sufficient current flows through the coils to provide maximum contact pressure in the energized position. As a matter of fact, pick-up has become the more commonly used term to describe the fully energized values.

The labels also include the coil resistance in ohms. Track relay coil resistance will normally range from less than one ohm to four ohms and line relays are generally one hundred ohms or more.

Provision is made at the bottom of the label to indicate any special operating features of the relay. The label in Figure 2(c) is from a slow release relay. This relay will remain up for 1.8 seconds after an energizing voltage of 8 volts is removed from the coil circuit.

To describe the differences in characteristics between types of relays, those in Figure 2 will be compared. Those not familiar with typical track and line circuit operation should refer to Figure 3 and the explanation found later in this bulletin before proceeding.

There are significant differences in the amount of operating current required in the track relay, Figure 2(a), and the line relays shown in Figure 2(b) and 2(c). This is due to the variance in circuit operation. In track circuit application the relay is normally energized until a shunt is applied across the circuit. This shunt is usually the wheels and axles of cars or engines. The amount of resistance to current flow offered by the shunt is dependent on many factors including rusty rails, weight of train, etc. In any case the shunt never provides a path of zero resistance and since the relay coil is in parallel with the train shunt, some current will continue to flow through the coil. However, this flow of current will be less than the required drop-away value.

For this reason the pick-up and drop-away current for track relays are much higher than for line relays. The voltage to line relays is either on or off. When a line circuit is opened there are no alternate current paths to the line relay coil. Because of this, line relays are designed to operate on very low currents, to conserve power.

If the track relay were operated at line relay values, the current flowing through the coils when the track is occupied by a train would continue to keep the armature up, which could not be tolerated. Through proper selection of components and circuit adjustment the current through the coils with the track shunted would be far less than 0.054 amperes which is the drop-away value of the track relay in Figure 2(a).

Another factor that must be considered in track relay design is the fact that even when the track circuit is unoccupied the current through the coils will fluctuate. This is caused by variations in ballast resistance. When ballast is wet its resistance is lower than when dry or frozen, therefore on wet days some current will be shunted from the coil. If the tolerance between pick-up and drop-away were as narrow as the line relay in Figure 2(b), (pick-up 0.0070 amp, drop-away 0.0037 amp) which is less than 5 milliamps, the circuit would not be reliable.

The slow release line relay in Figure 2(c) operates at slightly higher values than the neutral line relay in Figure 2(b). To provide the slow drop away feature, it is necessary to maintain the magnetic flux for a period after the voltage has been removed from the coil circuit. One method often employed is to replace part of the coil windings with copper slugs. The slugs being good electrical conductors will provide a low resistance path for the current generated by the decaying flux of the deenergized relay and hold the relay up for a period. The higher the current that flows in the coil in the energized mode the stronger the field of flux produced. When coil voltage is removed the flux will take longer to dissipate and the relay will take longer to release.

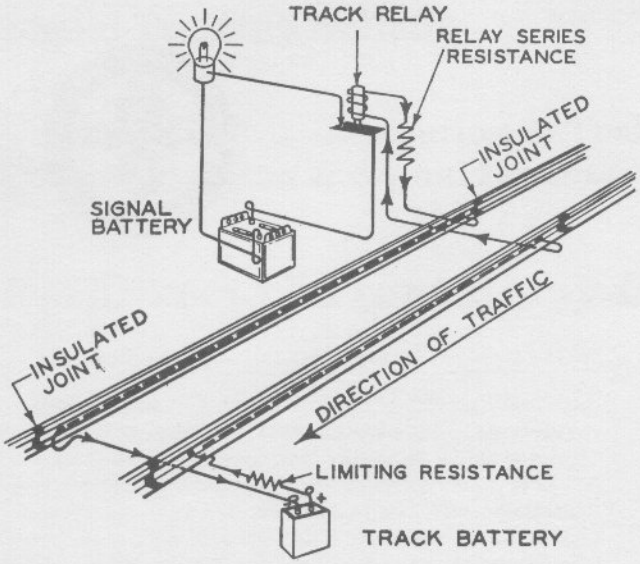

Figure 3(a) Unoccupied track circuit

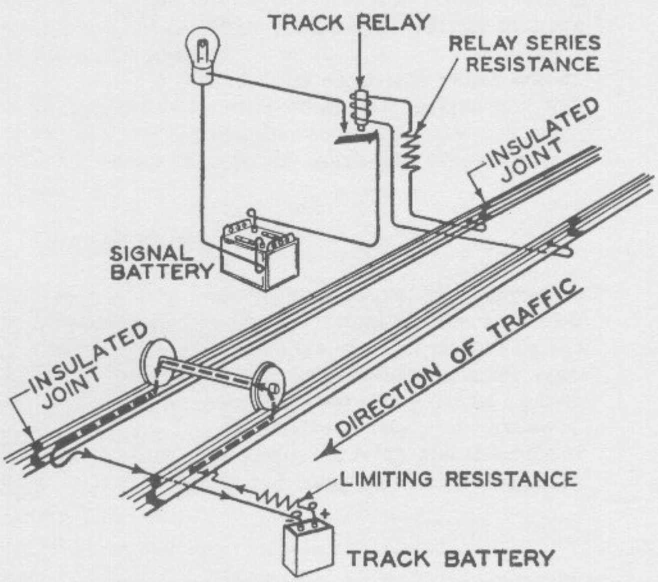

Figure 3(b) Occupied track circuit

Note that the coil resistance of the slow release relay is half that of the neutral line relay. The voltage applied to both relays would be the same but twice as much current will flow through the lower resistant coils of the slow release relay to produce the stronger field of flux.

From the pictorial illustration of track circuit operation in Figures 3(a) and 3(b) it may be seen that when the track circuit is unoccupied (normal), there is a current path from battery through the limiting resistor, through one rail of the track, the relay series resistor, the coil of the relay and back to battery through the other rail.

When a train occupies the circuit the low resistance of the train wheels and axle provide an alternate path for the current. Some current will still flow in the relay coil because the wheels and coil are in parallel. Because the wheels provide such a low resistance path compared to the relay series resistor and coil resistance most of the current will take this path. The current through the relay coil will be reduced well below the drop-away value of the relay and it will drop.

In a typical line circuit as illustrated in Figure 4 it may be seen that several contacts are in series with the line relay coil. This relay will be energized whenever all the contacts are in the position shown. Should any one of these contacts open, the relay coil will be de-energized.

For the purpose of understanding the Detailed Operation portion of this bulletin it is important to recognize that the track relay has a small amount of current flow through its coils even when the track is shunted (occupied). The line relay has either maximum current flow or no current flow depending on whether the circuit is open or closed.

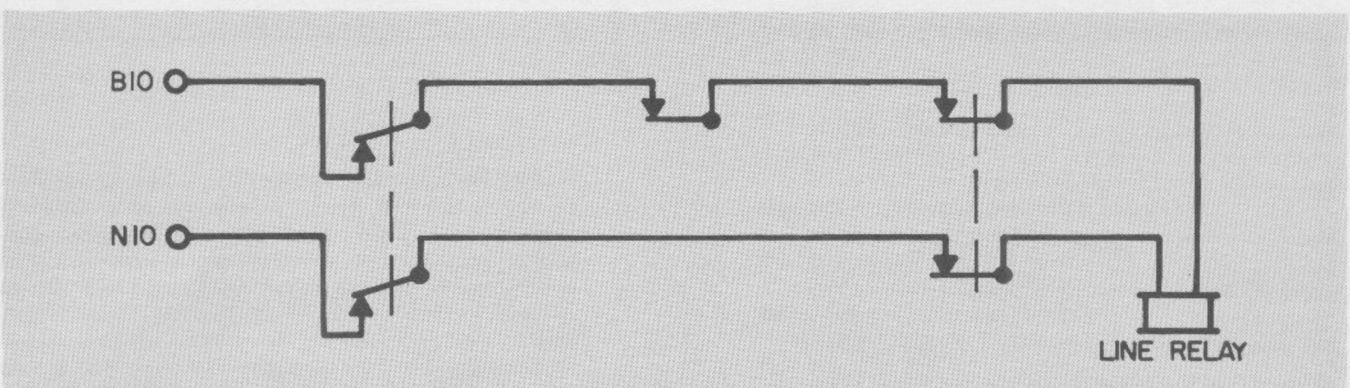

Figure 4