Relays are important components in any automated test system, for they switch power and excitation signals to a UUT; they also connect a UUT’s output signals to a test system’s measuring instruments. Most relays used in automated test stations are mechanical devices, so don’t assume that relays are perfect. They add resistance to a circuit, they take time to switch on and off, and they degrade with time and use.

When selecting a relay for a test system, don’t simply rely on the manufacturer’s specs. Expect to run some tests on a few samples of different types of relays and on relays from different manufacturers before you decide which ones to use. You’ll need to perform both parametric tests and life tests on the relays to ensure they will function properly.

Begin your evaluation by defining the characteristics of the switching waveforms that will drive each relay and define the signals that you want the relay to carry. You should simulate these signals when testing the relays.

Check Maximum Ratings

If the relay is part of a test circuit that may be subject to short-circuit current (such current occurs during a breakdown test or an isolation test), make sure that the current won’t exceed the relay’s maximum rating. Check the power needs of the devices you’ll be testing. Be sure the relay can pass the maximum current that the devices connected to the relay will draw.

Once you define the operating conditions, you can estimate your relay’s typical and maximum switching voltage and current. Be sure to add a safety margin, and then you’ll know what ratings to look for. The safety margin should be between 25% and 50% above the relay’s typical voltage and current ratings, but you may choose a higher or lower margin.

A relay’s performance over its lifetime is important because relays are often part of the measurement circuit and are activated at least once for each UUT. A relay’s characteristics will degrade with use, and they may eventually introduce too much measurement error to be useful. To calculate a relay’s useful life expectancy, you need to know your test system’s expected throughput. That will help you estimate how long a relay will be acceptable in your application.

The typical useful life expectancy of a relay can range from millions of operations for a dry reed relay or an electromechanical relay to several billions of operations for mercury-wetted reed relays to near infinity for solid state relays (SSRs).

Because many circuits can’t tolerate relay on resistances greater than 200 mV to 300 mV, engineers rarely use SSRs in test applications. New mechanical relays typically have on resistances less than
100 mV, but that value rises as the component ages.

Make a Choice

With your needs defined, you’re ready to select a relay. Most relay manufacturers have a complete line of relays with various switching capabilities and life expectancies. The manufacturers, however, usually define these parameters under specific conditions that are often different from those in your test system. Therefore, you should perform parametric tests and life tests under conditions similar to those the relay will see in your test station.

Parametric tests should check the performance of a relay’s major parameters. One set of parametric tests involves measuring a relay’s contact resistance. Other tests check the relay’s operate (pick-up) voltage, release (drop-out) voltage, and actuate time (also called operate time including bounce or time to stable closure).

Contact-resistance tests can take on several forms. First is the static contact-resistance test. For this test, you’ll have to apply an excitation voltage to the relay’s coil and make a resistance measurement after waiting at least 50 ms for the contacts to stabilize. An extension of the static contact-resistance test is the contact-resistance-stability test. In this test, you perform static contact-resistance tests several times and then check the difference between the minimum and maximum values against a limit. That limit will depend on the range of contact resistance that your test application can tolerate.

A second test is the dynamic contact-resistance (DCR) test. This test is similar to the static contact-resistance test except that you measure the contact resistance approximately 1.5 ms after applying an excitation voltage to the relay’s coil. The DCR test tells you how quickly a relay’s contact resistance falls below a set threshold.

Figure 1. This test circuit lets you measure a relay’s contact resistance, actuate time, operate voltage, and release voltage.
Figure 2. A dynamic contact-resistance measurement reveals that this relay’s contact resistance is below the test limit.

Figure 3. The peak-to-peak contact resistance, while below the test limit, may be unacceptable for automated testing applications.

Figure 4. A Weibull plot helps you predict a relay’s life expectancy.

An extension of the DCR test is the DCR peak-to-peak test. The DCR peak-to-peak measures the variation of the contact resistance within a window in time after the excitation. The DCR and the DCR peak-to-peak tests are excellent indicators of a relay’s expected longevity. To perform these
tests, you need an oscilloscope, a constant-current power supply, a function generator, and a test fixture for the relay. Use a low-insertion force (LIF) or zero-insertion force (ZIF) socket to hold the relay and provide test points. Figure 1 shows a diagram of the test setup. I suggest setting the power supply to provide 50 mA to the relay, but any level is acceptable provided the current is constant.

The forward-biased diode across the relay contact guarantees that the power supply is always supplying current. Without that diode, you’d have to wait for the power supply’s output to ramp up before making any measurements. When the relay closes, current flows through the relay instead of through the diode.

Before inserting the relay into the socket, insert a 200-mV resistor into the socket’s pins that will connect to the relay’s contact pins. Using the scope, measure the voltage across that resistor. This measurement becomes a reference for measuring contact resistance. If you’re measuring the resistance with a digital storage oscilloscope (DSO), you can set the DSO to display the vertical scale in ohms rather than volts. If your DSO is connected to a PC, you can use the computer to convert the scale, too.

**Measure Resistance**

Remove the resistor from the socket, and insert the relay under test into the socket. Set the function generator to produce a square wave with amplitude from 0 V to the relay’s nominal coil voltage. Set the frequency of the square wave to be slow enough to let you perform the DCR measurement and set the scope to trigger on the rising edge of the excitation voltage. You should see a waveform similar to that in Figure 2. The waveform indicates a relay whose resistance drops below the test limit in plenty of time.

**Figure 3**

depicts the waveform of an atypical relay. This relay meets the test limits, but it is questionable for automated testing because of the excessive peak-to-peak contact resistance. This increase in peak-to-peak variation is indicative of relays that exhibit reduced life. Compare the peak-to-peak resistance to the relay in Figure 2.

You can also measure a relay’s actuate time when you perform the DCR tests. The actuate time is the time from when the excitation voltage is applied to the coil to when the relay’s contact resistance drops below a threshold and stays below that level. When developing an automated test system, you may need to know that time so you can program your system to wait until a relay settles before making a measurement.

You should also measure the relay’s operate and release voltages. The operate voltage is the voltage where the relay switches from open to closed; the release voltage is the voltage where the relay switches from closed to open. Typically, these voltages will be different. To make these measurements, you must slowly increase and decrease the excitation voltage between 0 V and the coil’s nominal operating voltage. A good way to perform this test is to substitute an adjustable DC power supply for the function generator. Manually ramp up the supply’s output for measuring operate voltage, and manually ramp down for release voltage.

Besides performing the parametric tests, you should perform life tests on a relay. And, you should test the relay under load conditions similar to those the relay will encounter in your test system.
During the life test, monitor the relay’s contact resistance each time it closes. When the contact resistance rises above a limit that you’ve chosen, you can consider the relay to have failed. A Weibull plot of the life-test results will provide a typical life expectancy of a relay (see Fig. 4). Compare this anticipated performance to your test system’s requirements. From the anticipated life expectancy, you can estimate how many tests your test system will perform before you have to replace the relays. T&MW

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