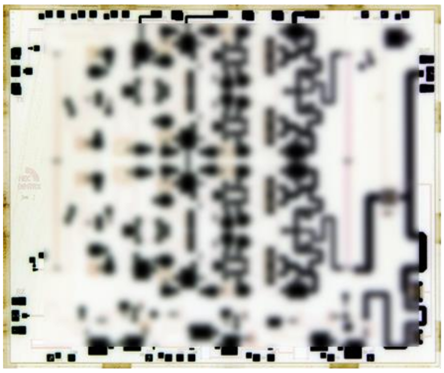
MECX15SCFE

X-Band GaN Single-Chip Transceiver Module



Product Description

MECX15SCFE is a 0.15 µm GaN based MMIC integrating the main functions of a T/R Module Frontend (HPA, TR Switch and LNA) for X-band Radar applications in the frequency range 8.5 – 11.5 GHz.

Optimized to be compliant with space de-rating standard, the transmitting path can deliver a saturated power of 15 W with a PAE of 34% and 26 dB of large signal Gain. The receive chain offers 24 dB Gain with Noise Figure of 2.5 dB and saturated output power internally limited to 15 dBm. The SCFE (Single-Chip Front-End), satisfy the reliability constraints with input power at the Antenna port up to 23 dBm, during nominal operating conditions, and up to 30 dBm in Off mode (DC floating).

The Tx/Rx switching time is faster than 50 ns, while the Recovery time of the receive path is lower than 10 ns after a jamming signal of 20 dBm.

One single control voltage required for Tx/Rx switching.

The SCFE is designed to be tolerant to power reflection up to VSWR of 3:1 of mismatch at the antenna port.

Applications

- Satellite SAR
- Commercial and Military Radar

Main Features

- 0.15 µm GaN/SiC space evaluated process
- Frequency range: 8.5 – 11.5 GHz
- Chip Size: 6.0 x 5.0 x 0.07 mm^3
- Switching Time: 50 ns

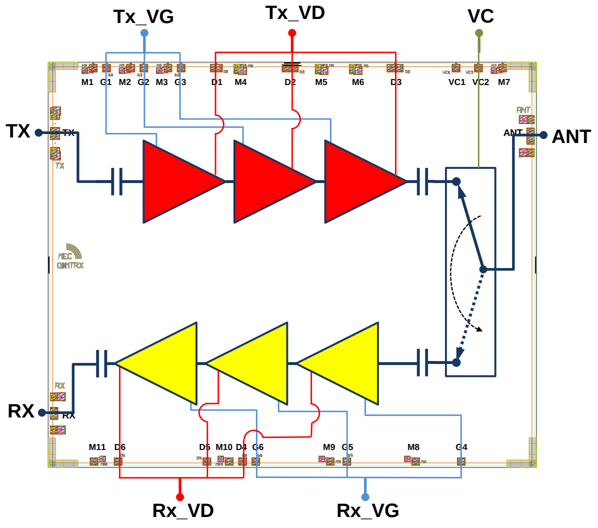
Tx chain (pulsed)

- Small Signal Gain: 37 dB
- Large Signal Gain: 26 dB
- Output Power @ PAEmax: 42 dBm
- PAE: 33%
- Harmonic Suppression: 30 dBc
- Tolerance to Load-pulling: 3:1 VSWR
- Bias: Vd = 17.5 V, Idq = 750 mA

Rx chain (CW)

- Small Signal Gain: 24.5 dB
- Noise Figure: 2.5 dB
- Saturated Power: 15 dBm
- Output TOI: 15 dBm
- Input P1dB: -10 dBm
- Phase Stability: 0.1 °pp / 250 MHz
- Recovery Time: 10 ns
- Bias: Vd = 10 V, Idq = 42 mA

Functional Block Diagram



Nominal Operating Conditions

Parameter	Value	Description
Tamb	-30 to +90 °C	Operating temperature range
Transmit Mode		
VC	0 V	TX/RX control voltage
IC	0 A	Current drained by control voltage VC
Gate Pulse Length	up to 100 µsec	
Gate Pulse Duty Cycle	up to 40%	
Tx_VG	-2.8 V (Typ.)	TX Gate Voltage – to be pulsed in the rage [-5 to -2.8] V
Tx_VD	17.5 V	TX Drain Voltage
Tx_IDq	0.75 A	TX Drain quiescent Current
Tx_IG	0 mA	TX Gate Current
Rx_VG	-7 V	RX Gate Voltage
Rx_VD	10 V	RX Drain Voltage
Rx_IDq	0 A	RX Drain quiescent Current
Receive Mode		
VC	-20 V	TX/RX control voltage
IC	0 A	Current drained by control voltage VC
Tx_VG	-5 V (Typ.)	TX Gate Voltage – to be pulsed in the rage [-5 to -2.8] V
Tx_VD	17.5 V	TX Drain Voltage
Tx_IDq	0 A	TX Drain quiescent Current
Rx_VG	-2.6 V	RX Gate Voltage
Rx_VD	10 V	RX Drain Voltage
Rx_IDq	42 mA	RX Drain quiescent Current
Rx_IG	0 mA	RX Gate Current

Absolute Maximum Rating

Parameter	Description	Value
Tx_VD, Rx_VD	Drain Voltage	27 V
Tx_IDq	TX Quiescent Drain Bias Current (pulsed)	1.5 A
Rx_IDq	RX Quiescent Drain Bias Current	70 mA
Tx_VG, Rx_VG	TX Gate Voltage	-7 to -1 V
Tx_IG	TX Gate Current	200 mA
Rx_IG	RX Gate Current	24 mA
VC	TX/RX control voltage	-50 V
IC	TX/RX control voltage	20 mA
Pin_Tx	Input power at TX port	20 dBm
Pin_Rx	Input power at ANTENNA port	23 dBm
Tch	Channel temperature	230 °C
Tmnt	Mounting Temperature (<30 sec)	260 °C
Tstg	Storage Temperature range	-55 to +150 °C

Operation of this device above anyone of these parameters may cause permanent damage.

Electrical Characteristics – Transmit

Test conditions unless otherwise noted: Tx_VD = 17.5 V, Tx_IDq = 0.75 A, VC = 0 V, TX_VG pulse = (150 µs – 30%), Rx_VD = 10 V, Rx_VG = -7 V. Tbase = 30°C.

Parameter	Min	Typ	Max	Unit
Operating frequency	8.5		11.5	GHz
Small Signal Gain		27		dB
Input Return Loss	20			dB
Output Return Loss	25			dB
Output Power at PAE max. (Pin=16.5 dBm)	42		42.5	dBm
Output Power at Saturation (Pin = 19 dBm)		42.8		dBm
PAE max. (Pin=16.5 dBm)		34		%
Harmonic Suppression	30		36	dBc
Isolation TX-RX		50		dB
Power Leakage at RX port			-30	dBm
Supply Drain Current at PAE max. (Pin=16.5 dBm)	2.7		3.1	A
Supply Drain Current at Saturation (Pin = 19 dBm)	2.8		3.3	A
Gate Leakage Current		0		mA
Switching Setting Time(1), Rising & Falling			30	ns

(1) From 50% trigger signal to 90% of RF on (Rising) or 10% of RF off (Falling).

Electrical Characteristics – Receive

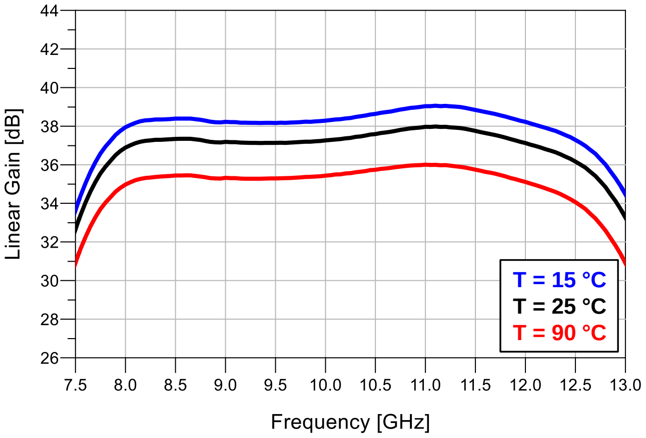
Test conditions unless otherwise noted: Rx_VD = 10 V, Rx_IDq = 42 mA, VC = -20 V, Tx_VD = 17.5 V, Tx_VG = -5 V. Tbase = 30°C.

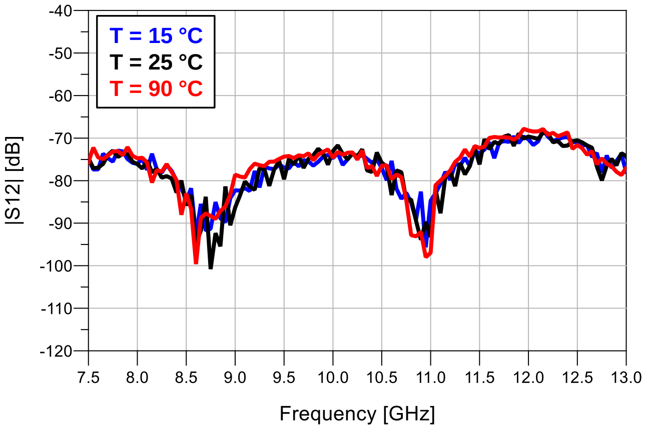
Parameter	Min	Typ	Max	Unit
Operating frequency	8.5		11.5	GHz
Small Signal Gain, over frequency	24.5		25.5	dB
Small Signal Gain @ +15 °C to 90 °C	22.5		26	dB
Gain Temperature Coefficient		-0.03		dB/°C
Noise Figure		2.5		dB
Input Return Loss	13			dB
Output Return Loss	12			dB
Saturated Output Power		15		dBm
Output TOI @ -33 dBm Pin / Tone		15		dBm
Recovery Time			10	ns
Gate Leakage Current		0		mA
Switching Setting Time(1), Rising & Falling			30	ns

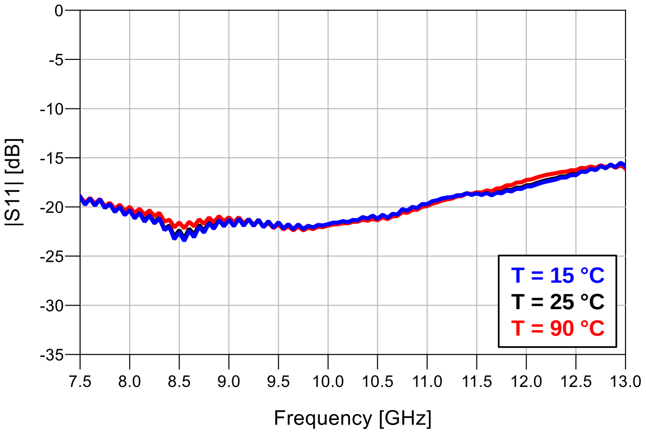
(1) From 50% trigger signal to 90% of RF on (Rising) or 10% of RF off (Falling).

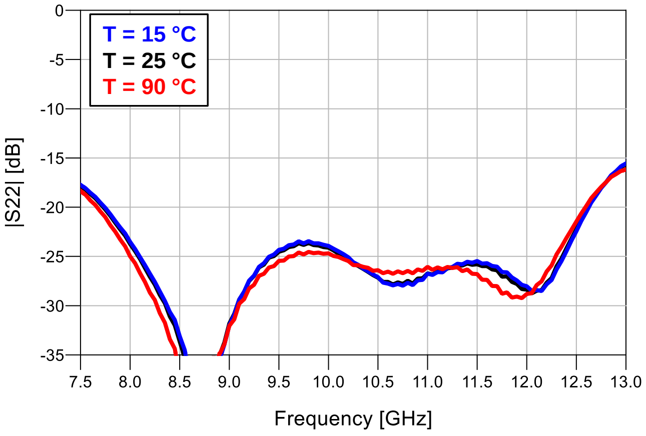
Small Signal Performance – Transmit

Test conditions unless otherwise noted: Tx_VD = 17.5 V, Tx_IDq = 0.75 A, VC = 0 V, Rx_VD = 10 V, Rx_VG = -7 V. Pulse Width = 150 µs, Duty Cycle = 30%.


Linear Gain Vs. Temperature

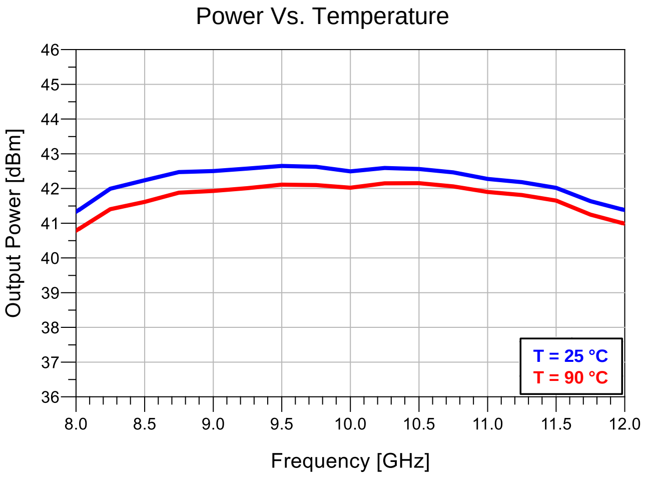

Reverse Isolation Vs. Temperature

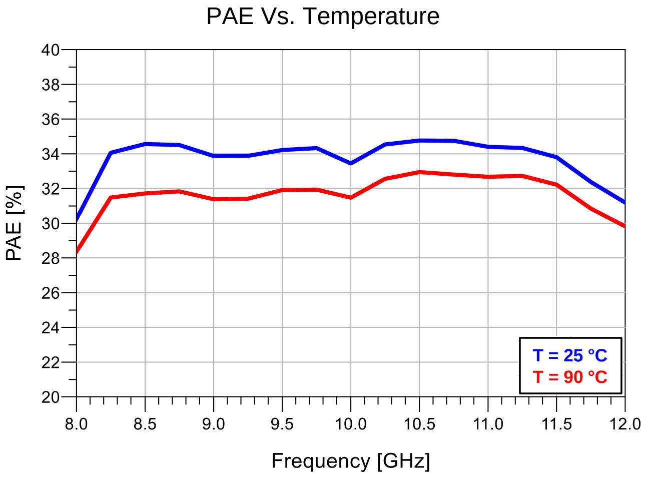

Input Return Loss Vs. Temperature

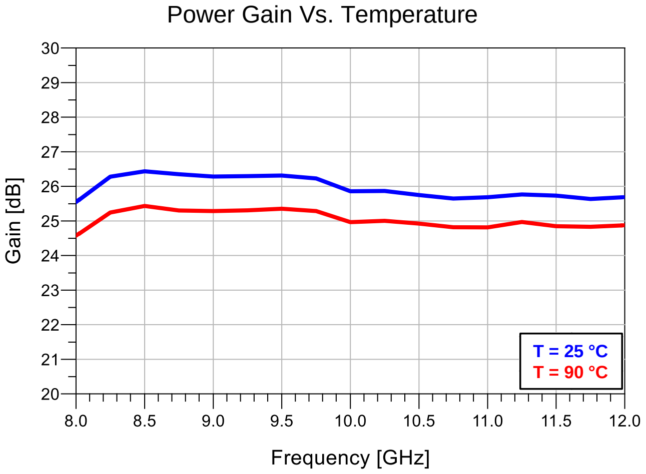

Output Return Loss Vs. Temperature

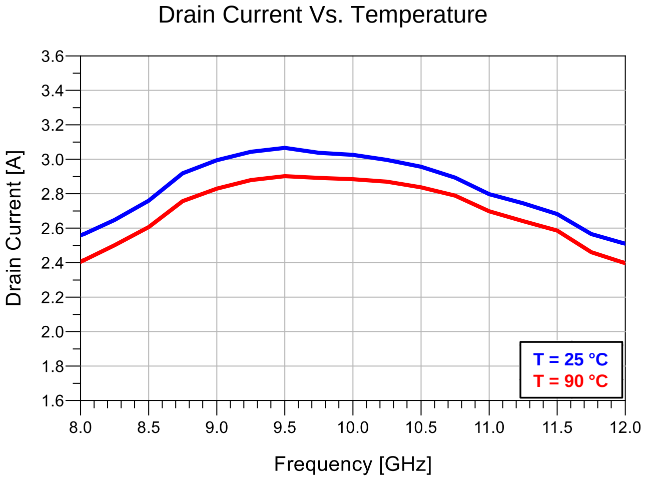
Power Performance – Transmit

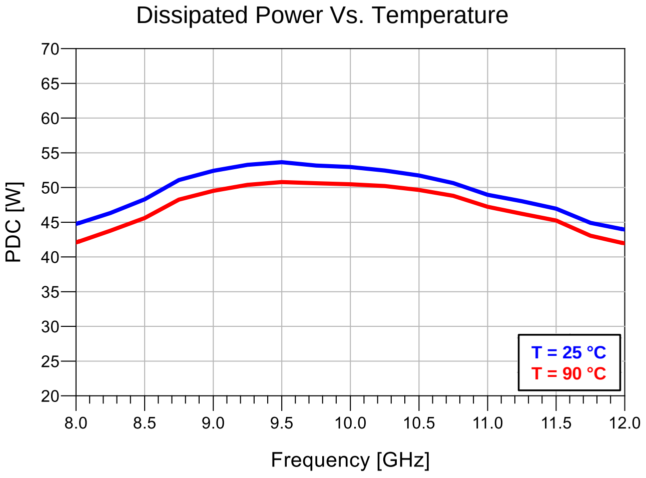
Test conditions unless otherwise noted: Tx_VD = 17.5 V, Tx_IDq = 0.75 A, VC = 0 V, Rx_VD = 10 V, Rx_VG = -7 V.
Pulse Width = 150 µs, Duty Cycle = 30%. Pin = 16.5 dBm

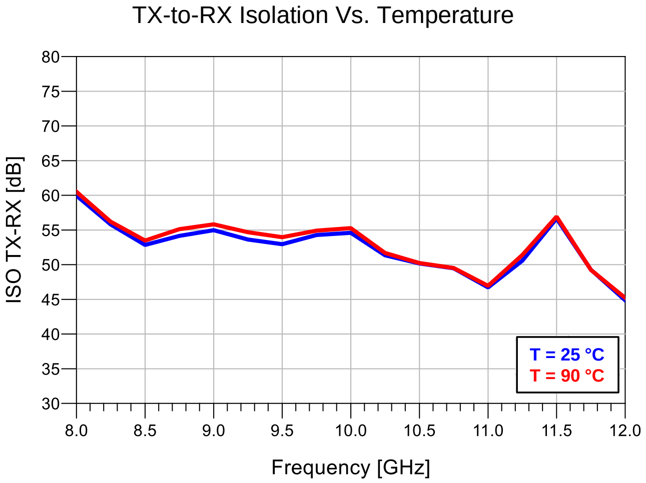






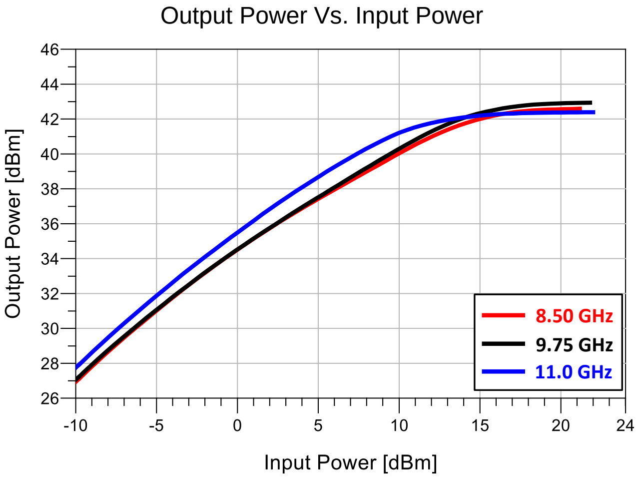


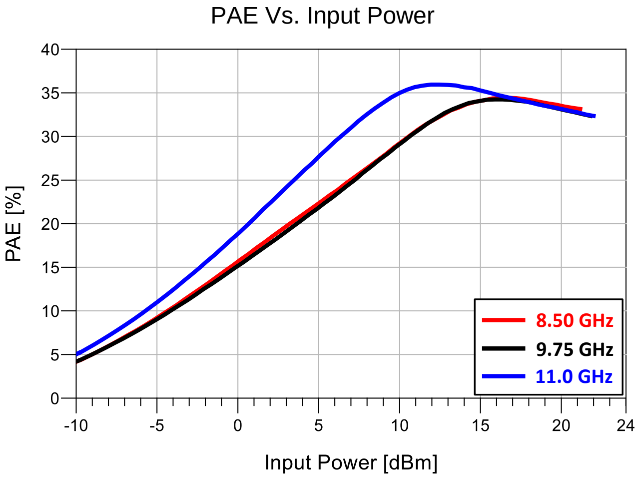


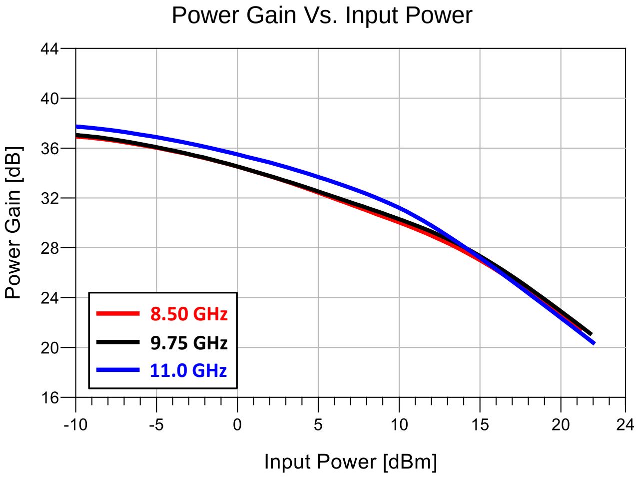


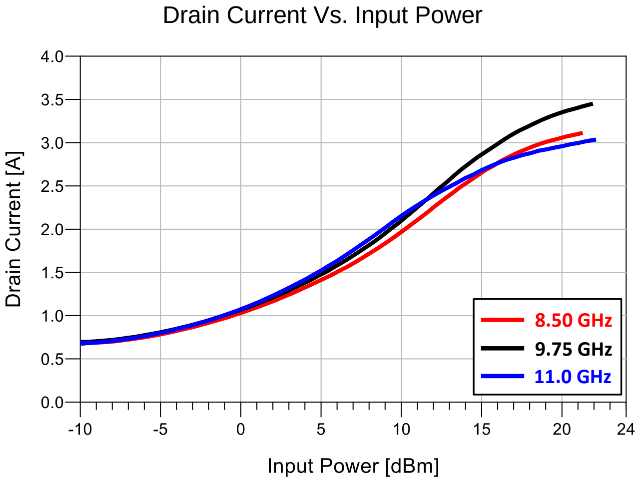
Power Performance – Transmit

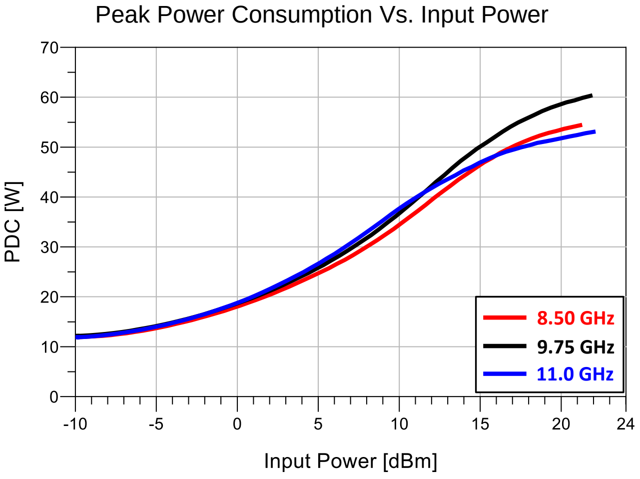
Test conditions unless otherwise noted: Tx_VD = 17.5 V, Tx_IDq = 0.75 A, VC = 0 V, Rx_VD = 10 V, Rx_VG = -7 V. Pulse Width = 150 µs, Duty Cycle = 30%. 25 °C.

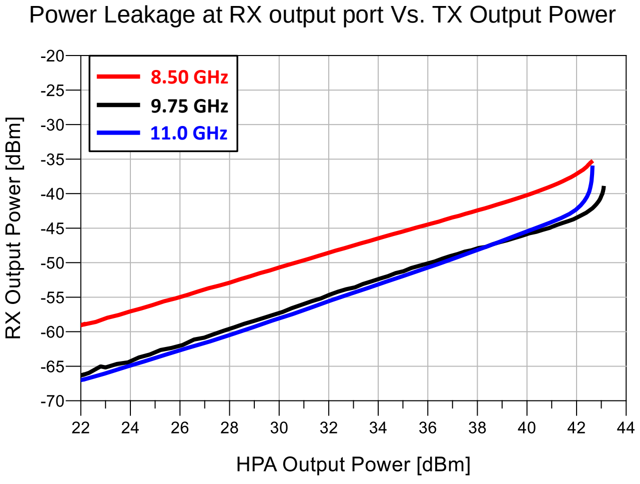






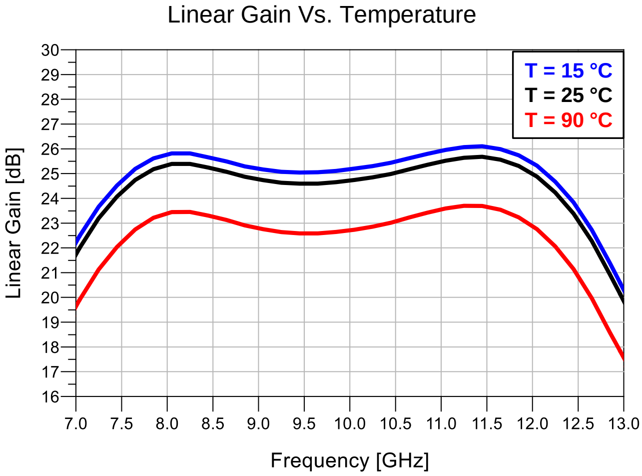


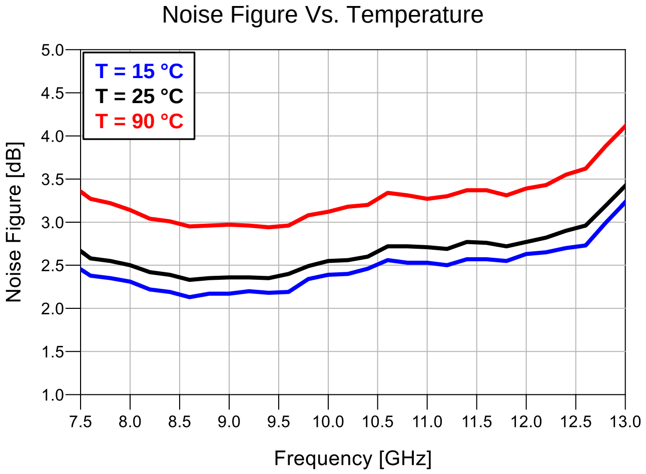


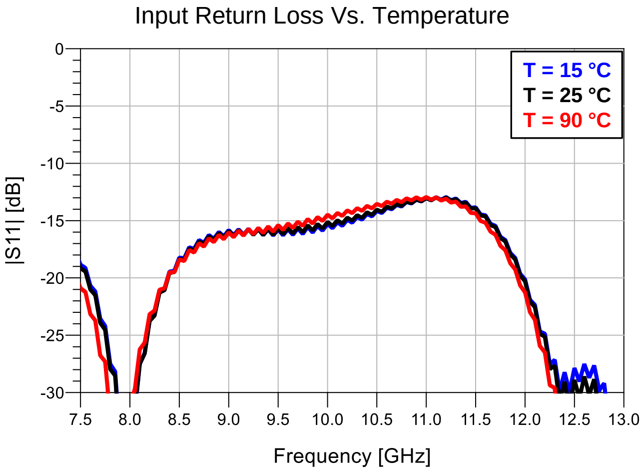


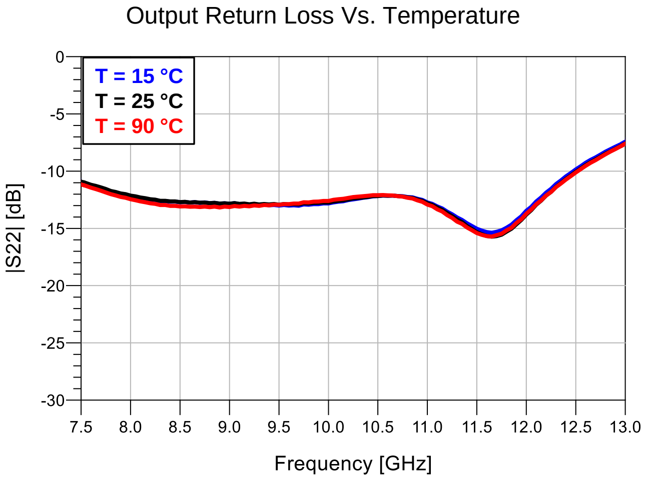
Small Signal Performance – Receive

Test conditions unless otherwise noted: Rx_VD = 10 V, Rx_IDq = 42 mA, VC = -20 V, Tx_VD = 17.5 V, Tx_VG = -5 V.



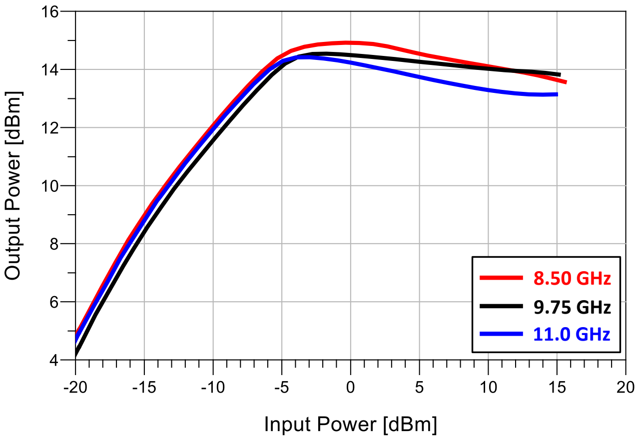


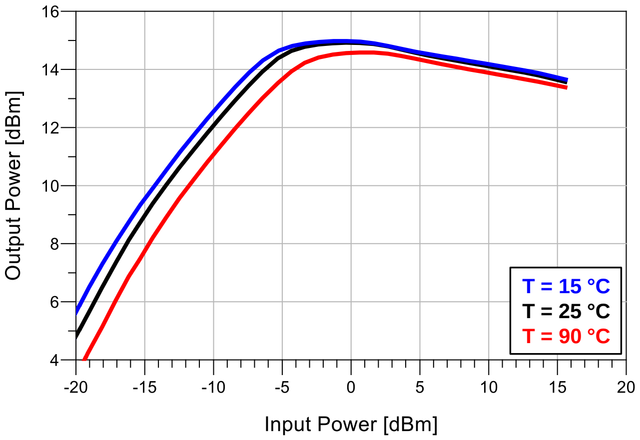


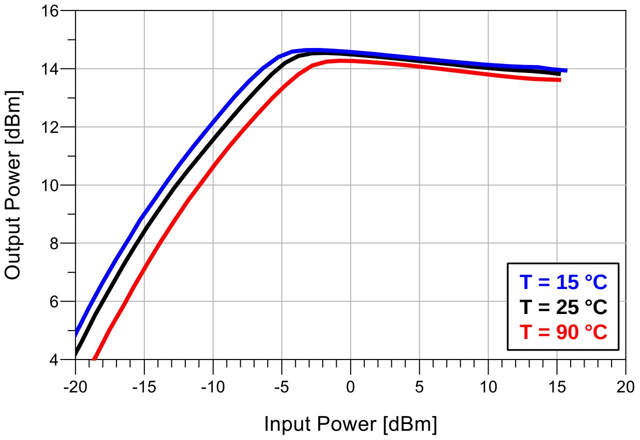


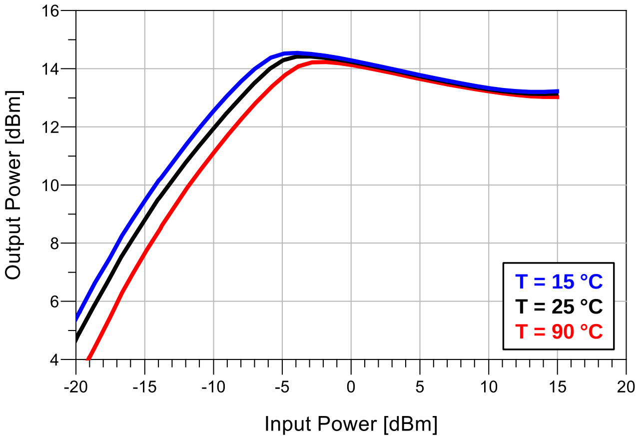
Power Performance & Linearity – Receive

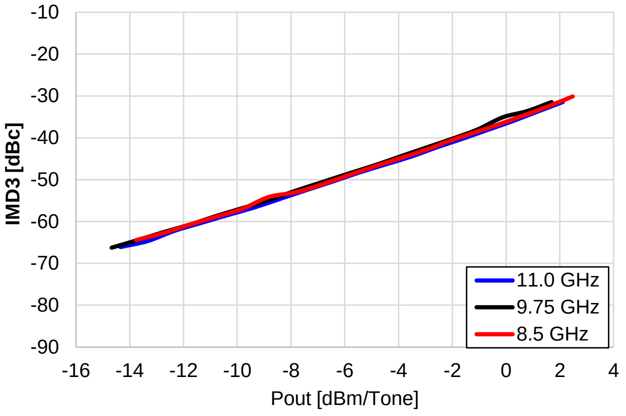
Test conditions unless otherwise noted: Rx_VD = 10 V, Rx_IDq = 42 mA, VC = -20 V, Tx_VD = 17.5 V, Tx_VG = -5 V. 25 °C.

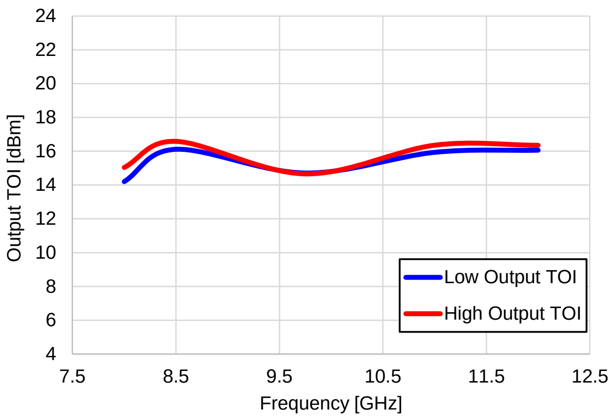

Output Power Vs. Input Power @ 25 °C


Output Power Vs. Input Power @ 8.5 GHz


Output Power Vs. Input Power @ 9.75 GHz


Output Power Vs. Input Power @ 11.0 GHz


IMD3 Vs. Output Power

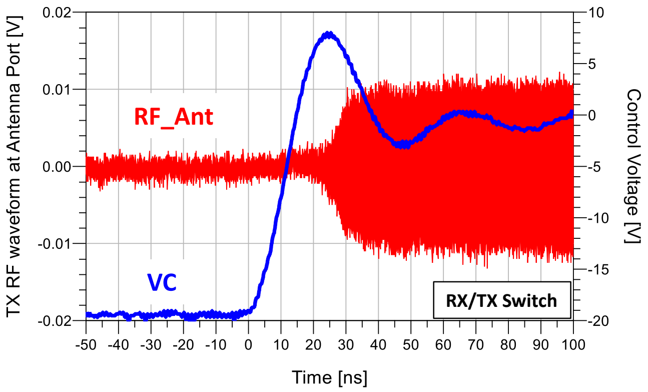

Output TOI @ -33 dBm / Tone

Timing Performance

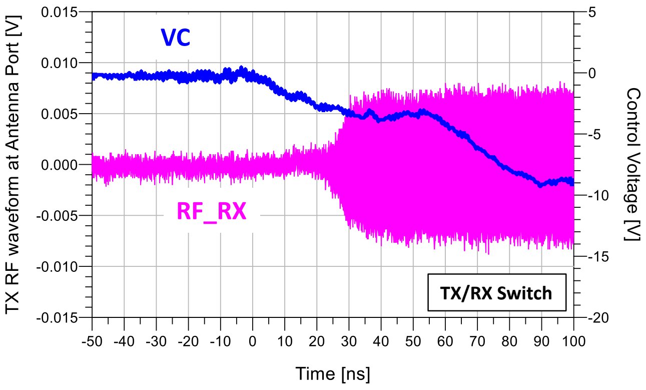
Test conditions unless otherwise noted:

- *Transmit: Tx_VD = 17.5 V, Tx_IDq = 0.75 A, VC = 0 V, Rx_VD = 10 V, Rx_VG = -7 V. (150 µs, 30%). 25 °C.*
- *Receive: Rx_VD = 10 V, Rx_IDq = 42 mA, VC = -20 V, Tx_VD = 17.5 V, Tx_VG = -5 V. 25 °C.*

Rx to Tx switching time – RF signal @ Antenna



Tx to Rx switching time – RF signal @ RX port

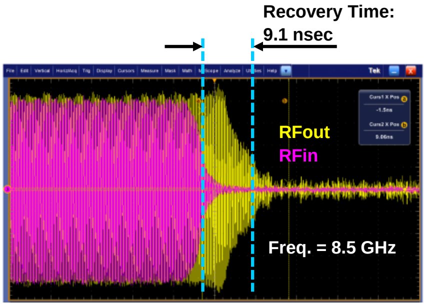


Recovery Time on Receive chain

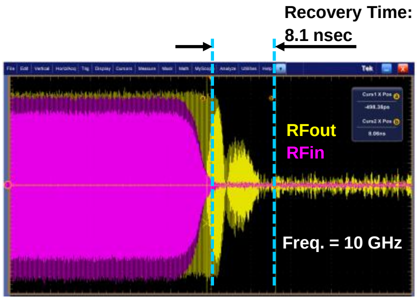
RFin: Input Power at Antenna port; RFout: Output Power at RX port

Jamming signal: 20 dBm

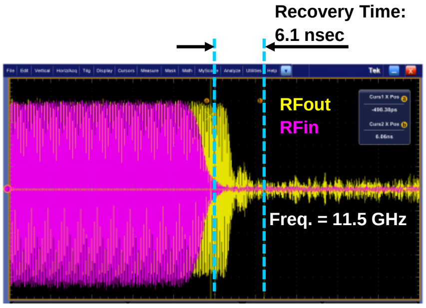
8.5 GHz


Recovery Time:
9.1 nsec

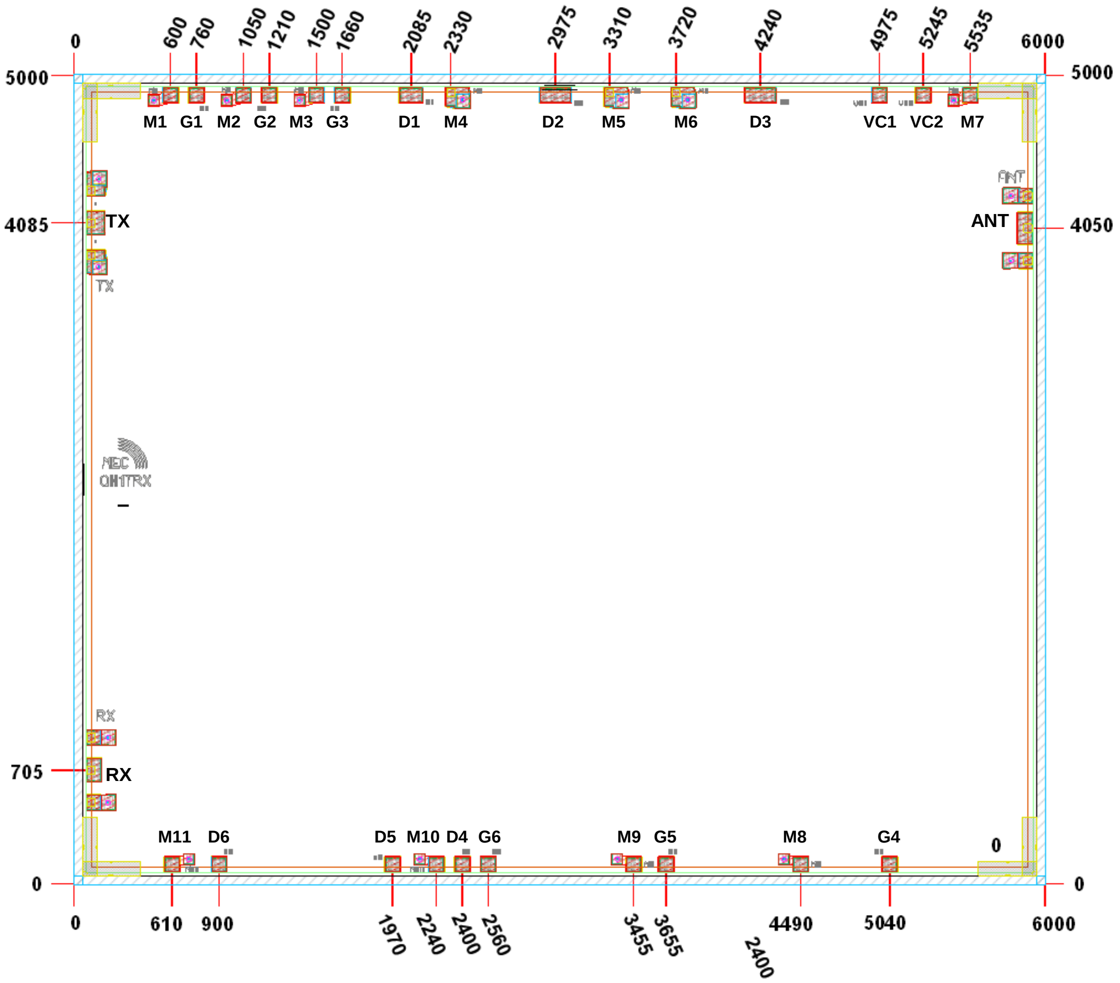
10 GHz


Recovery Time:
8.1 nsec

11.5 GHz


Recovery Time:
6.1 nsec

Mechanical information

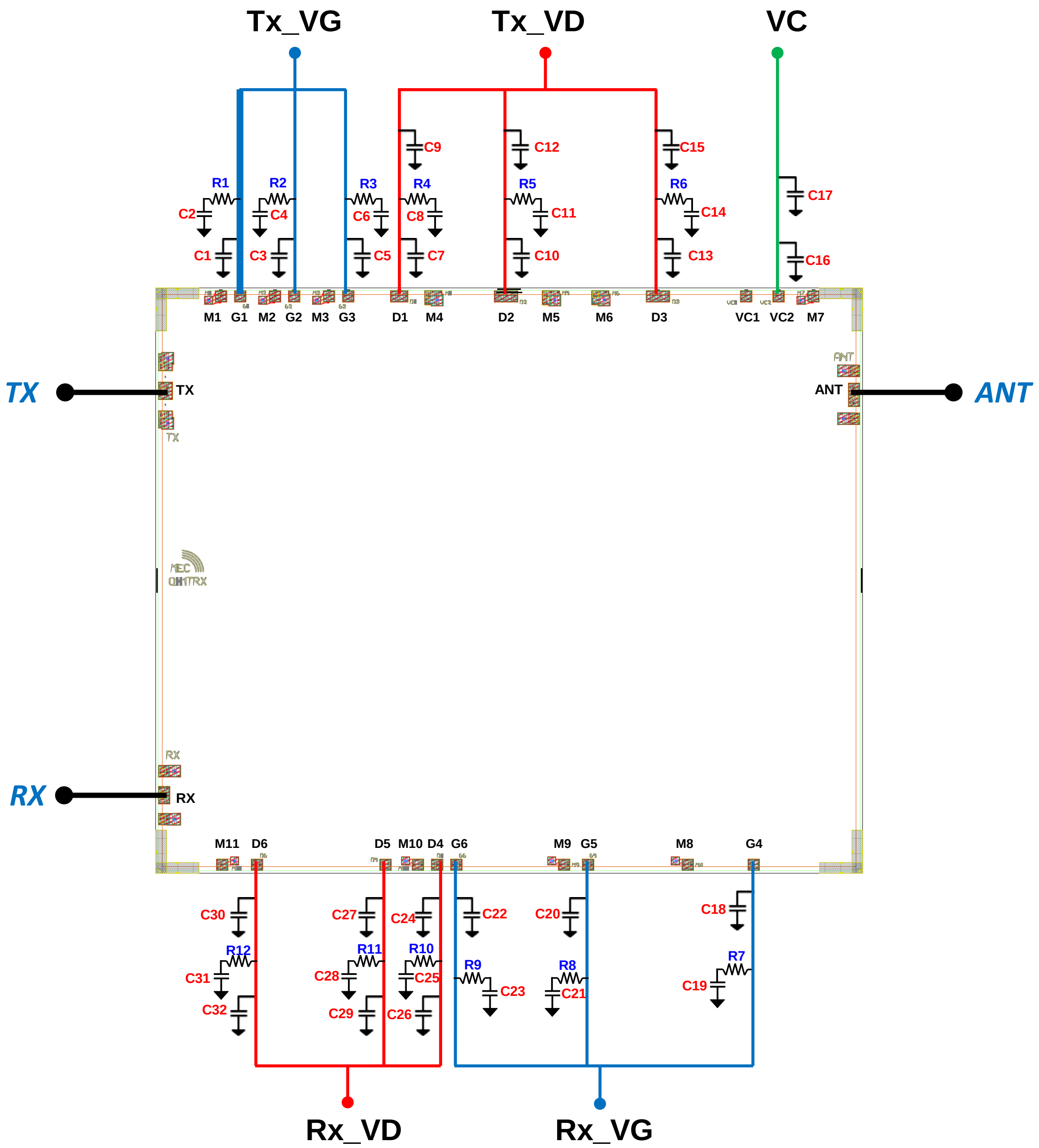


- Units: micrometres (µm)
- Chip dimensions: 6000 µm x 5000 µm ± 35 µm
- Chip Thickness is 70 µm ± 5 µm
- Chip edge to bond pad dimensions are shown to center of pad
- Ground is backside of die

Bond Pad Description

Bond Pad #	Pad Size (µm)	Description
TX	150 x 120	Input transmit RF Port
RX	150 x 100	Output receive RF Port
ANT	200 x 100	Antenna In/Out RF Port
VC2	100 x 100	Control Voltage for Tx/Rx switch
G1 … G3	100 x 100	Gate Bias for Transmit chain. Typ. values and current at p. 2.
G4 … G6	100 x 100	Gate Bias for Receive chain. Typ. values and current at p. 2.
D1 … D3	200 x 100	Drain Bias for Transmit chain. Typ. values and current at p. 2.
D4 … D6	100 x 100	Drain Bias for Receive chain. Typ. values and current at p. 2.
M1 … M11	100 x 100	Ground pad
VC1	100 x 100	Not Connected

Assembly Plan



Ref.	Component	Value	Description
C1, C3, C5, C7, C10, C13, C16, C18, C20, C24, C27, C30	MIM Capacitor	100 pF	Low Frequency Bypass Capacitor
C2, C4, C6, C8, C11, C14, C17, C19, C21, C23, C25, C28, C31	SMT Capacitor	10 nF	Low Frequency Bypass Capacitor
C9, C12, C15, C26, C29, C32	SMT Capacitor	1 µF	Low Frequency Bypass Capacitor
R1… R12	SMT Resistor	5 Ω	Low power Resistor

Bias-up Procedure

1. Set current limits:
    - Tx_ID = 4 A; Rx_ID = 50 mA; IC = 5 mA; Tx_IG = Rx_IG = 10 mA
2. Set Tx_VG = -5 V and Rx_VG = -7 V;
3. Set VC = 0 V (-20 V) for Transmit (Receive);
4. Set Tx_VD = 17.5 V and Rx_VD = 10 V;
5. Adjust Tx_VG (Rx_VG) to achieve required current for Transmit (Receive) keeping Rx_VG = -7 V (Tx_VG = -5 V).
6. Apply RF signals.

Bias-down Procedure

1. Turn off RF signals.
2. Set Tx_VG = -5 V and Rx_VG = -7 V;
3. Set Tx_VD = 0 V and Rx_VD = 0 V;
4. Turn off drain supply;
5. Turn VC;
6. Turn off gate supply.

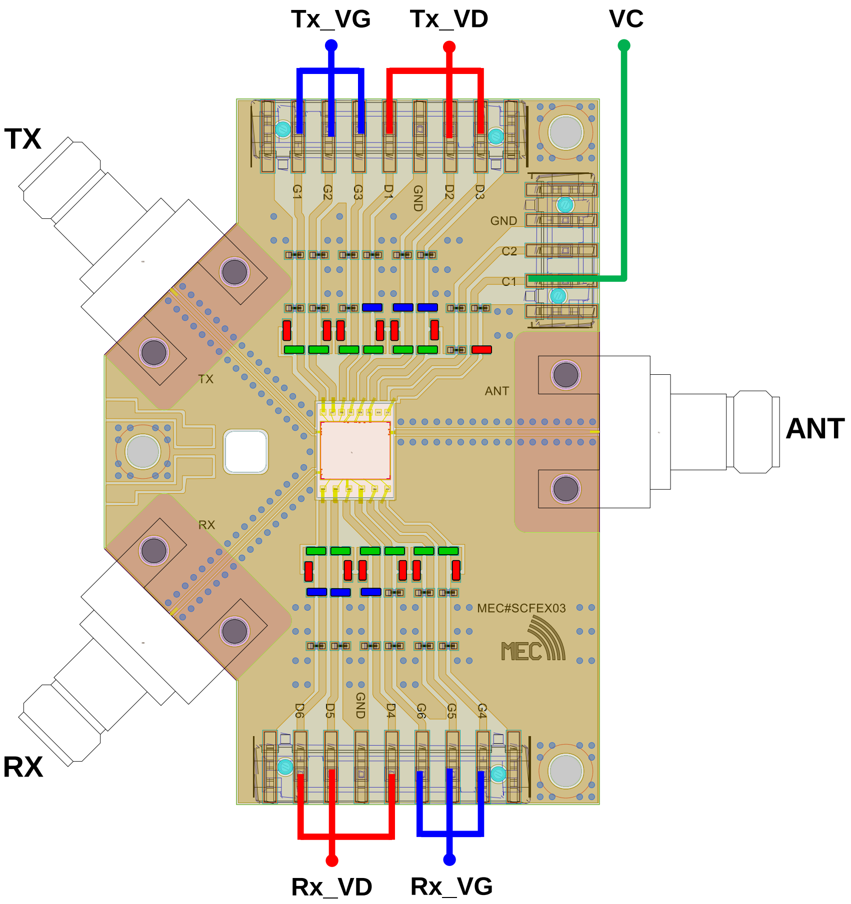
Evaluation Board and Bonding Diagram

🟨 **MIM CAP, 100 pF, 25 V**

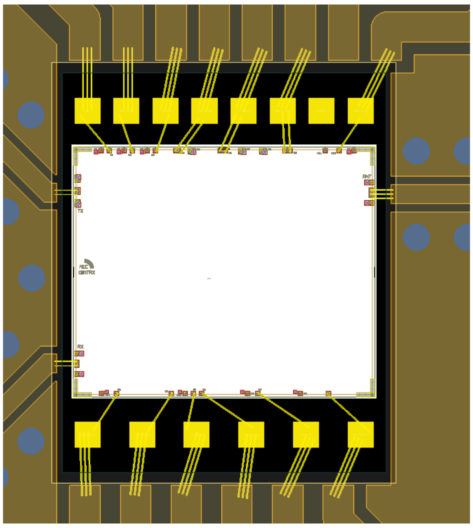
🟦 **CAP 0402, 1 uF, 25 V**

🟥 **CAP 0402, 10 nF, 10 V**

🟩 **RES 0402, 5 Ohm**



Bonding Diagram



0.008” thick Rogers Corp. RO4003C (ε_r = 3.35) with copper coin and 0.04” copper carrier. Metal layers 0.5 oz. copper cladding. Microstrip to Coplanar transition optimized to access the MMIC. Microstrip to coplanar transition for connector interface optimized for the Southwest Microwave end launch 1092-01A-6.

Assembly Guideline

The backside of the MMIC is RF ground. Die attach should be accomplished with electrically and thermally conductive epoxy only. Eutectic attach is not recommended. Follow manufacture instructions for epoxy curing.

Standard assembly procedures should be followed for high frequency devices. The top surface of the semiconductor should be made planar to the adjacent RF transmission lines. Vacuum pencils and/or vacuum collets are the preferred method of pick up. Do not make contact directly with the die surface as this will damage the monolithic circuitry. Air bridges must be avoided during placement. Handle with care.

RF connections should be made as short as possible to reduce the inductive effect of the bond wire. Use of a 25 µm thermosonic wedge bonding is highly recommended as the loop height will be minimized. Force, time, and ultrasonic are critical parameters.

RoHS Compliance

The product is compliant with the 2011/65/EU RoHS directive 2015/863/EU and REACH N° 1907/2006.

Contact Information

For additional technical Information and Requirements: **contact.mec@mec-mmic.com**

Notice

The furbished information is believed to be reliable. However, performances and specifications contained herein are based on preliminary characterizations and then susceptible to possible variations. On the basis of customer requirements, the product can be tested and characterized in specific operating conditions and, if needed, tuned to meet custom specifications.

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