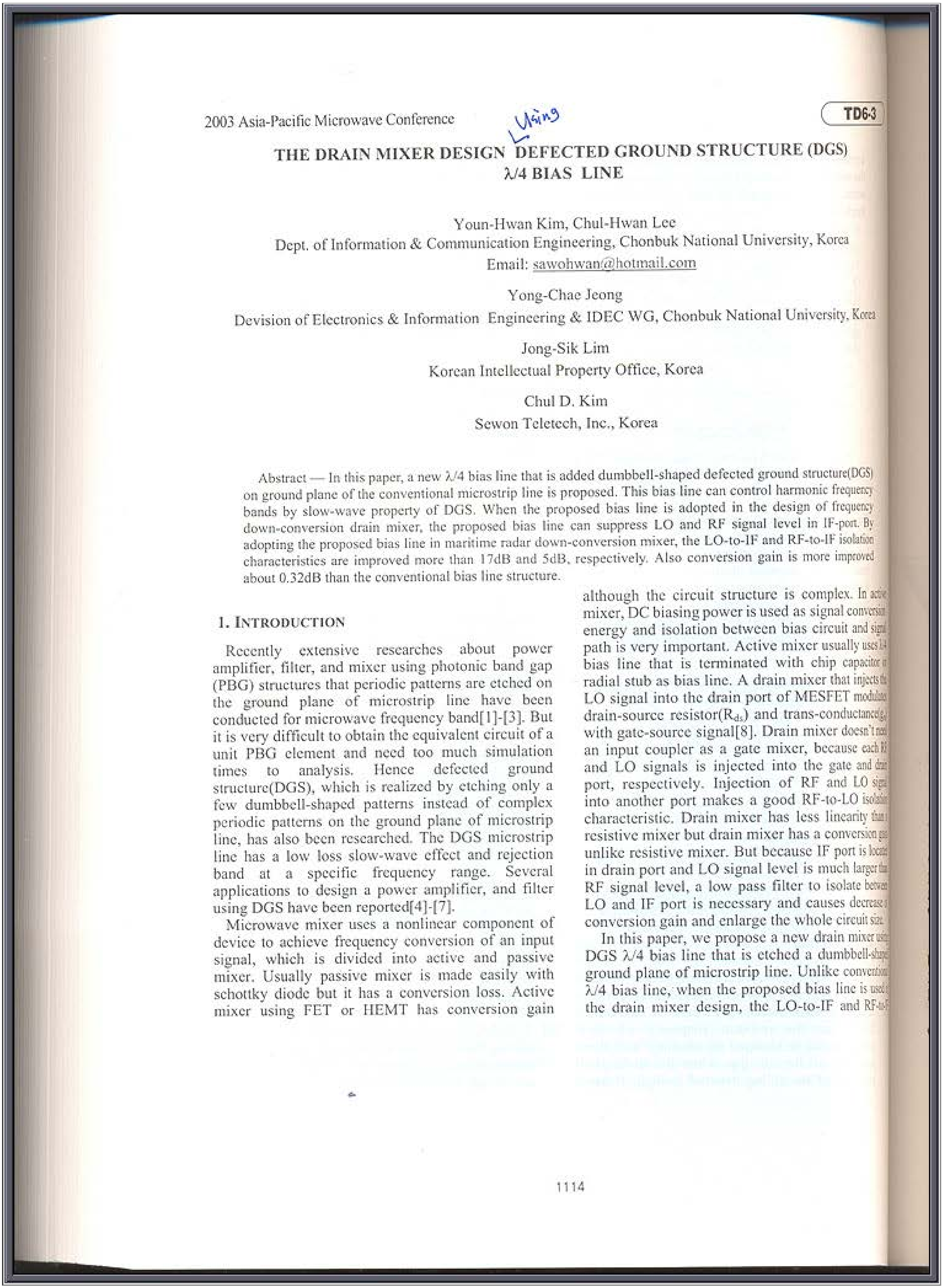

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THE DRAIN MIXER DESIGN Using DEFECTED GROUND STRUCTURE (DGS) λ/4 BIAS LINE

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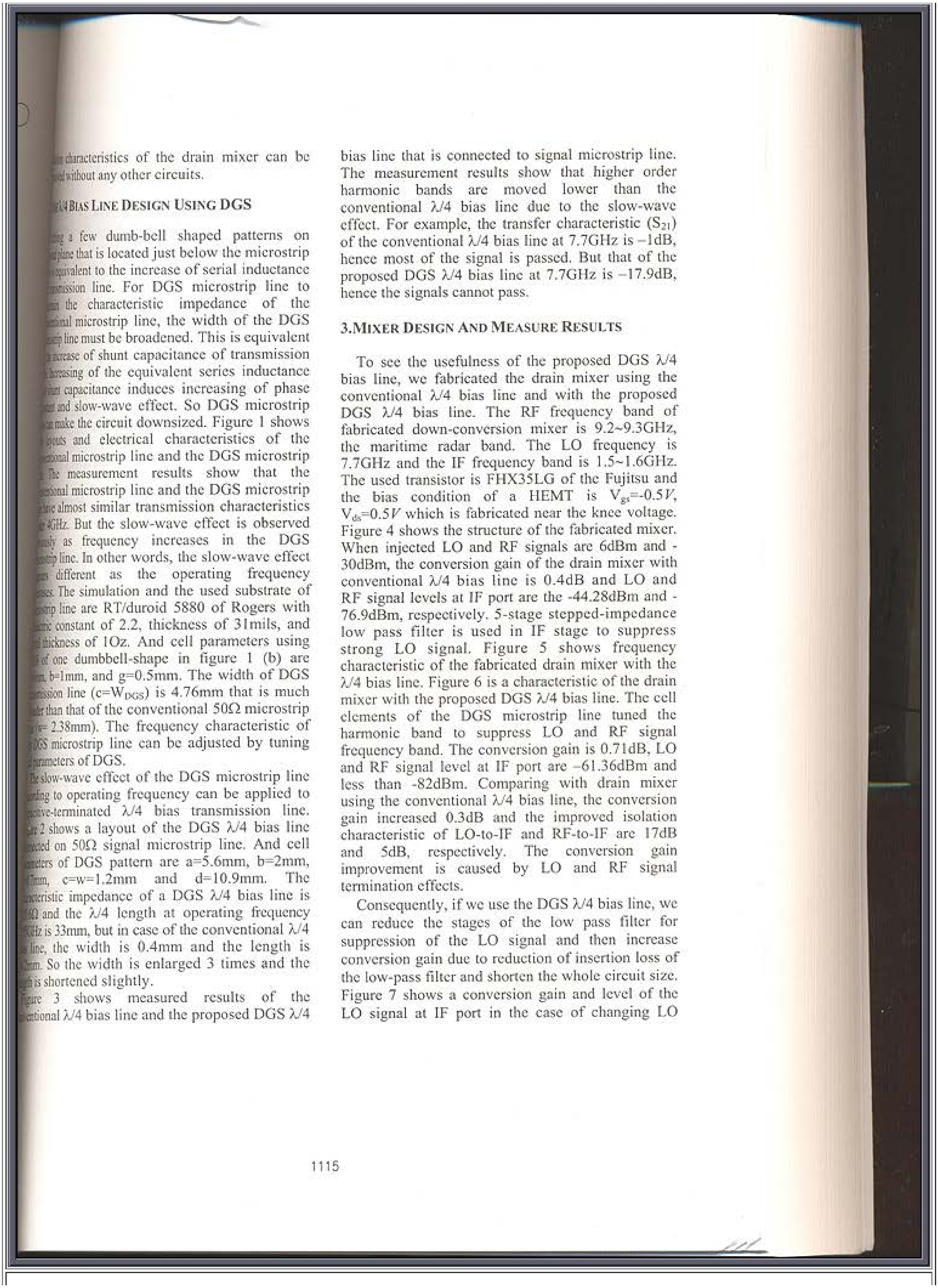
Abstract — In this paper, a new λ/4 bias line that is added dumbbell-shaped defected ground structure(DGS) on ground plane of the conventional microstrip line is proposed. This bias line can control harmonic frequency bands by slow-wave property of DGS. When the proposed bias line is adopted in the design of frequency down-conversion drain mixer, the proposed bias line can suppress LO and RF signal level in IF-port. By adopting the proposed bias line in maritime radar down-conversion mixer, the LO-to-IF and RF-to-IF isolation characteristics are improved more than 17dB and 5dB, respectively. Also conversion gain is more improved about 0.32dB than the conventional bias line structure.

1. INTRODUCTION

Recently extensive researches about power amplifier, filter, and mixer using photonic band gap (PBG) structures that periodic patterns are etched on the ground plane of microstrip line have been conducted for microwave frequency band[1]-[3]. But it is very difficult to obtain the equivalent circuit of a unit PBG element and need too much simulation times to analysis. Hence defected ground structure(DGS), which is realized by etching only a few dumbbell-shaped patterns instead of complex periodic patterns on the ground plane of microstrip line, has also been researched. The DGS microstrip line has a low loss slow-wave effect and rejection band at a specific frequency range. Several applications to design a power amplifier, and filter using DGS have been reported[4]-[7].

Microwave mixer uses a nonlinear component of device to achieve frequency conversion of an input signal, which is divided into active and passive mixer. Usually passive mixer is made easily with schottky diode but it has a conversion loss. Active mixer using FET or HEMT has conversion gain although the circuit structure is complex. In acti
mixer, DC biasing power is used as signal conversi
energy and isolation between bias circuit and sig
path is very important. Active mixer usually uses λ/4
bias line that is terminated with chip capacitor o
radial stub as bias line. A drain mixer that injects th
LO signal into the drain port of MESFET modula
drain-source resistor(R_{ds}) and trans-conductance(g
with gate-source signal[8]. Drain mixer doesn't ne
an input coupler as a gate mixer, because each R
and LO signals is injected into the gate and dra
port, respectively. Injection of RF and LO sig
into another port makes a good RF-to-LO isolati
characteristic. Drain mixer has less linearity tha
resistive mixer but drain mixer has a conversion ga
unlike resistive mixer. But because IF port is loca
in drain port and LO signal level is much larger th
RF signal level, a low pass filter to isolate betwe
LO and IF port is necessary and causes decrease
conversion gain and enlarge the whole circuit size.

In this paper, we propose a new drain mixer usi
DGS λ/4 bias line that is etched a dumbbell-shape
ground plane of microstrip line. Unlike conventio
λ/4 bias line, when the proposed bias line is used
the drain mixer design, the LO-to-IF and RF-to-



characteristics of the drain mixer can be d without any other circuits.

λ/4 BIAS LINE DESIGN USING DGS

g a few dumb-bell shaped patterns on plane that is located just below the microstrip quivalent to the increase of serial inductance mission line. For DGS microstrip line to the characteristic impedance of the onal microstrip line, the width of the DGS rip line must be broadened. This is equivalent ncrease of shunt capacitance of transmission reasing of the equivalent series inductance nt capacitance induces increasing of phase t and slow-wave effect. So DGS microstrip n make the circuit downsized. Figure 1 shows youts and electrical characteristics of the onal microstrip line and the DGS microstrip The measurement results show that the tional microstrip line and the DGS microstrip ve almost similar transmission characteristics 4GHz. But the slow-wave effect is observed ly as frequency increases in the DGS trip line. In other words, the slow-wave effect different as the operating frequency ses. The simulation and the used substrate of strip line are RT/duroid 5880 of Rogers with ric constant of 2.2, thickness of 31mils, and thickness of 1Oz. And cell parameters using of one dumbbell-shape in figure 1 (b) are m, b=1mm, and g=0.5mm. The width of DGS ssion line (c=W_{DGS}) is 4.76mm that is much r than that of the conventional 50Ω microstrip w= 2.38mm). The frequency characteristic of DGS microstrip line can be adjusted by tuning parameters of DGS.

e slow-wave effect of the DGS microstrip line ding to operating frequency can be applied to ive-terminated λ/4 bias transmission line. re 2 shows a layout of the DGS λ/4 bias line cted on 50Ω signal microstrip line. And cell meters of DGS pattern are a=5.6mm, b=2mm, mm, c=w=1.2mm and d=10.9mm. The cteristic impedance of a DGS λ/4 bias line is Ω and the λ/4 length at operating frequency GHz is 33mm, but in case of the conventional λ/4 line, the width is 0.4mm and the length is m. So the width is enlarged 3 times and the h is shortened slightly.

gure 3 shows measured results of the ntional λ/4 bias line and the proposed DGS λ/4 bias line that is connected to signal microstrip line. The measurement results show that higher order harmonic bands are moved lower than the conventional λ/4 bias line due to the slow-wave effect. For example, the transfer characteristic (S_{21}) of the conventional λ/4 bias line at 7.7GHz is –1dB, hence most of the signal is passed. But that of the proposed DGS λ/4 bias line at 7.7GHz is –17.9dB, hence the signals cannot pass.

3.MIXER DESIGN AND MEASURE RESULTS

To see the usefulness of the proposed DGS λ/4 bias line, we fabricated the drain mixer using the conventional λ/4 bias line and with the proposed DGS λ/4 bias line. The RF frequency band of fabricated down-conversion mixer is 9.2~9.3GHz, the maritime radar band. The LO frequency is 7.7GHz and the IF frequency band is 1.5~1.6GHz. The used transistor is FHX35LG of the Fujitsu and the bias condition of a HEMT is V_{gs}=-0.5*V*, V_{ds}=0.5*V* which is fabricated near the knee voltage. Figure 4 shows the structure of the fabricated mixer. When injected LO and RF signals are 6dBm and -30dBm, the conversion gain of the drain mixer with conventional λ/4 bias line is 0.4dB and LO and RF signal levels at IF port are the -44.28dBm and -76.9dBm, respectively. 5-stage stepped-impedance low pass filter is used in IF stage to suppress strong LO signal. Figure 5 shows frequency characteristic of the fabricated drain mixer with the λ/4 bias line. Figure 6 is a characteristic of the drain mixer with the proposed DGS λ/4 bias line. The cell elements of the DGS microstrip line tuned the harmonic band to suppress LO and RF signal frequency band. The conversion gain is 0.71dB, LO and RF signal level at IF port are –61.36dBm and less than -82dBm. Comparing with drain mixer using the conventional λ/4 bias line, the conversion gain increased 0.3dB and the improved isolation characteristic of LO-to-IF and RF-to-IF are 17dB and 5dB, respectively. The conversion gain improvement is caused by LO and RF signal termination effects.

Consequently, if we use the DGS λ/4 bias line, we can reduce the stages of the low pass filter for suppression of the LO signal and then increase conversion gain due to reduction of insertion loss of the low-pass filter and shorten the whole circuit size. Figure 7 shows a conversion gain and level of the LO signal at IF port in the case of changing LO input signal level. In case of the DGS $\lambda/4$ bias line, conversion gain is increased about 0.2~0.7dB and the attenuation characteristic of the LO output signal increased 16~18dB.

Table I summarizes signal levels at IF port when RF signal is changed in 9.2~9.3GHz that LO and RF signal levels are 6dBm and –30dBm, respectively. The results are almost same in frequency band.

4. CONCLUSION

The DGS $\lambda/4$ bias line offers the slow-wave effect and it is possible to tune band reject characteristic by adjusting the cell parameters of DGS. In the design of the drain mixer, the DGS $\lambda/4$ bias line operates as an open circuit in the IF band, but short circuit in LO and RF bands. So isolation characteristics of LO-to-IF and RF-to-IF are improved and a high conversion gain is obtained.

So if we use the applied DGS $\lambda/4$ bias line, we can reduce the stages of the low pass filter for the suppression of LO signal, with this result we can take the increase of conversion gain and shorten the whole circuit size.

5. ACKNOWLEDGEMENT

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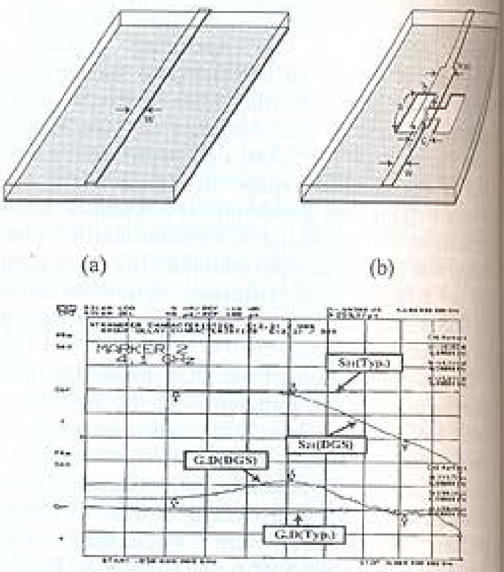

(a) (b)

(c)

Fig.1. (a) Layout of a conventional microstrip line (b) Layout of a DGS microstrip line (c) Comparison of transfer characteristics.

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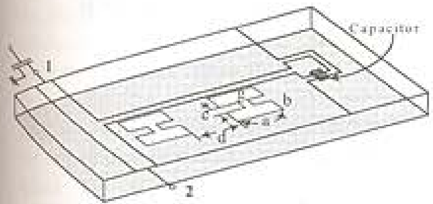
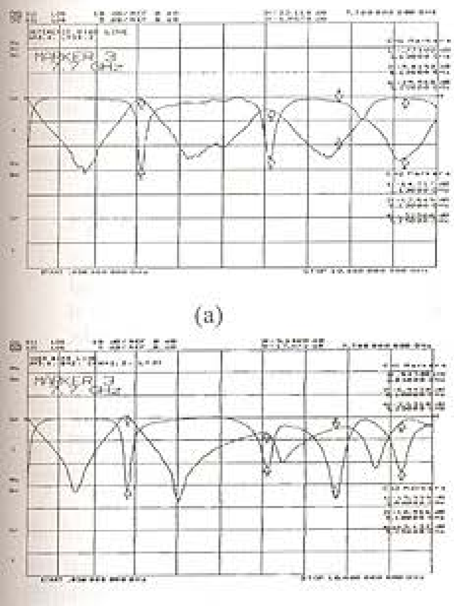


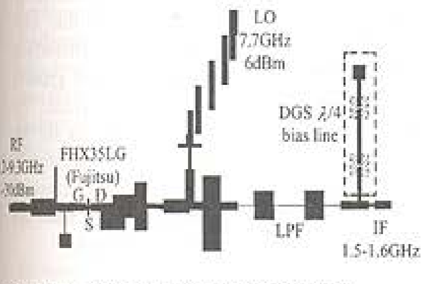
ig.2. Layout of DGS λ/4 bias line.



(a)

(b)

ig.3 (a) Measured result of the λ/4 bias line.
(b) Measured result of the DGS λ/4 bias line.



ig.4. Structure of the fabricated drain mixer.

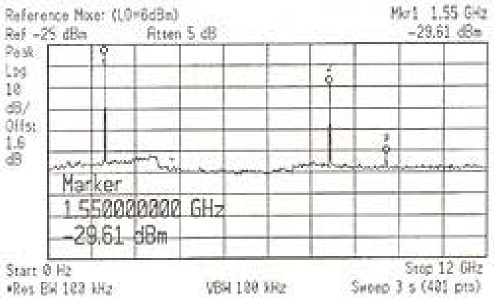


Fig. 5. The frequency characteristics of drain mixer using conventional λ/4 bias line. (@P_{LO}=6dBm, P_{RF}=-30dBm)

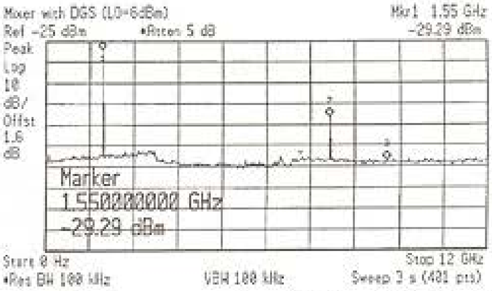


Fig. 6. The frequency characteristics of drain mixer using DGS λ/4 bias line. (@P_{LO}=6dBm, P_{RF}=-30dBm)

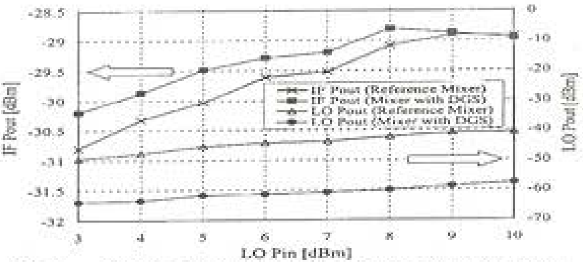


Fig. 7. Conversion gain and power level of LO output signal at IF port in case of changing LO input signal.

TABLE I
THE OUTPUT LEVEL CHARACTERISTIC BY RF FREQUENCY

	Reference Mixer			Mixer with DGS		
	9.2 GHz	9.25 GHz	9.3 GHz	9.2 GHz	9.25 GHz	9.3 GHz
IF Pout [dBm]	-29.66	-26.61	-29.8	-29.4	-29.29	-29.67
LO Pout [dBm]	-44.2	-44.28	-43.42	-62.82	-61.36	-61.05
RF Pout [dBm]	-78.74	-76.9	-78.38	x	x	x