SWITCHES WITH CAPACITOR CANCELLED PARASITIC INDUCTANCE OF FET

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ABSTRACT — **GaAs SPDT FET switches have been developed with capacitor cancelled parasitic inductance of FET The switches employed series-shunt configuration The switches have shown to be significantly high isolation and high frequency operation compared to conventional switch. Isolation of 28.9dB at 18GHz and 30GHz has been achieved.**

I. INTRODUCTION

Series-shunt FET switches are often used for low frequency application (1.9GHz PHS etc)[1]-[4].

The switch has the advantage of small size and broadband operation, however, when operating at the high frequency the switch has not had sufficiently high isolation.

This paper discusses the cause of degrades isolation for series-shunt FET switches was increasing impedance by parasitic inductance of shunt FET in high frequency and suggest circuits adding capacitor to cancel the parasitic inductance by series resonant and realizing the high isolation of series-shunt FET switch.

Applying the series resonant circuit to shunt FET of series-shunt FET switches for VDL employed in the active phased array transmitter/receiver modules operating in Ku and K-band for use in the satellite communication systems required to small gain ripple, isolation of the switch 28.9dB at 18GHz and 30GHz are achieved.

II. CIRCUIT DESIGN

Fig.1 shows a schematic diagram of conventional series-shunt FET switch. In order to achieve high isolation performance of the switch at Ku - K-band, we approach to find the cause of the isolation degrades at high frequency.

First, the performance of shunt FET was analyzed. Isolation of the switch depends on the ‘on’state of the shunt FET.

To achieve high isolation characteristic of the switch, the equivalent circuit ‘on’state shunt FET should be low resistance and small reactance.

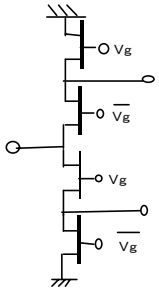

Fig. 1. Schematic diagram of conventional series-shunt FET switch

A simplified switch FET model of two states is shown in Fig.2. The FET model are consist of intrinsic elements Ron, Coff and extrinsic elements Lp,C1,C2.

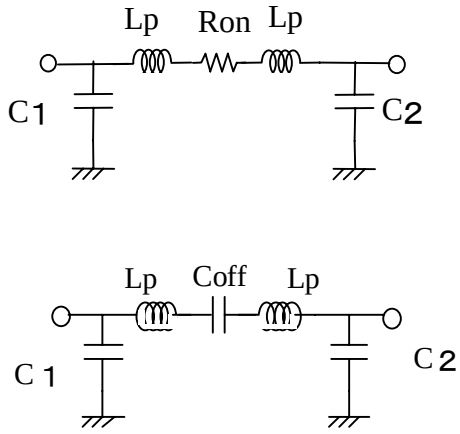

Fig. 2 A simplified switch FET model of two states

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Fig3.shows a schematic diagrams and calculated data of shunt FET as 'off'state of switch. The FET's gate-width is 300um. And value of extrinsic capacitance C1,C2 (=0.0096pF) are neglected.

It is clear that degrades isolations in fig.3 are caused by extrinsic inductance of FET.

Therefore the cause of the isolation degrades at high frequency is due to increasing impedance by extrinsic inductance of FET.

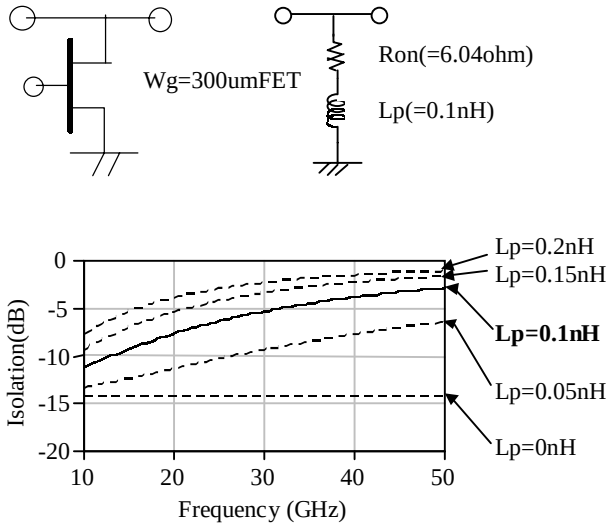


Fig3. Schematic diagram and calculated data of shunt FET as 'off'state of switch

Next, the circuit suggested realizing high isolation of shunt FET switch at high frequency shown in Fig4.

The circuit was adding series capacitor to conventional shunt FET switch. The series capacitor cancelled the extrinsic inductor of FET by series resonant at center frequency.

The series capacitor is expressed as follows:

$$C=1/(\omega^2 Lp)$$

With this relationship value of C is calculated for 18GHz and 28GHz shunt FET switches.

In Fig4.the calculated isolation of shunt FET with series capacitor is 14.2dB at 18GHz and 28GHz equal one's of shunt resistor consisted of FET model.

The isolation improved by shunt FET switch with series capacitor is about 6dB at 18GHz and about 9dB at 28GHz.

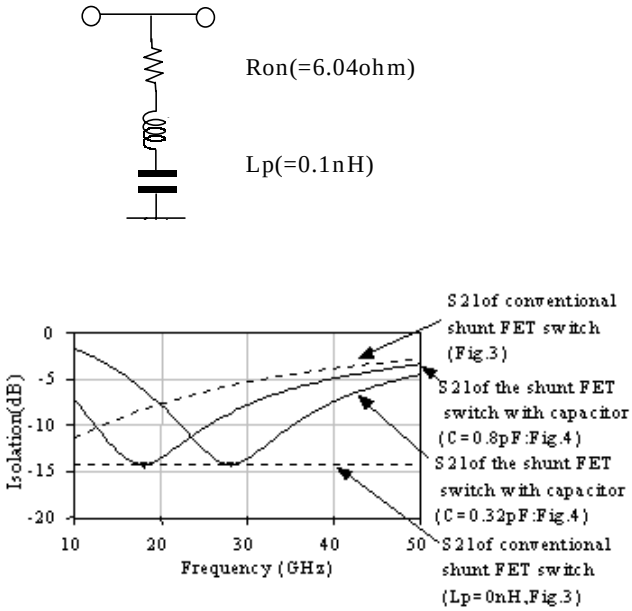


Fig.4 Schematic diagram and calculated data of shunt FET with capacitor as 'off'state of switch

The shunt FET switch with series capacitor applied to conventional series-shunt FET switch .The schematic diagram of the series-shunt FET switch shown in Fig5.In order to operate same as conventional series-shunt FET switch the resistor R was added to shunt FET for maintaining 0V of Vds. To verify of excellent isolation performance of the SPDT switch, the series-shunt FET switch with capacitor and conventional series-shunt FET switch was designed in 18GHz and 28GHz.

The photograph of the SPDT switches is Fig.6

III. MEASURED PEFORMANCE

The measured performance of the 18GHz-band SPDT switches .are shown in Fig8 and table1.

At 18GHz,it is clearly shown in Fig8 and table1, that the isolation of the switch is better than 11dB compared to conventional one's. And insertion loss input return loss is not significantly degraded at 18GHz.

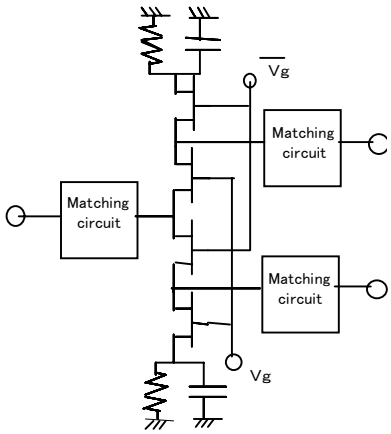
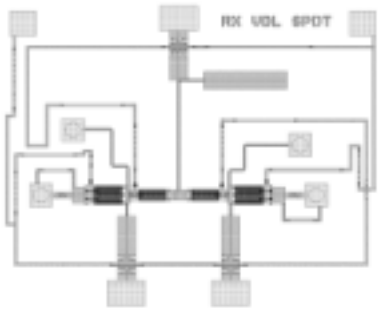
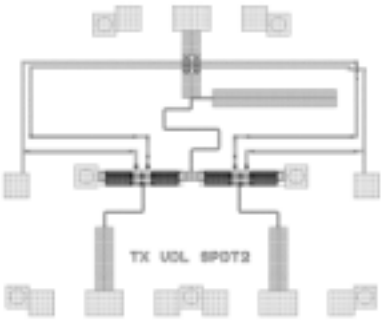


Fig. 5 Schematic diagram of the series-shunt FET switch



(a)The SPDT switch with capacitor



(b) Conventional SPDT switch

Fig.6 A photograph of the 18GHz-band SPDT switches

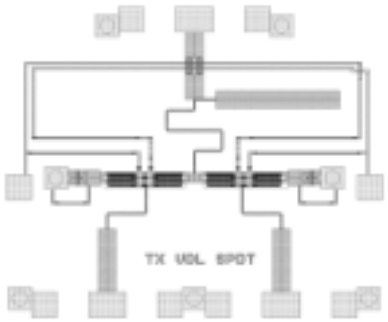
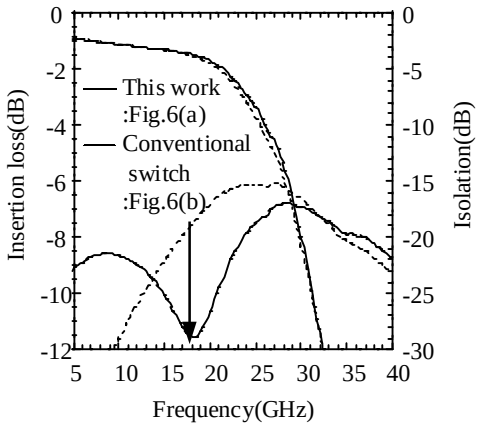
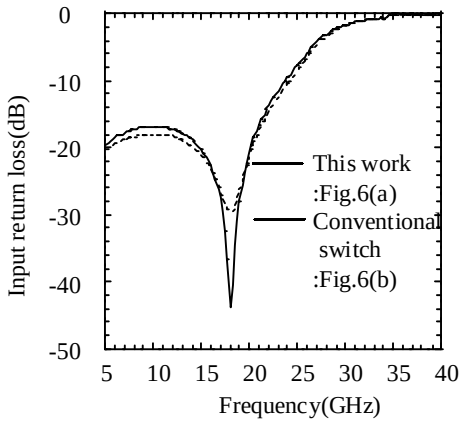


Fig.7 A photograph of the 30GHz-band SPDT

The measured performance of the 30GHz-band SPDT switches .are shown in Fig.9 and table1.



(a)



(b)

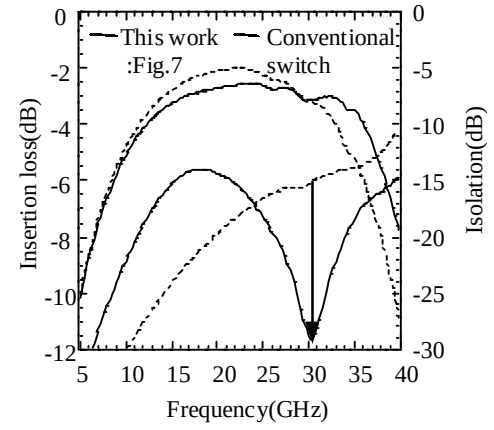
Fig.8 Measured performance of the 18GHz-band SPDT switch.(a) Insertion loss and Isolation. (b) Input return loss.

the isolation is better than 14dB compared to conventional one's. And insertion loss input return losses are not significantly degraded at 30GHz.

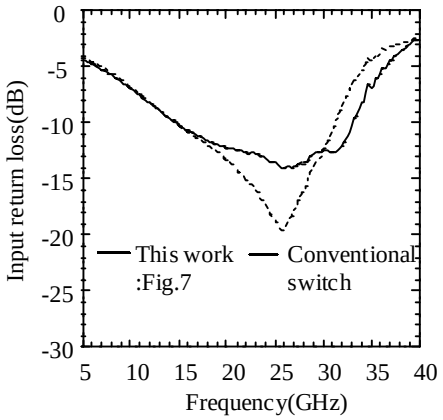
Table1

Summary of performance for 18GHz-band SPDT switches

Performance	This work	Conventinal switch
Frequency	18GHz	18GHz
Ins.loss(dB)	1.49	1.5
Isolation(dB)	28.9	18.8
Input retun loss(dB)	29.6	43.8



(a)



(b)

Fig.9 Measured performance of the 30GHz-band SPDT switch.(a) Insertion loss and Isolation (b) Input return loss.

Table2

Summary of performance for 30GHz-band SPDT switches

Performance	This work	Conventinal sw
Frequency	30GHz	30GHz
Ins.loss(dB)	3.1	3.1
Isolation(dB)	28.9	15.4
Input retun loss(dB)	12.5	12.5

IV. CONCLUSIONS

To achieve high isolation operating in high frequency and small switch, the series-shunt FET switches with capacitor cancelled parasitic inductance of FET in 18GHz and 30GHz are developed. Isolation of the switch is 28.9dB at 18GHz and 30GHz. These results demonstrates that the series-shunt FET switches would be useful for the switch operating in Ku and K-band

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