Coaxial Switch Evaluation

H. G. Nishimura
R.F. Systems Development Section

Miniature coaxial transfer switches from various manufacturers were tested for the purpose of finding an acceptable replacement for the larger switch now used in the Deep Space Instrumentation Facility (DSIF). The switches, which are planned for use in the S- through X-bands, were tested to determine both their mechanical and electrical properties. Two units were considered acceptable. These switches will reduce the size and cost of future microwave equipment and will also provide the requirements for meeting increasing performance demands.

I. Introduction

The Antenna Microwave Subsystem of the Deep Space Instrumentation Facility (DSIF) has for years been using coaxial transfer switches for configuration control of the receiver and exciter signals. Transfer switches are essentially double-pole, double-throw RF switches. The switches are employed within equipment mounted on the antenna structure and in the control room; most are controlled by push-button switches from equipment in the control room.

The DSIF equipment has been mounting in complexity and, with the advent of X-band equipment as well, there is an urgent need for smaller components. In order to prepare for future hardware requirements, a simulated life test was conducted on a number of newer types of miniature coaxial switches.

Miniature coaxial transfer switches from several different manufacturers were extensively tested for the purpose of selecting one or two units for use in the Deep Space Instrumentation Facility. The switches were submitted to both mechanical and electrical tests. The radio frequency (RF) tests were conducted in the lower S-band only, although most of the switches are rated for use in the X-band as well.

II. Test Description

Prior to testing, the switches were mounted on a test chassis as shown in Fig. 1. Table 1 shows in detail the manufacturer's rating of each switch and serves to point out the differences among the various units. The switches are latching types with indicator contacts and are actuated by 115 Vac. They all employ SMA RF connectors. Tests were conducted as described below.

A. Connector Pin and Dielectric Depth Measurements

The female SMA connectors of the switches consist of an outer shell and center pin with Teflon dielectric between the two segments. The pin and dielectric are pressure-fitted within the outer shell. Because of internal forces during switching, both pin and dielectric can be displaced during the life of a switch. Initially, the pin and dielectric depths below a fixed point were measured to establish a reference for a later measurement to be made at the conclusion of the simulated life test.

B. RF Tests

The switches were tested for voltage standing wave ratio (VSWR), insertion loss, and isolation at 5-MHz intervals between 2000 and 2300 MHz. These readings were made at ambient temperatures of 0, 25, and 50°C. This temperature range is adequate, because of the controlled environment of the DSIF equipment. The switches were sent to a commercial testing firm equipped with automatic microwave testing equipment, resulting in a significant cost reduction.

C. Simulated Life Test

The units were continuously switched from position 1 to position 2 for more than 200,000 complete cycles. A cycling period of 10 s was employed. RF power was not applied during the test.

D. Connector Pin and Dielectric Depth Measurements

The measurements of Subsection A above were repeated after the simulated life test. The two sets of readings provide reasonable data on pin and dielectric displacements as a result of continuous switching.

E. RF Tests

The RF measurements discussed in Subsection B above were repeated, with the exception that the measurements at ambient temperatures of 0 and 50°C were omitted. Because there were only negligible changes at varying ambient temperatures in the previous measurements, little was left to be gained by repeating this portion of the test. Instead, an RF repeatability test was substituted, consisting of three readings at each data point, each reading taken after switching through one complete cycle. The purpose of this test was to ascertain the repeatability of the switch properties for any given position of the switch.

III. Test Results

Table 2 summarizes some of the data from the tests. The figures shown are average values.

As a result of the simulated life test, three of the switch types were considered failures. At 20,000 cycles, the first failure occurred when the switch froze in one of its positions. Another switch developed an intermittent latching problem at 23,000 cycles. A third switch, which had displayed an annoying 60-cycle hum from the outset, had an indicator circuit failure at 80,000 cycles.

The two switches which displayed no mechanical malfunction during the simulated life test revealed data inconsistency during the RF repeatability test. When one of the manufacturers was contacted, it was indicated that a similar problem occurred at the manufacturer's facility after the JPL evaluation switch had been purchased. The gold plating on the RF contacts had worn due to cycling, exposing the beryllium copper contacts, and creating a higher than normal dc contact resistance. The manufacturer assured JPL that corrective action had been taken, and subsequent cycling of his switch had indicated that the steps taken were satisfactory.

The contact resistances of the JPL switches were measured with a Wheatstone Bridge, and there was correlation between the resistance measurements and the contacts that had shown intermittent performance.

The switches were taken apart, including the RF head, for a visual inspection of workmanship and design.

IV. Conclusion

The tests were helpful in two ways: (1) they were invaluable in ascertaining whether the manufacturer's specifications met his claims; (2) they have resulted in the selection of two switches of outstanding characteristics, either of which may be utilized on future design within the DSIF. The selected switches are manufactured by Teledyne Microwave and Transco Products.

Future plans include tests at X-band and additional simulated life tests.

Table 3 shows a comparison of specifications between the presently used switch and one of the miniature switches selected as a result of the tests.

Table 1. Manufacturer's ratings

Characteristic	Switch type				
	RLC Electronics SR-T-R-A-I-L	Wavecom Industries 2921-0500	Microwave Associates MA7531-TMNA	Transco Products 700C70400	Teledyne Microwave CS-37S7C-1
Frequency, GHz	DC-12.4	DC-3	DC-18	0.1 – 12.4	DC-18
VSWR at Frequency, GHz	1.30:1 at DC-7 1.80:1 at 7-12.4	1.20 at DC-3	1.25:1 at DC-4 1.35:1 at 4-8 1.50:1 at 8-12.4 1.70:1 at 12.4-18	1.25 at DC-4 1.35 at 4-8 1.50 at 8-12.4	1.25:1 at DC-6 1.40:1 at 6-12 1.50:1 at 12-18
Isolation, dB Min. at Frequency, GHz	60 at DC-12.4	75 at DC-3	60 at DC-18		70 at DC-6 60 at 6-12 60 at 12-18
Insertion Loss, dB (max.)	0.3 at DC-7 0.6 at 7-12.4	0.25 at DC-3	0.3 at DC-7 0.5 at 7-11 0.7 at 11-12.4 0.9 at 12.4-18	0.25 at DC-4 0.35 at 4-8 0.50 at 8-12.4	0.2 at DC-6 0.3 at 6-12 0.5 at 12-18
RF power handling capability, W	50	Not available	30	20	20
Switching time, ms (max.)	15	25	20	20	10
Operating ambient temperature, °C	Not available	−40 to +85	−55 to +55	−40 to +85	−54 to +100
Dimensions, overall, cm	5.1 × 5.7 × 10.0	4.8 × 6.0 × 7.0	3.5 × 3.8 × 6.2	3.3 × 5.5 × 7.3	3.7 × 5.7 × 4.6
Weight, g	511	312	169	156	85
Connection	Solder lugs	Connector	Solder lugs	Solder lugs	Solder lugs
Life, cycles	1,000,000	200,000	200,000	100,000	1,000,000

Table 2. Performance data summary, before and after life test

Characteristic	Switch type									
	RLC		Wavecom		MA		Transco		Teledyne	
	Before	After	Before	After	Before	After	Before	After	Before	After
Pin depth, 10^{-3} in.	+13.0	+12.0	+10.0	+9.0	−2.0	+2.0	−2.0	+1.0	+14.0	+14.0
Dielectic depth, 10^{-3} in.	−2.0	+3.0	−2.0	+2.0	+3.0	+5.0	−1.0	0	+11.0	+11.0
VSWR	1.06	—[b]	1.11	—[b]	1.12	1.17	1.07	1.07	1.09	1.10
Isolation, dB[a]	>75	—[b]	>75	—[b]	73	75	>75	>75	>75	>75
Insertion loss, dB	0.09	—[b]	0.16	—[b]	0.15	0.10	0.21	0.19	0.16	0.12

[a]75 dB is limit of test equipment.
[b]No rf tests were made on these switches.

Table 3. Comparison of switch specification (f = 2.3 GHz)

Characteristic	Former switch	New minature switch
Weight, g	1225	113
Volume, cm^3	1066	164
Cost	$364	$234
Delivery, days	90	45
VSWR	1.3:1	1.25:1
Insertion Loss, dB	0.35	0.20
Isolation, dB	60	70
Life, cycles	60,000	200,000

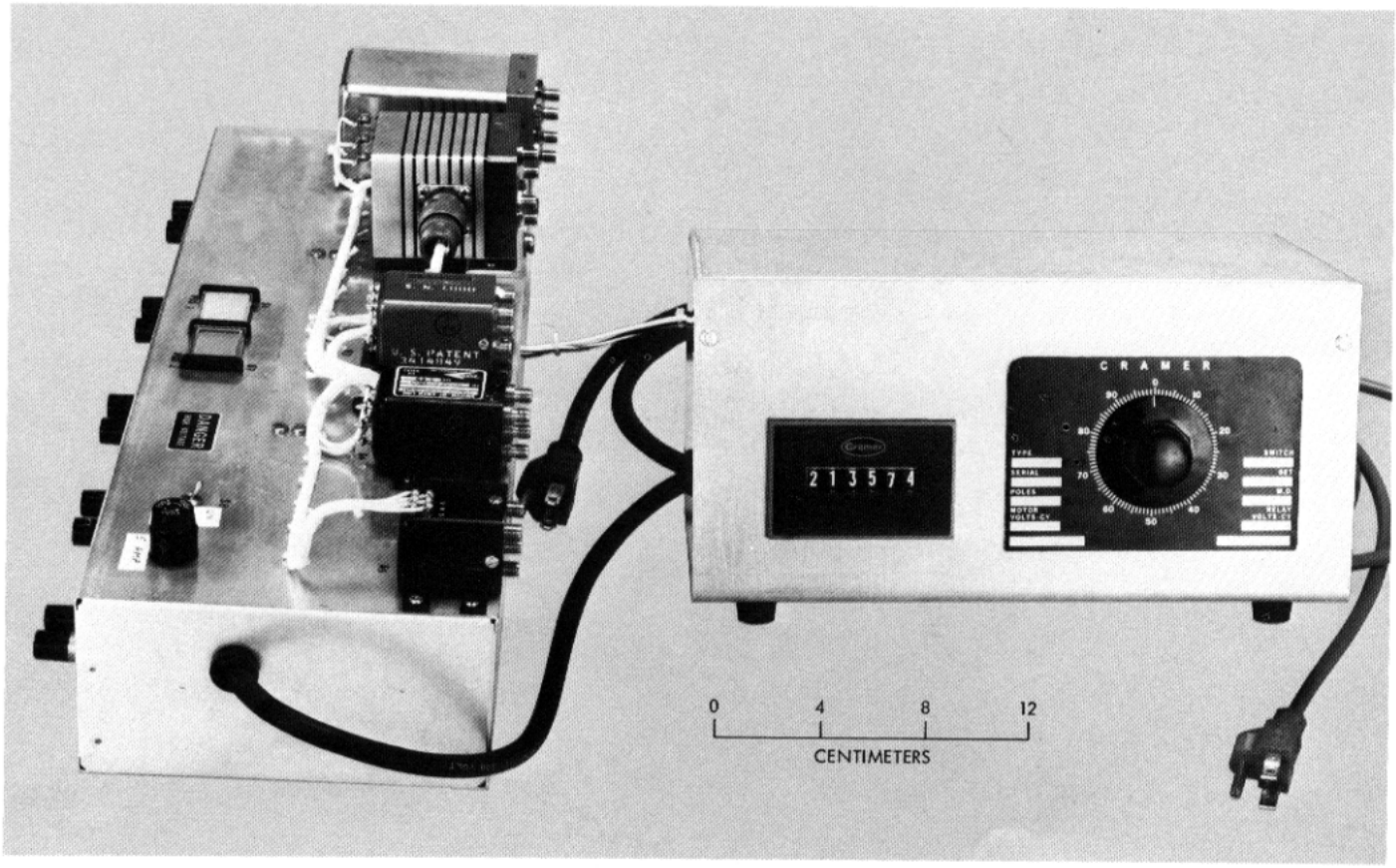

Fig. 1. Switches evaluated, shown with cycling switch and counter