SWITCH APPLICATION NOTE

3mm Rotary Switch for RF Applications

One of the problems RF circuit designers encounter is the selection of a switch that will perform its desired function without distorting the signal. A potential solution to this dilemma comes in the form of a 3mm Rotary device.

This new product is a surface mount Single Pole Double Throw switch that has unique construction characteristics that allow it to perform at RF frequencies to 1 GHz. The performance charts that are presented here were generated by an actual user of the device during the qualification testing of the switch.

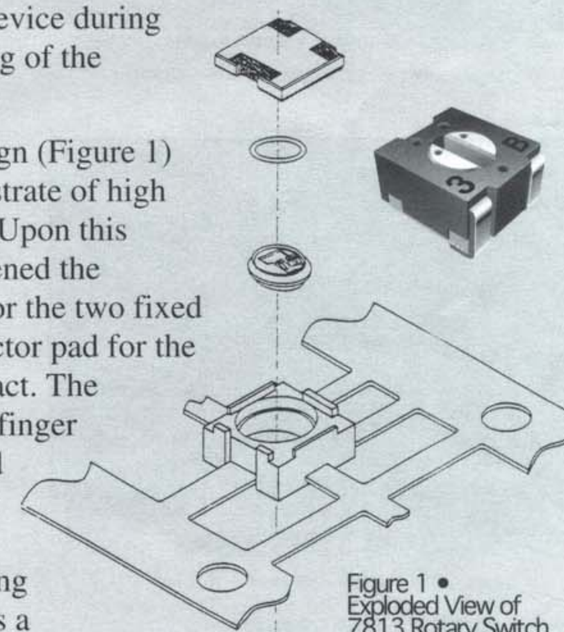

Figure 1 • Exploded View of 7813 Rotary Switch

The product design (Figure 1) utilizes a ceramic substrate of high purity alumina oxide. Upon this substrate are silk screened the termination patterns for the two fixed contacts and the collector pad for the wiper or moving contact. The wiper itself is a multi-finger design that is mounted into the rotor which is designed of high temperature engineering plastic. The switch has a permanent o-ring seal of silicone rubber. The entire device is protected by a housing manufactured from the same plastic as the rotor. This material gives the switch good thermal stability during board mounting processes.

This non-traditional approach to switch design has allowed this unique component to exhibit exceptional performance at frequencies between 300 kHz to 1 GHz. Because of its small size and the minimum amount of metallization, there are levels of performance demonstrated that are not possible in many other popular switch designs on the market today.

The data to be presented was generated on an HP 8753 Network Analyzer. (HP is a trademark of Hewlett-Packard Corporation.) Briefly, the frequency range of the analyzer is from 300 kHz to 6 GHz. Various test fixtures were used to mount the switches and implement the proper load characteristics for the test sequences. All measurements were taken at room ambient conditions of 25°C, 50% R.H. unless otherwise noted. All loads are 50 ohms to ground unless otherwise noted. It is important to note that this data was taken on a small sample but that the results for each device tested were essentially the same.

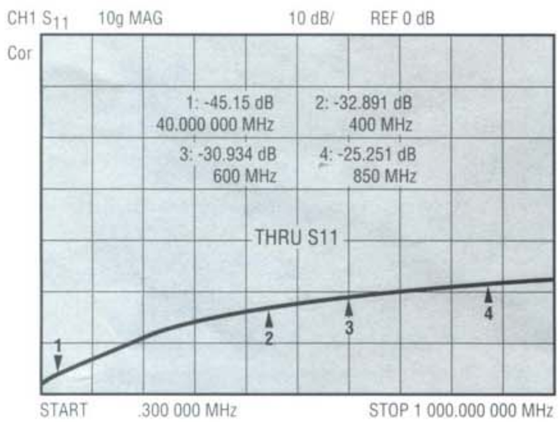

FIGURE 2 • RETURN LOSS

The first test to be performed was an evaluation of the Return Loss of the device. The unit was mounted into a test fixture with the signal being impressed onto the moving contact. The output is loaded to ground and the measurement is taken at the loaded fixed terminal. S11 on Fig. 2 represents one terminal; S22 on Fig. 3 represents the other. The vertical calibration is 10dB/cm. The far left side of the charts horizontal scale is 300 kHz; the right is 1 GHz. The baseline is at the midpoint vertically on the chart representing zero (0) dB. The frequency marks on the chart are identified in the text on the chart. The minimum return loss acceptable to the customer was 20 dB down in their operating range of between 400 and 600 MHz. You can see by the trace that even at 1 GHz, the switch exceeded minimum performance at approximately 28 dB down.

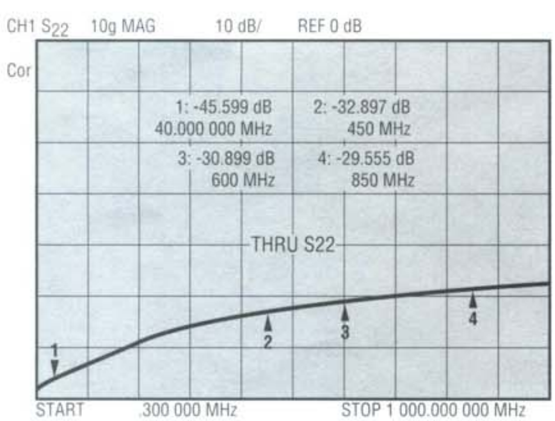

FIGURE 3 • RETURN LOSS

The next test was a comparison of Return Loss at room ambient to +70°C (Fig. 4 and Fig. 5). The heat source was a commercial style hair dryer so the heat could be applied without disturbing the test fixture. The calibrations were the same as they were for the first test setup.

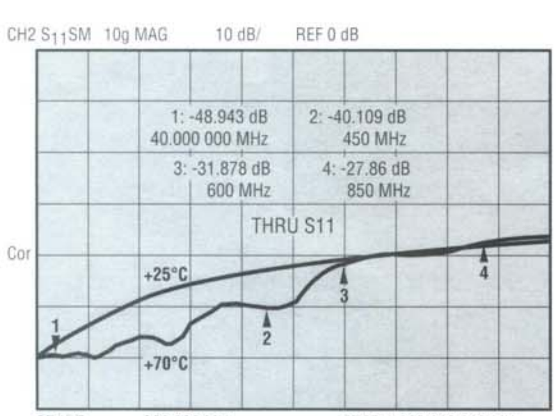

FIGURE 4 • RETURN LOSS: ROOM AMBIENT VS. +70°C

You can see by the traces on Fig. 4 and 5 that the performance of the switch actually improved with the presence of heat at the customer's operating frequencies, while at the same time the performance at 1 GHz is essentially unchanged. This may be accounted for by the thermal coefficient of expansion of the conductor particles in the thick film ink used in the contacts. This, however, is strictly opinion at this time and has not been confirmed and is not a concern of this investigation.

The next characteristic to be tested is the loss through the switch. This test determines how much of the signal loss occurs as a result of the switch being in the circuit. The only change in calibration here is the vertical now represents 0.5dB/cm. The horizontal remains the same as the previous two tests.

We also compared the losses at room ambient to those at +70°C. The results as read from Fig. 6 indicate that at room ambient the loss was approximately 0.1 dB and at +70°C, it was approximately 0.15 dB.

Our fourth test (Fig. 7) determines the amount of electrical delay that occurs as a result of the switch being in the circuit. The chart calibrations horizontally for frequency remain unchanged.

The vertical calibration now represents 2 degrees/cm. Again, the zero (0) is at the midpoint vertically of the chart. You can see that at room ambient the angular change is essentially zero at all frequencies. At +70°C the angle is approximately 1.5 degrees at the peak frequency of 1GHz.

The final evaluation to be discussed is that of isolation. In this test we are trying to determine how much interaction occurs between the load fixed contact and the open fixed contact (no connection). In this test we again place a 50 ohm load between one of the fixed contacts and ground. We impress the input signal onto the moving contact terminal. But in this test we measure the output at the open or unloaded fixed contact.

The signal level that is measured is a result of the proximity of the two terminals and their interaction electronically. The chart display shows that at 1 GHz the isolation is a respectable 22 dB down. At the operating range of 400 to 600 MHz the isolation is 25 dB down or better.

With the release of this new switch technology to the marketplace, the RF designer now has an effective high performing option when the manipulation of circuit functions are required. By taking advantage of proven thick film techniques and placing them in a small package, this unique switch can outperform many of the existing switch designs in its ability to transport RF signals reliably and without distortion.

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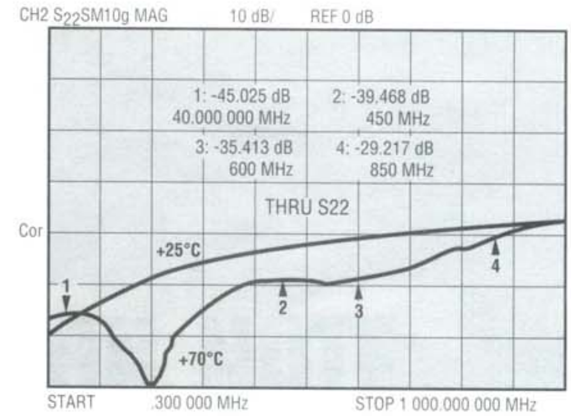

FIGURE 5 • RETURN LOSS: ROOM AMBIENT VS. +70°C

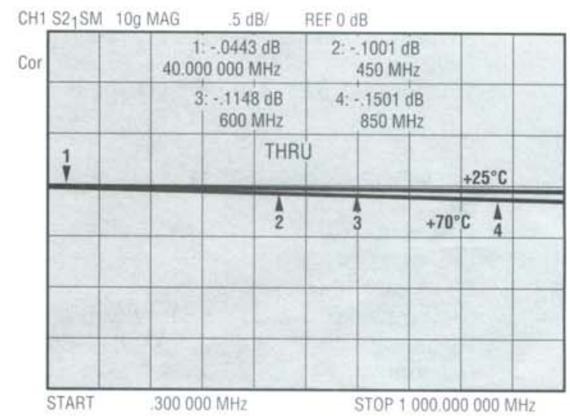

FIGURE 6 • THROUGH DELAY, ELECTRICAL

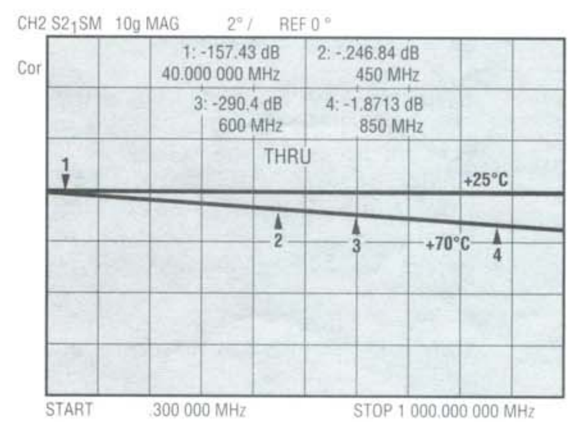

FIGURE 7 • THROUGH DELAY, ELECTRICAL

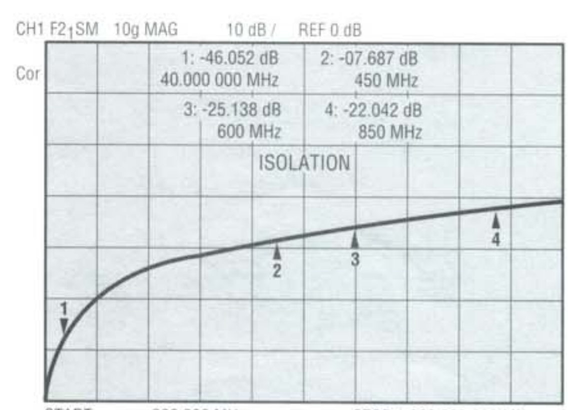

FIGURE 8 • ISOLATION: WITH 50 OHM LOAD

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