4 GHz 8×8 SWITCH MATRIX FOR SDMA SYSTEM

Masahisa Yamaguchi, Yasuhiko Ito and Masao Kyogoku

Research and Development Laboratories, Kokusai Denshin Denwa Co., Ltd., Tokyo, Japan

Tatsuo Kudo and Munekazu Akao

Fujitsu Ltd., Kawasaki, Japan

Abstract

An engineering model of an on-board rearrangeable 8×8 switch matrix has been developed using 168 PIN diodes and MIC technique. The matrix shows 14±1 dB insertion loss and 40 dB isolation over the frequency range of 3.7 to 4.2 GHz.

Introduction

Recently, the Space-Division Multiple-Access (SDMA) on-board switching system[1] applied with the Time-Division Multiple-Access (TDMA) system has been noticed to be a promising technique for the future in the field of high-capacity satellite communication system. Feasibility of this technique depends mainly upon the performance of the Microwave Switching Matrix (MSM) on-board the satellite which interconnects each spotbeam coverage in a rapid sequence. However, the MSM for such a purpose has not been reported yet elsewhere.

This paper presents the experimental results of an engineering model of 8×8 MSM with good performance. The matrix is composed of 168 PIN diodes and is fabricated with Microwave Integrated Circuit (MIC) technique. The experimental results show the insertion loss of 14±1 dB and isolation greater than 40 dB over the frequency range of 3.7 to 4.2 GHz.

Matrix configuration

The matrix presented here is called the Rearrangeable Multi-stage (RM) network[2]. This matrix consists of a number of DPDT switches (β -elements), and is superior to other matrices in the following points:

- High reliability resulting from small number of necessary switching elements.
- Good cost-performance.
- Easiness of designing a redundant matrix structure for the failure of switching elements.

[a] β -element

The β -element is a switch having two possible states, "0" and "1", as shown in Fig.1.

The characteristics of a single β -element are the essential factor to determine the overall matrix performance. In order to reduce the deviation of insertion loss in each path, careful considerations should be taken into account to obtain the elements with identical characteristics.

A β -element circuit with bias line and the mechanical configuration are shown in Figs.2 and 3, respectively.
Advantageous points of the configuration are:

(1) In order to prevent direct coupling between the two non-connected lines, the structure shown in Fig.3 is commendable where a short coaxial line called "feed-through" is adopted to connect the two lines on both substrates separated by the conductor.

(2) Biasing circuit of Fig.3 makes it possible to fix the state of the element to either "0" or "1" in the case of diode failure.

(3) Two diodes connected in series are placed with 3/2 wavelength spacing to realize highest isolation.

[b] 8×8 microwave switch matrix

Fig.4 shows the RM type 8×8 matrix which is composed of 21 DPDT switches (β -elements).

It should be noted that the configuration in Fig.4 has a fault protection structure permitting one β -element failure, provided that the failed element should be fixed to either state "0" or "1".

Nine β -elements in the input and output stages are constructed in an independent body. The rests are grouped into two packages of 4×4 matrix. Fig.5 shows the 4×4 MSM package as the middle stage of the 8×8 MSM.

Experimental results

The following summarizes the characteristics of the RM type 8×8 switch matrix measured over the frequency range of 3.7 to 4.2 GHz:

(a) Insertion loss---- The lower curve in Fig.6 shows the typical insertion loss of 320 possible "on"-paths.
Measured values were 14±1 dB. It should be noted that a certain compromise is needed to achieve optimum insertion loss and switching speed.

(b) Isolation---- The transmission loss between any non-connected "off"-port exceeds the "on" insertion loss by 40 dB.
The typical characteristics is shown in Fig.6.

(c) Input VSWR---- Less than 1.2.

(d) Group delay---- The group delay measured for any connected path is within 0.5 nsec.

(e) Switching speed---- Rise time is typically 100 nsec.
(For the worst case, when all elements along the signal path are switched at the same time, rise time is 150 nsec.)
Fall time is typically 40 nsec.
Fig.7 shows the typical switching waveforms.

Conclusion

An engineering model of an on-board 8×8 microwave switch matrix was constructed and tested. The network structure called the Rearrangeable Multi-stage network with redundancy was selected for the purpose of achieving a highly reliable performance.

The measured characteristics of the matrix developed here is considered to be sufficient for the microwave on-board switching system.

It is expected that the development of this matrix will contribute to the technical feasibility for an actual use of the SDMA system.

Acknowledgement

The authors wish to appreciate Dr. H. Kaji and Dr. T. Satoh, R&D Labs, Kokusai Denshin Denwa Co., Ltd. for useful advice and encouragement.

References

(1) Ito, Y., and Kyogoku, M. : " SDMA on-board Switching System using Rearrangeable Multi-stage Network, "
IEE. International Conference on Satellite Communication Systems Technology, April 1975.

(2) Opferman, D.C., and Tsao-Wu, N.T. : " On a Class of Rearrangeable Switching Networks," B.S.T.J., May-June 1971, p.1579.

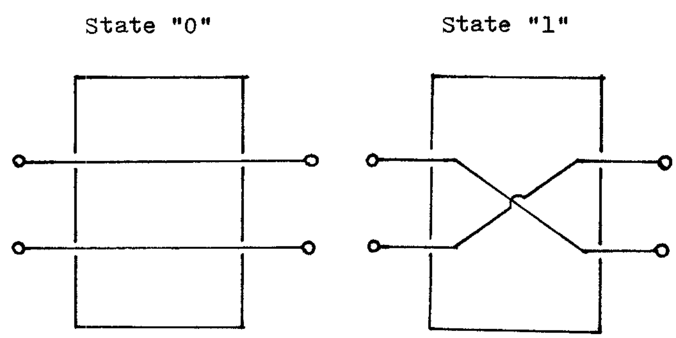


Fig. 1 Function of β -element

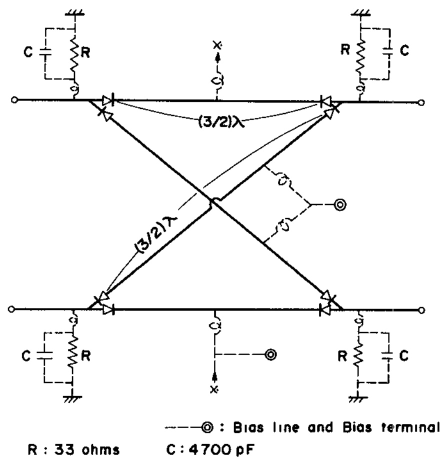


Fig. 2 β-element circuit with bias line

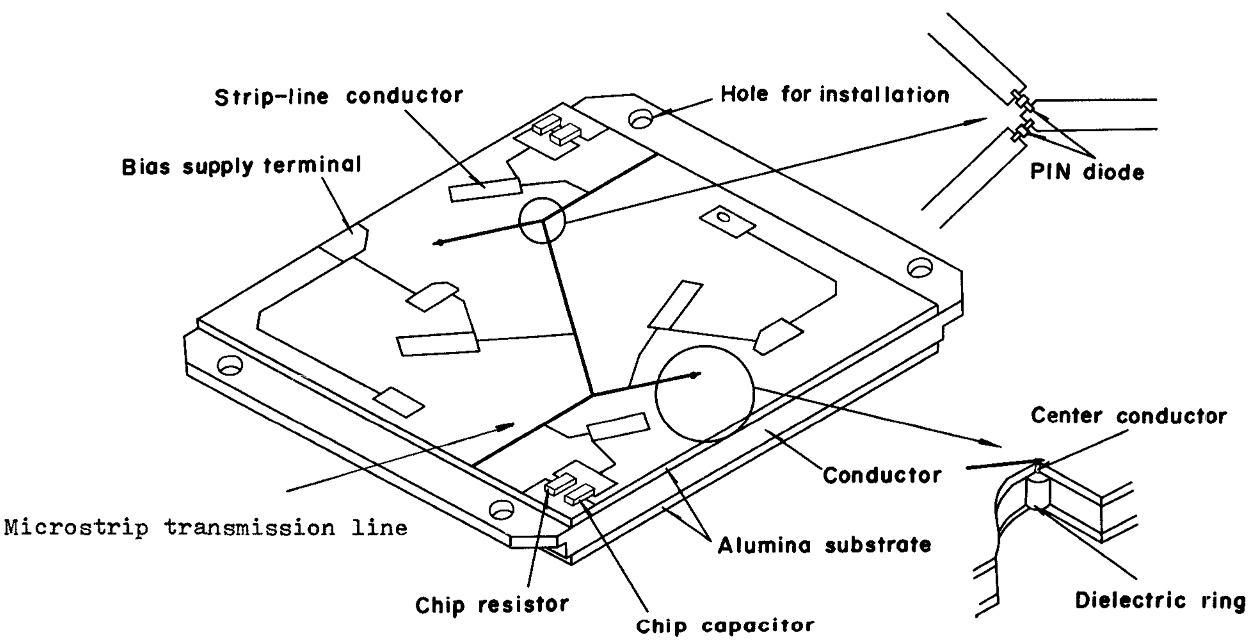


Fig.3 Mechanical configuration

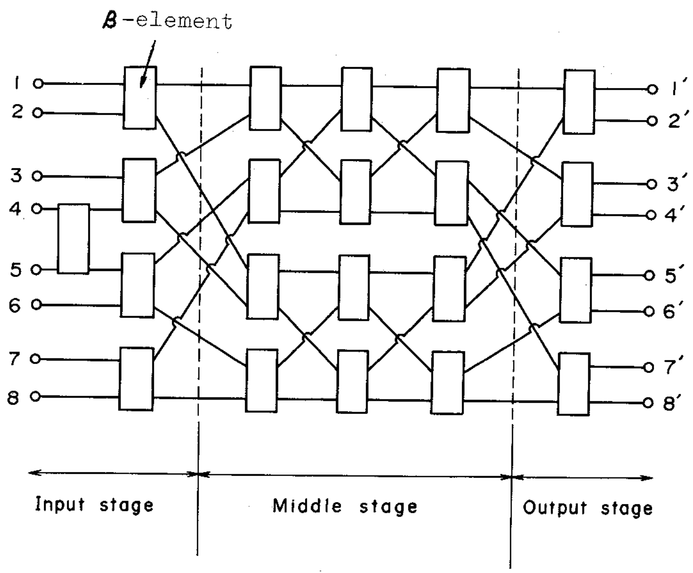
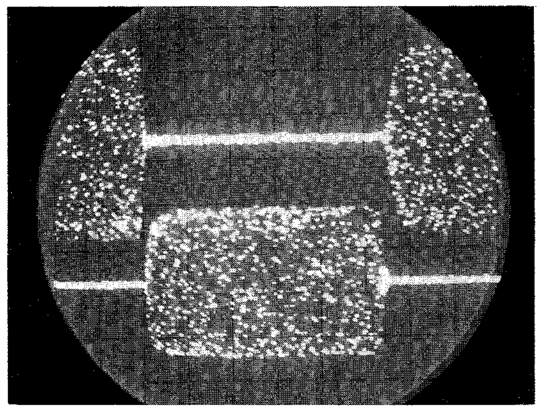


Fig. 4 RM type 8x8 matrix



Horizontal scale: 100nsec/div.

Fig. 7 Switching waveforms

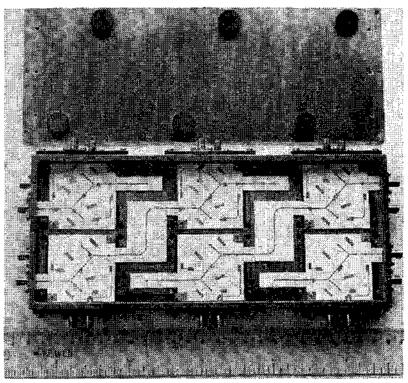


Fig. 5 4x4 MSM package

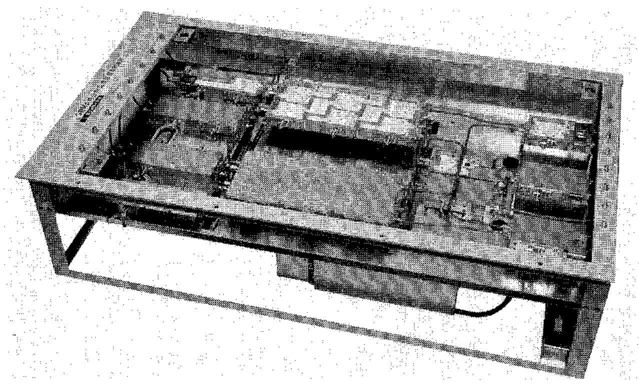


Fig. 8 Outer view of 8x8 Matrix

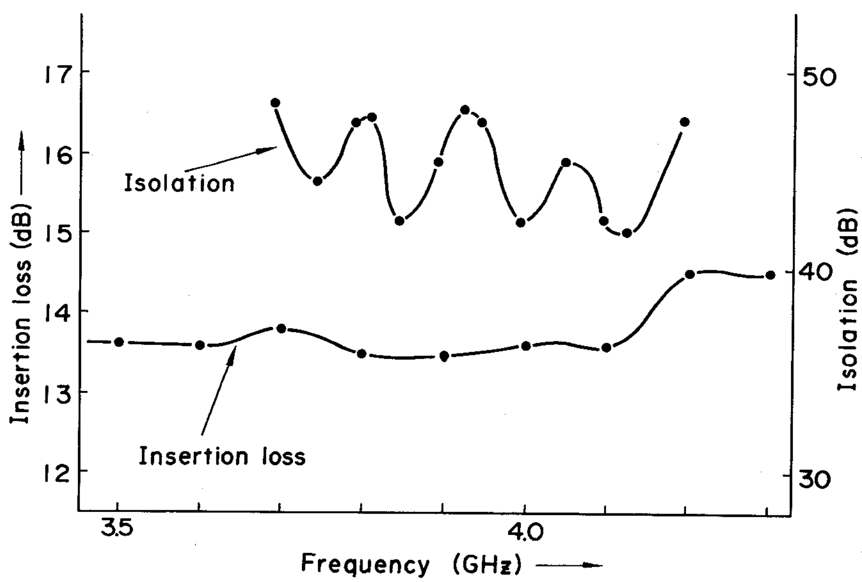


Fig.6 Insertion loss and isolation