

# OPTIMIZING CABLE TESTER SWITCHING ARCHITECTURE

## USING THE COTO TECHNOLOGY 9104-0022 HIGH VOLTAGE REED RELAY

Cable tester manufacturers face competing design challenges when designing cable testers that may have thousands of channels and must provide continuity testing between every possible pair of conductors, make highly accurate resistance measurements, and run high voltage AC breakdown tests. Wire harness and backplane testing presents similar problems.

Resistance measurements may be done in two-wire mode, or for ultimate accuracy, by 4-wire Kelvin mode testing. Two-wire mode is sufficiently accurate to determine a map of the cable connections and test if all the conductors are mapped correctly from one end of the cable harness to the other.

Relays operated under program control are needed to switch the test voltages from conductor to conductor, and need to have both low and stable resistance for the resistance measurements, and high breakdown voltage for the

breakdown testing. In addition, a low relay capacitance is needed to minimize AC leakage current when HV AC testing is required. Excessive leakage will cause offsets and inaccuracies in the measurements.

**The use of series/parallel relay architectures can reduce total AC leakage currents in a 3000 channel tester to under 5  $\mu$ A at 1000V AC.**



Coto Technology's 9104 series reed relays are therefore ideal for use in cable testers. The 9104-0022, for example, offers 3000 V peak AC dielectric strength, 1000 V hot switching capability at up to a 10 W load, 0.150  $\Omega$  closed contact resistance, 1 pF open contact capacitance and 10<sup>11</sup>  $\Omega$  isolation resistance.

A simple architecture for a cable tester relay matrix is shown in Figure 1. In this architecture, master relays  $K_{M1}$  and  $K_{M2}$  switch

either a 1 kV line frequency signal or a forcing current to a bank of 9104-0022 relays  $K_1, K_2, \dots, K_{6000}$ , that sequentially switch in each cable conductor to measure its DC ohmic resistance or its AC leakage current under the 1 kV 50 Hz load. For maximum life, all the 9104-0022 relays should be cold switched while both  $K_{M1}$  and  $K_{M2}$  are off. Since the operate and release times of the 9104-0022 relay are 0.75 and 0.50 ms respectively, turn-on and turn-off delays of 10 ms should be programmed

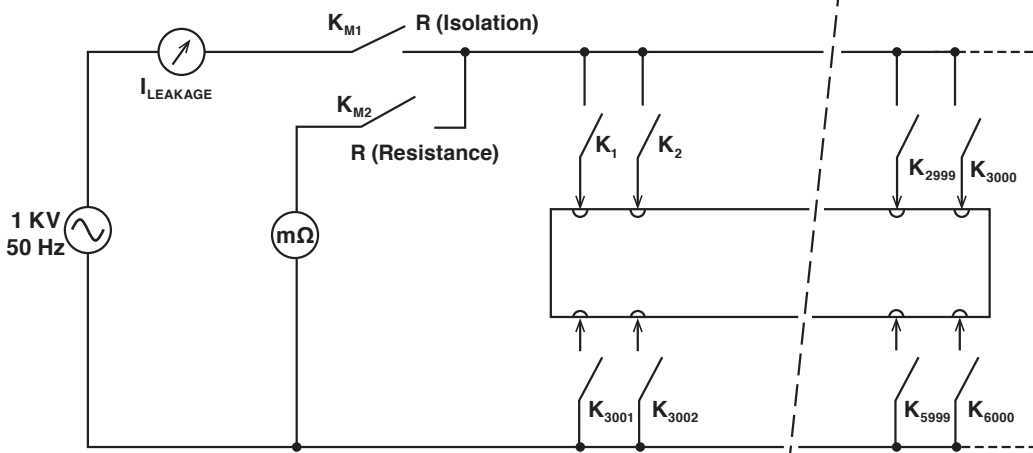


Fig. 1 Basic cable tester architecture

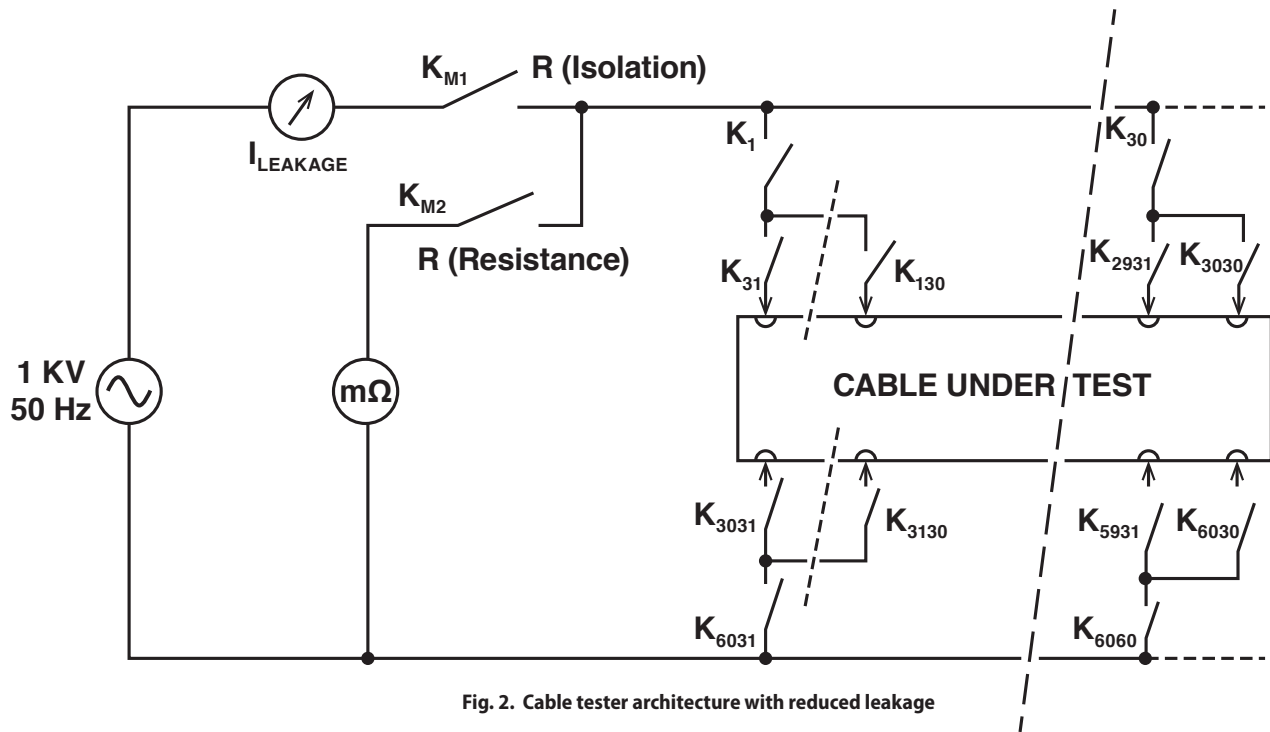


Fig. 2. Cable tester architecture with reduced leakage

before the HV AC source is ramped. During low voltage resistance testing, the resistance of the test circuitry including the two 9104-0022 relays (which add only 0.3 Ω) is subtracted off, or canceled out automatically in a 4-wire system.

For HV 50 Hz AC testing the leakage current through the relay banks can be calculated, since each relay can be modeled as a  $10^{11}$  Ω resistor in parallel with 1 pF capacitance, giving each relay an impedance of 3.08 GΩ at 50 Hz. (2.58 GΩ at 60 Hz) The 6000 open series/parallel relays therefore leak about 0.48 mA at 1000 V, and show a spurious resistance of 2.1 MΩ.

**By using Coto's 9104-0022, it is possible to achieve 100% less leakage by adding 1% more relays to the circuit.**

This leakage current can be reduced greatly by adopting the architecture shown in Figure 2. A single block selector relay is used to control a sub-block of 100 relays, and there are 30 such selectors and sub-blocks. The fan-out of  $K_1$  to  $K_{31}$ ,  $K_{32} \dots K_{130}$  coupled with the use of 30 sub-blocks is shown by a few network calculations to reduce the total system leakage current to 4.8 μA, a reduction factor of 100 at a cost of only 1% more relays!

For systems that provide only low-voltage testing, Coto's optically isolated CS128 solid state relay with its extremely low 0.033 Ω on-resistance and 40 V switching capability is ideal for switching matrices. The CS128 has on-board ESD protection and is rated for 2000 V HBM. Contact us for further technical information on

protecting the relay from the heavy capacitive inrush currents that can arise during cable testing.

#### Expected system reliability.

The mean cold-switching cycle life of the 9104-0022 relay is 300 million cycles with a Weibull beta of not less than 1.5. Therefore a cable test system containing 6000 relays will provide approximately 900 thousand tests before at least one relay out of the 6000 fails. This figure excludes the master relays  $K_{M1}$  and  $K_{M1'}$ , which should be heavy duty electromechanical relays and should be replaced according to their manufacturer's recommendation.

#### Conclusions

The 9104-0022 high voltage reed relay, with its unique combination of 0.15Ω on-resistance,  $10^{11}$  Ω off-resistance, 1 pF contact-to-contact capacitance and 3000 V breakdown voltage, is ideal for use in cable tester, wire harness and backplane test switching matrices where both low resistance conductor testing and HV breakdown testing are required. The use of series/parallel relay architectures can reduce total AC leakage currents in a 3000 channel tester to under 5 μA at 1000V AC. For low voltage cable testers, the CotoMOS™ CS128 optically-isolated SSR with 0.033  $R_{ON}$  is an ideal choice.



9104



CS128 Datasheet