BIASED PIN FOR 45KW, X-BAND DUPLEXING

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ABSTRACT

Branched duplexer in a radar system usually uses gas filled TR and ATR tubes. These gas filled devices are getting replaced by more reliable PIN diode limiter and switches. Though in literature PIN diode limiter design is throughly described, PIN diode switch used as ATR tube is not discussed at all. This paper gives design and experimental results of waveguide PIN diode ATR tube. The design takes into consideration of high power handling capacity. The unit handled 45 KW peak power, 1 us pulse width at a frequency of 9.375 GHz as ATR tube in branched duplexer with external bias. Insertion loss of 0.4 db and isolation of 40 db were achieved.

Introduction

Branched duplexer in a radar systems usually uses gas filled TR and ATR tubes[1] to facilitate the use of single antenna both for transmission and reception and to protect the sensitive receiver from transmitter leakage. These tubes are getting replaced by highly reliable semiconductor devices, viz. PIN diode limiter and switches which give better performance than TR and ATR tubes[2]. PIN diode limiter is used either in place of TR tube or as a TR limiter[3]. The design of limiter is extensively described in literature[4,5]. But there is no such design description is available for PIN diode switch used as ATR tube in literature. PIN diode ATR tube design is completely different from PIN diode limiter design. At high power level the ATR tube offers open circuit to the transmission path whereas limiter presents short circuit to the receiver path. Hence when PIN diode ATR tube present high impedance across transmission path, it has to handle high power. At low power level, PIN diode ATR tube present low impedance across transmission path and received power from antenna goes to receiver.

PIN Diode ATR Tube

PIN diode presents a low impedance when forward biased and high impedance when reverse biased. Natural choice for ATR tube will be reverse bias PIN diode. But the power handling capacity of PIN diode at reverse bias depends on its reverse breakdown voltage[6]. 40 KW peak power handling will require 2100 volts breakdown voltage of PIN diode when used in a 50 ohm line. Such a high breakdown voltage PIN diode at microwave frequency is difficult to get. Hence higher power handling of PIN diode at reverse bias is limited by breakdown voltage. The power handling of PIN diode at forward bias is dependent on power dissipation in the series resistance of the diode and its thermal impedance. In this case the diode can handle more power without having the limitation of breakdown voltage. Circuit which presents high impedance to the transmission path using forward biased PIN diode is a better choice for PIN diode ATR tube.

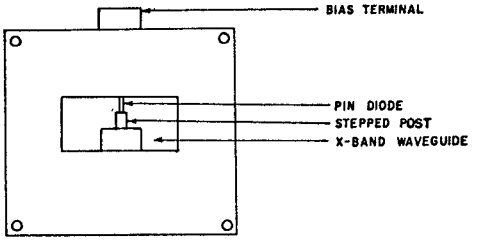

FIG. 1: PIN DIODE A TR TUBE

The configuration of the PIN diode ATR tube is shown in Fig.1. PIN diode is kept in between a stepped post and wall of the waveguide. When the diode is forward biased, the circuit becomes a parallel resonant circuit with diode inductance. With reverse bias, the circuit becomes a series resonant circuit with diode capacitance. The resonant frequency, insertion loss and isolation can be varied by changing diameters and lengths of the stepped post. Two dummy diodes are prepared one short circuit and another open circuit. These dummy diodes facilitated the study. The VSWR as a function of frequency is measured on a swept frequency system for the four cases (Fig.2) namely with dummy short circuit diode (curve 2), forward biased PIN diode (curve 1), dummy open circuit (curve 3) and zero biased PIN diode (curve 4). It may be seen that curve 1 and 2 are

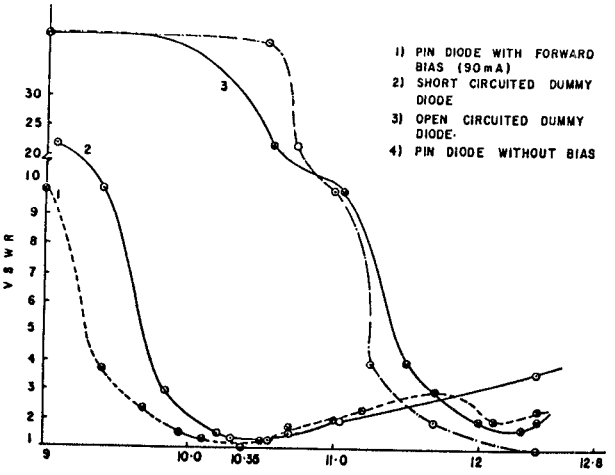

FIG. 2: FREQUENCY IN GHz

near equivalent. Similarly curve 3 and 4 are equivalent. Thus the simple equivalent circuit of the diode is valid for the package configuration used in our mount.

Results

The insertion loss and isolation are measured at low power level using PIN diode UM6010A (manufactured by Unitrode Corporation, USA) having breakdown voltage 1000 V and average power dissipation 6 watt. The measured characteristic is shown in Fig.3. At the center of the band, insertion loss of 0.4 db and isolation of 40 db are achieved.

The PIN diode ATR tube is used in a branched duplexer in place of a gas filled ATR tube and tested at 45 KW peak power, 1 us pulse width at a frequency 9.375 GHz without any degradation in performance. The received losses are shown in Fig.4.

Conclusion

A Solid State ATR tube using PIN diode is designed, fabricated and tested. This switch has got reverse property than the usual PIN diode switch viz. when forward biased this switch allows to pass microwave power through it. The test results show that gas ATR tube can be replaced by this semiconductor ATR tube at the power level of 45 KW resulting in higher reliability. PIN diode ATR tube developed by us makes it possible the all solid state branched duplexer using PIN diode limiter.

References

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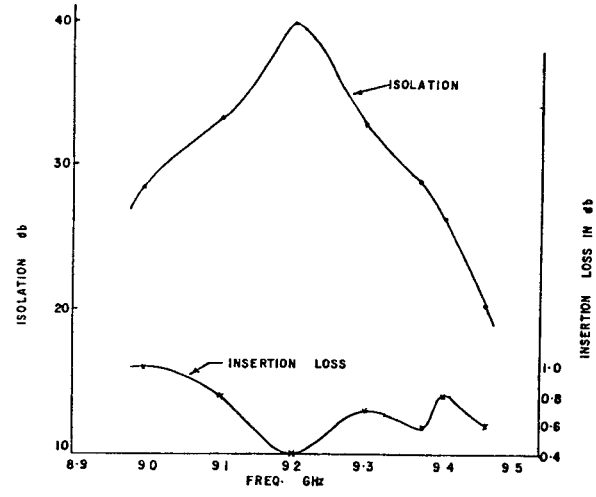

FIG. 3: INSERTION LOSS AND ISOLATION FOR PIN DIODE ATR TUBE

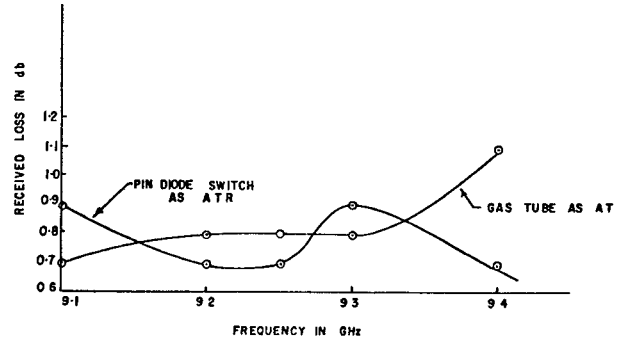

FIG. 4: RECEIVED LOSS USING PIN DIODE SWITCH AS AN ATR