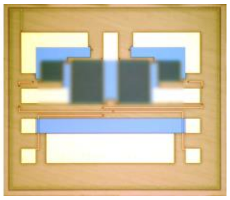
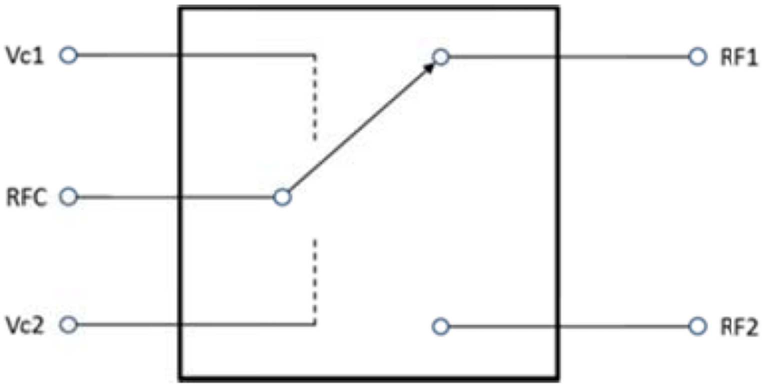
RFSW2100D

55W GaN-on-SiC Reflective SPDT RF Switch



Package: Bare Die 1mm x 0.8mm

The RFSW2100D is a GaN-on-SiC high power discrete RF switch designed for military and commercial wireless infrastructure, industrial/scientific/medical and general purpose broadband RF control and switching applications. Using an advanced high power density gallium nitride (GaN) semiconductor process, the RFSW2100D is able to achieve low insertion loss and high isolation with better than 10dB return loss across a wide band from 30MHz to 6GHz with proper die attach and heat sinking. The RFSW2100D is an SPDT RF switch suitable for many applications with 55W CW input power compression capability under controlled conditions, VSWR (3:1) and 25°C T_{CASE}, hot switching capable, as well as 0.34dB insertion loss, and 37dB small signal isolation at 2GHz.



Functional Block Diagram

Features

- Broadband Operation 30MHz to 6GHz
- Advanced GaN HEMT Technology
- 2GHz Typical Performance
  - Insertion Loss: 0.34dB
  - Isolation: 37dB
  - $P_{0.1}$dB of 55W at -40V V_{LOW}
- Small Form Factor
  - 1 x 0.8mm
- High Power Capability
  - $P_{0.1}$dB of 55W
- Designed to Present 50Ω I/O
- Hot Switching Capable

Applications

- Military Communicaiton
- Electronic Warfare
- Commercial Wireless Infrastructure
- Cellular and WiMAX Infrastructure
- Civilian and Military Radar
- General Purpose Broadband Amplifiers
- Public Mobile Radios
- Industrial, Scientific, and Medical

Ordering Information

RFSW2100D	55W GaN on SiC RF Switch

Absolute Maximum Ratings

Parameter	Rating	Unit
Max Control Bias	-60	V
CW RF Input Power	69	W
Storage Temperature Range	-55 to +125	°C
Operating Temperature (Case)	-40 to +85	°C
Operating Junction Temperature (T_J)	250	°C
Human Body Model (based on packaged device)	Class 1A	
MTTF @ -40V OFF Control Bias (95% Confidence Limits)* (T_J < 200°C)** (T_J < 250°C)**	 3.0×10^8 1.0×10^7	 Hours Hours
Thermal Resistance, R_{th} (junction to case)*** (Expected value at T_C = 85°C) DC	10.5	°C/W

Caution! ESD sensitive device.

RFMD Green: RoHS compliant per EU Directive 2011/65/EU, halogen free per IEC 61249-2-21, <1000ppm each of antimony trioxide in polymeric materials and red phosphorus as a flame retardant, and <2% antimony solder.

Exceeding any one or a combination of the Absolute Maximum Rating conditions may cause permanent damage to the device. Extended application of Absolute Maximum Rating conditions to the device may reduce device reliability. Specified typical performance or functional operation of the device under Absolute Maximum Rating conditions is not implied.

Operation of this device beyond any one of these limits may cause permanent damage. For reliable continuous operation, the device voltage and current must not exceed the maximum operating values specified in the table above.

*MTTF - median time to failure as determined by the process technology wear-out failure mode. Refer to product qualification report for FIT(random) failure rate.

**User will need to define this specification in the final application and ensure bias conditions satisfy the following expression: $P_{DISS} < (T_J - T_C) / R_{TH}$ J-C and $T_C = T_{CASE}$ to maintain maximum operating junction temperature and MTTF.

***The thermal resistance quoted here (10.5C/W) is the thermal resistance of the GaN-on-SiC die itself, not including the contribution of any particular attach method. R_{th} is defined as $(T_J - T_C)$ / Power, where T_C is measured at the bottom of the SiC.

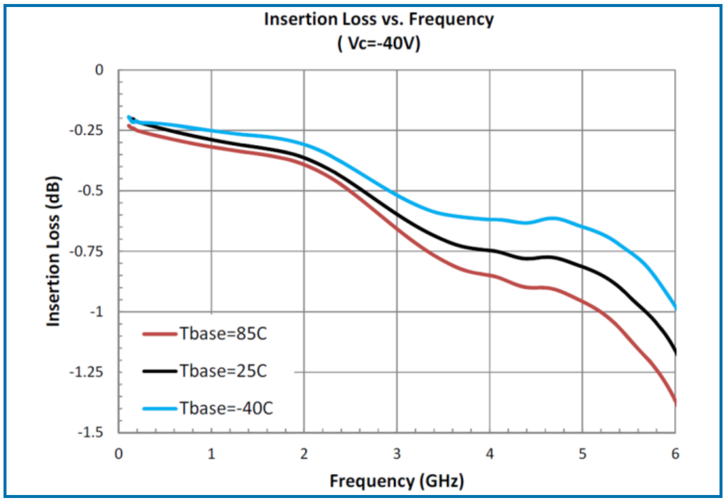
Nominal Operating Parameters

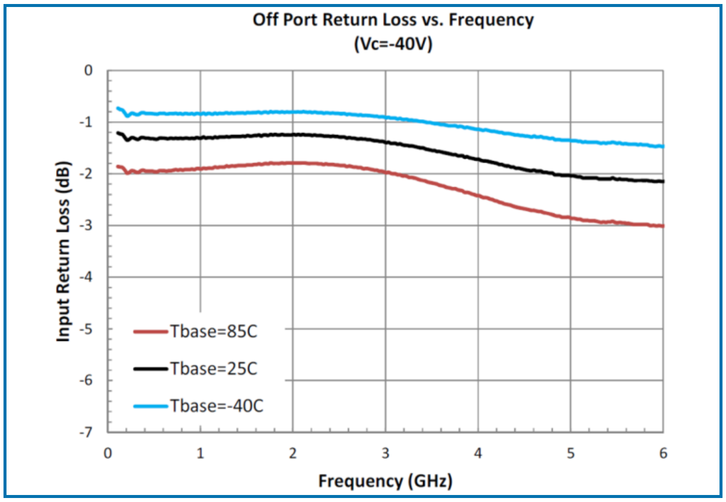
Parameter	Specification			Unit	Condition
	Min	Typ	Max		
Recommended Operating Conditions					
OFF Control Bias	-20	-40		V	
ON Control Bias		0		V	
RF I/O Impedance		50		Ω	
Functional Test					
RFC-RF1 Insertion Loss	-0.25			dB	Frequency = 880MHz P_{IN} = 30dBm V_C1 = 0V V_C2 = -10V
RFC-RF2 Insertion Loss	-0.25			dB	Frequency = 880MHz P_{IN} = 30dBm V_C1 = -10V V_C2 = 0V
RFC-RF1 Isolation			-60	dB	Frequency = 880MHz P_{IN} = 30dBm V_C1 = -10V V_C2 = 0V
RFC-RF2 Isolation			-60	dB	Frequency = 880MHz P_{IN} = 30dBm V_C1 = 0V V_C2 = -10V
RFC-RF1 2nd Harmonic			-20	dBm	Frequency = 880MHz P_{IN} = 30dBm V_C1 = 0V V_C2 = -10V
RFC-RF2 2nd Harmonic			-20	dBm	Frequency = 880MHz P_{IN} = 30dBm V_C1 = -10V V_C2 = 0V
RFC-RF1 3rd Harmonic			-10	dBm	Frequency = 880MHz P_{IN} = 30dBm V_C1 = 0V V_C2 = -10V
RFC-RF2 3rd Harmonic			-10	dBm	Frequency = 880MHz P_{IN} = 30dBm V_C1 = -10V V_C2 = 0V
RFC-RF1 - V_C1 Current			250	µA	Frequency = 880MHz P_{IN} = 30dBm V_C1 = 0V V_C2 = -10V
RFC-RF2 - V_C1 Current	-600			µA	Frequency = 880MHz P_{IN} = 3 0dBm V_C1 = -10V V_C2 = 0V
RFC-RF1 - V_C2 Current			250	µA	Frequency = 880MHz P_{IN} = 30dBm V_C1 = 0V V_C2 = -10V
RFC-RF2 - V_C2 Current	-600			µA	Frequency = 880MHz P_{IN} = 30dBm V_C1 = -10V V_C2 = 0V

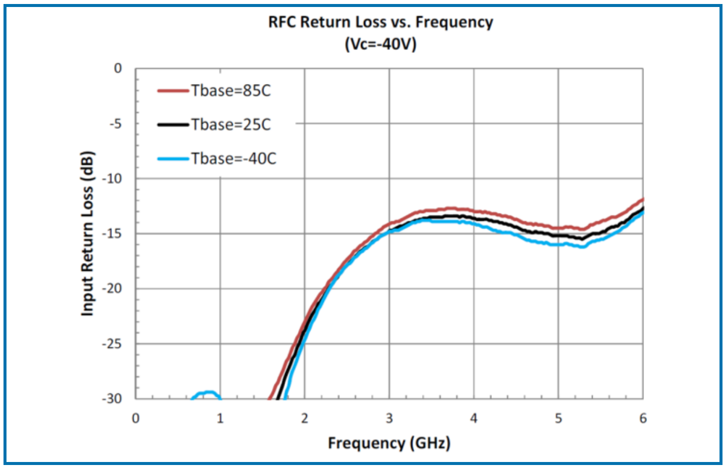
Parameter	Specification			Unit	Condition
	Min	Typ	Max		
Power Performance - Typical					
Frequency Range*	DC		6	GHz	Power performance measured at 2GHz, V_{LOW} control bias of -40V, controlled Tbase 25°C
$P_{0.1}$dB		55		W	
$P_{0.1}$dB		47.4		dbm	
Linearity - Typical					
Second Harmonic (Pf2)		82		dBc	P_{in} = 30dBm Frequency = 2GHz V_C = -40V
Third Harmonic (Pf3)		79		dBc	P_{in} = 30dBm Frequency = 2GHz V_C = -40V
Third Order Intercept		69		dBc	P_{in} = 30dBm and Tone1 = 1.995GHz Tone2 = 2.005GHz
Small Signal Performance of Packaged Device – Typical (ON/OFF port refers to either of RF1/RF2, as dictated by bias at V_C1 and V_C2, the truth table for which is shown on page 9).					
Insertion Loss (RFC to ON Port) Isolation (RFC to OFF Port) Input Return Loss (RFC)		-0.29 -48.1 -31.3		dB dB dB	F = 1GHz F = 1GHz F = 1GHz
Insertion Loss (RFC to ON Port) Isolation (RFC to OFF Port) Input Return Loss (RFC)		-0.35 -38.4 -23.7		dB dB dB	F = 2GHz F = 2GHz F = 2GHz
Insertion Loss (RFC to ON Port) Isolation (RFC to OFF Port) Input Return Loss (RFC)		-0.59 -31.1 -14.7		dB dB dB	F = 3GHz F = 3GHz F = 3GHz
Insertion Loss (RFC to ON Port) Isolation (RFC to OFF Port) Input Return Loss (RFC)		-0.74 -26 -13.6		dB dB dB	F = 4GHz F = 4GHz F = 4GHz

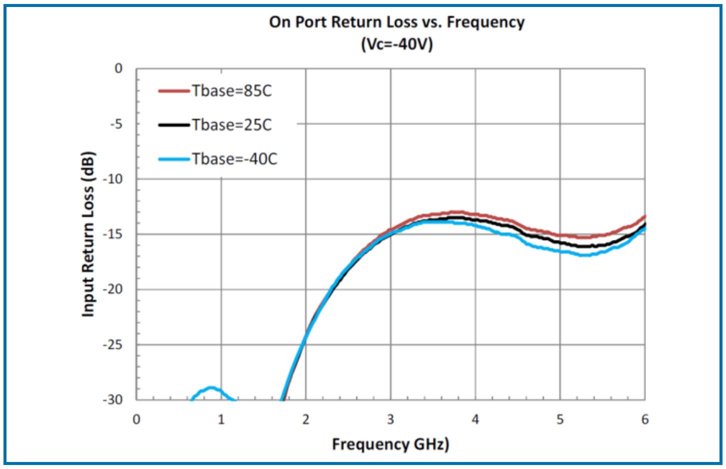
*Input power handling will reduce < 30MHz

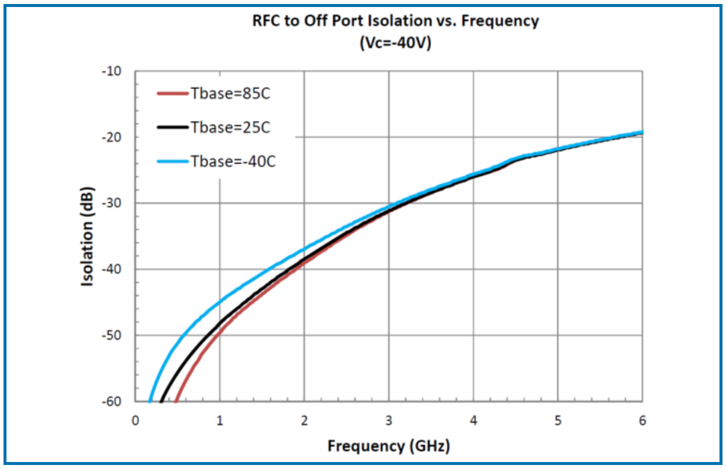
Typical Small Signal Performance (P_{IN} = 0dBm) verses Frequency, Measured with V_C = 40V Over Varying Temperature

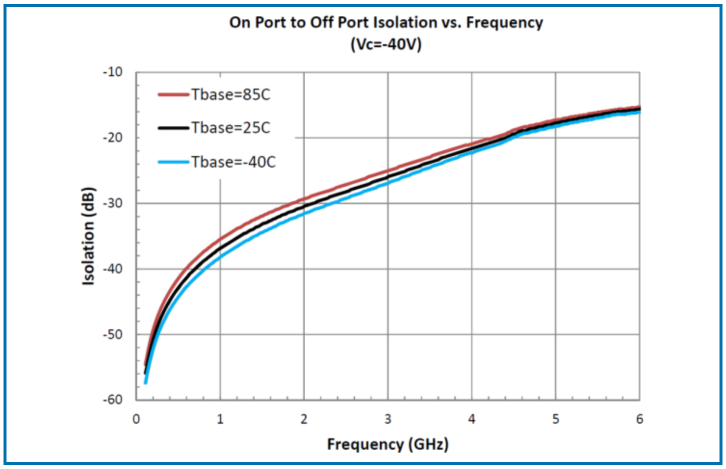




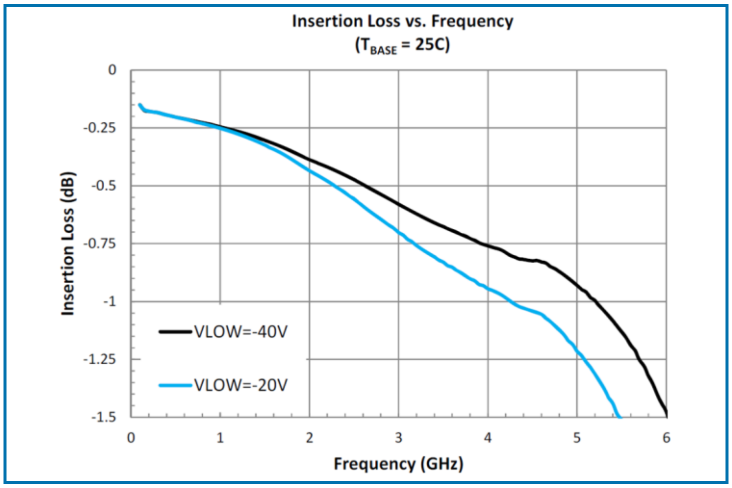


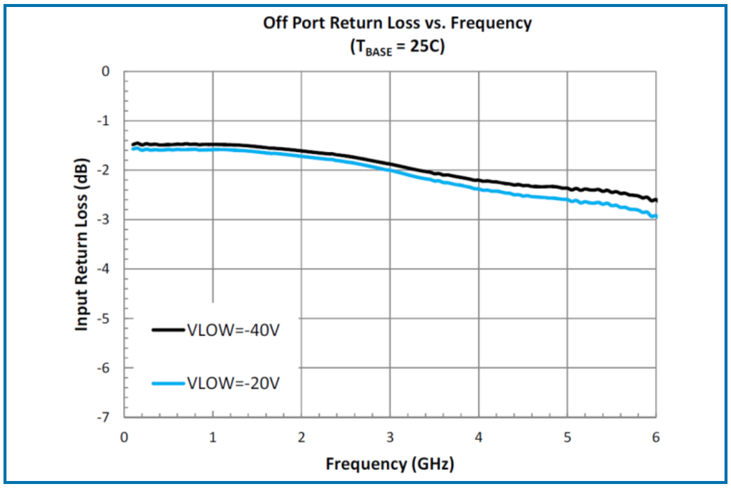


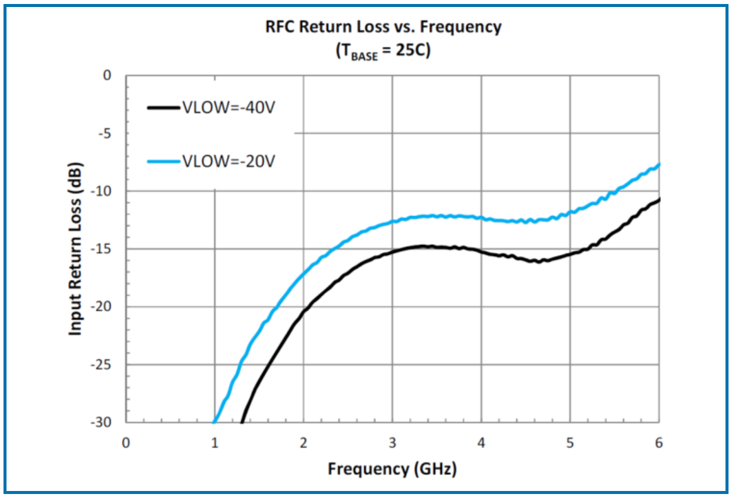


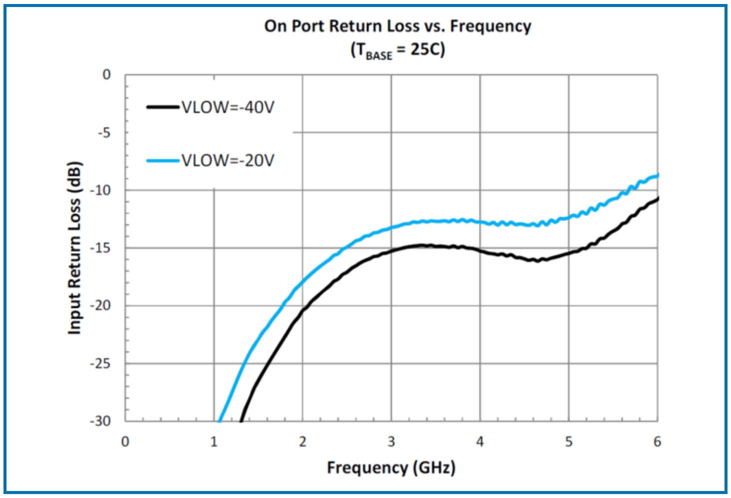


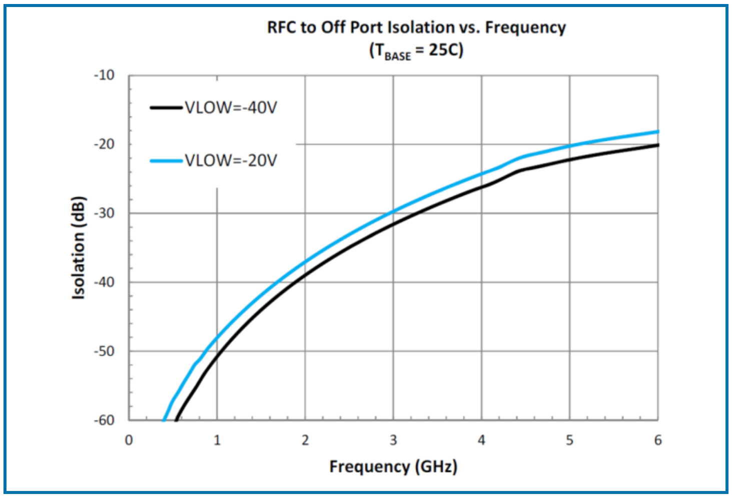
Typical Small Signal Performance (P_{IN} = 0dBm) verses Frequency, Measured at Room Temperature over Varying Control Bias

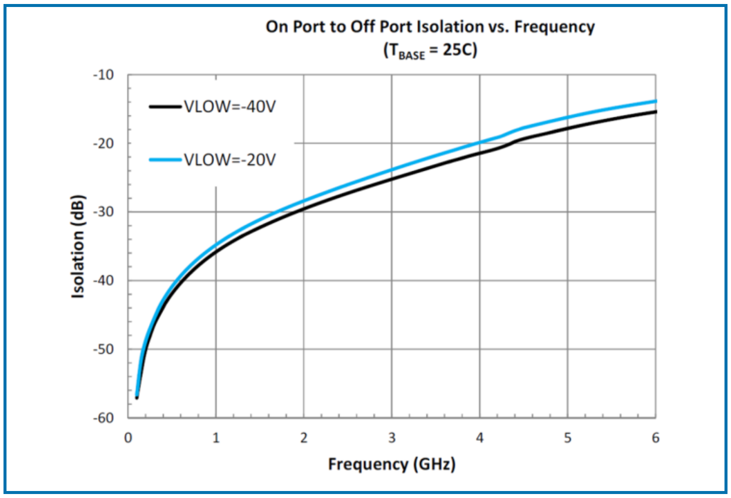




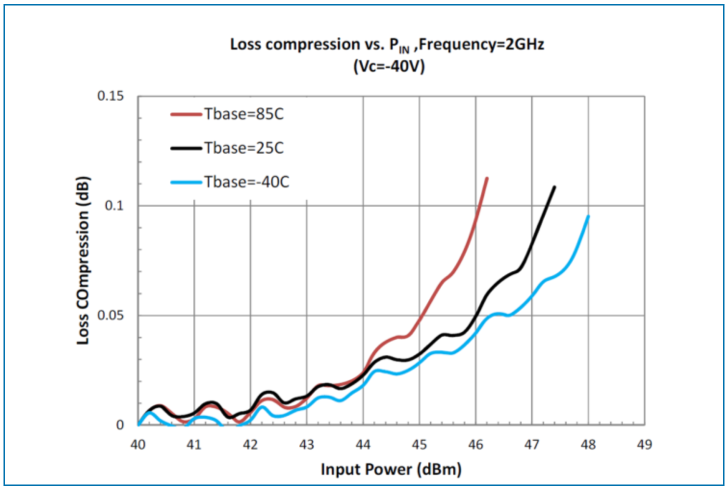


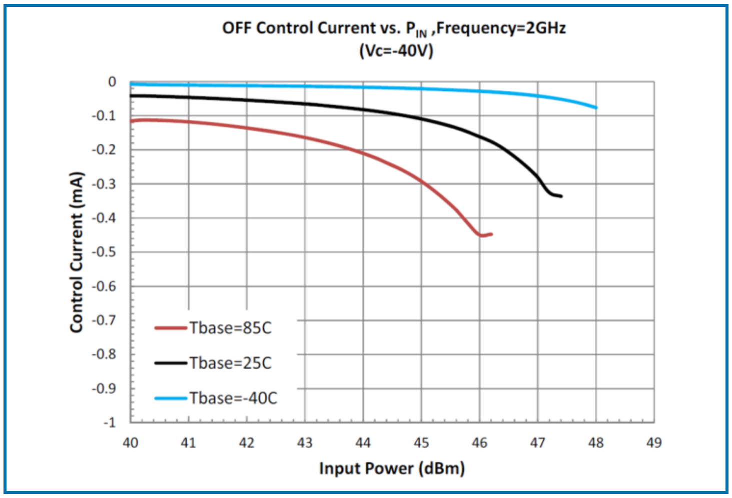


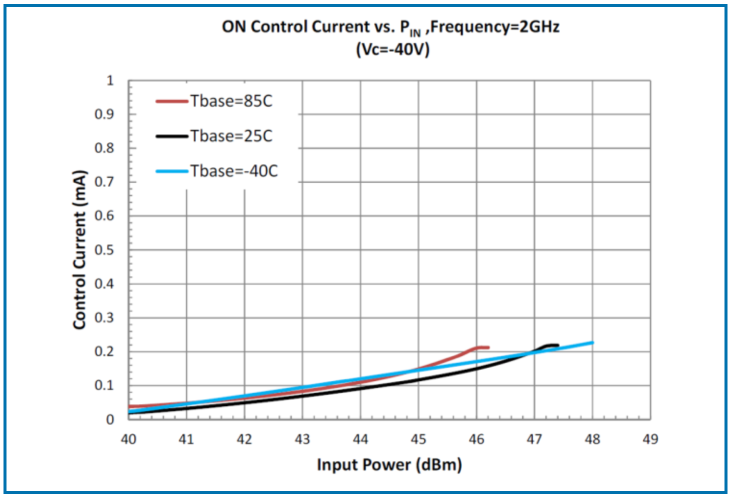




Typical Performance (continued)

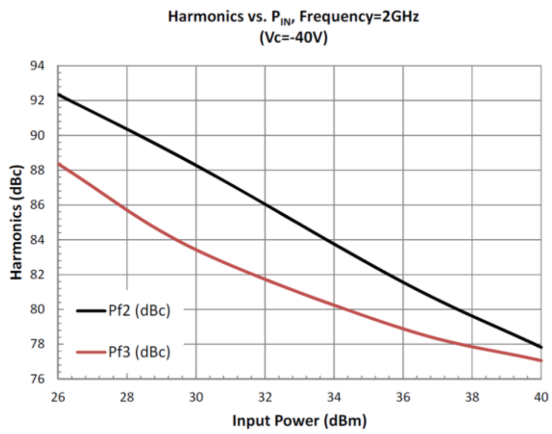




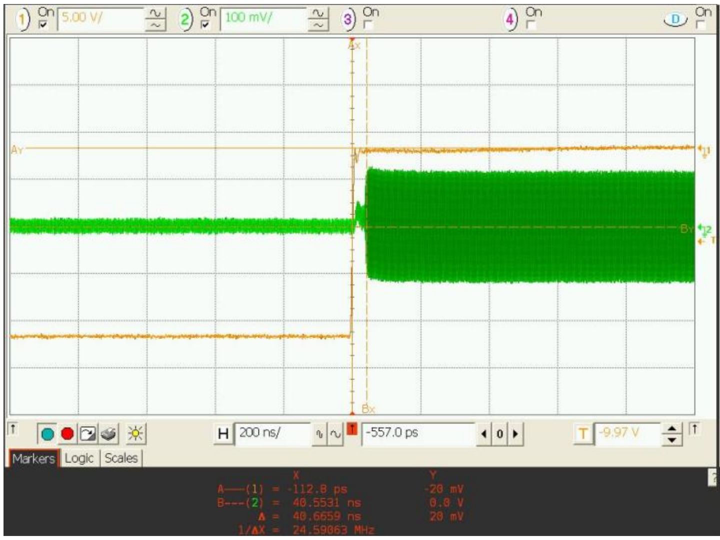


Test Conditions: CW Operation, base temperature measured via thermocouple embedded in heatsink mounted to evaluation pcb.

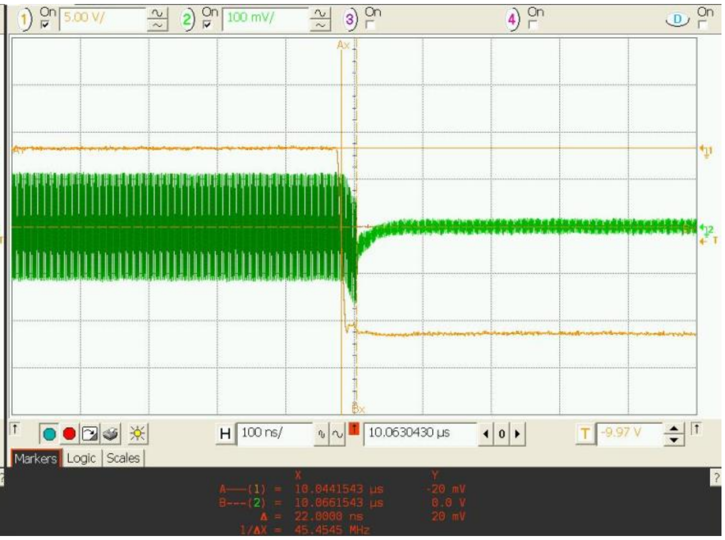
Harmonics



Switching Time

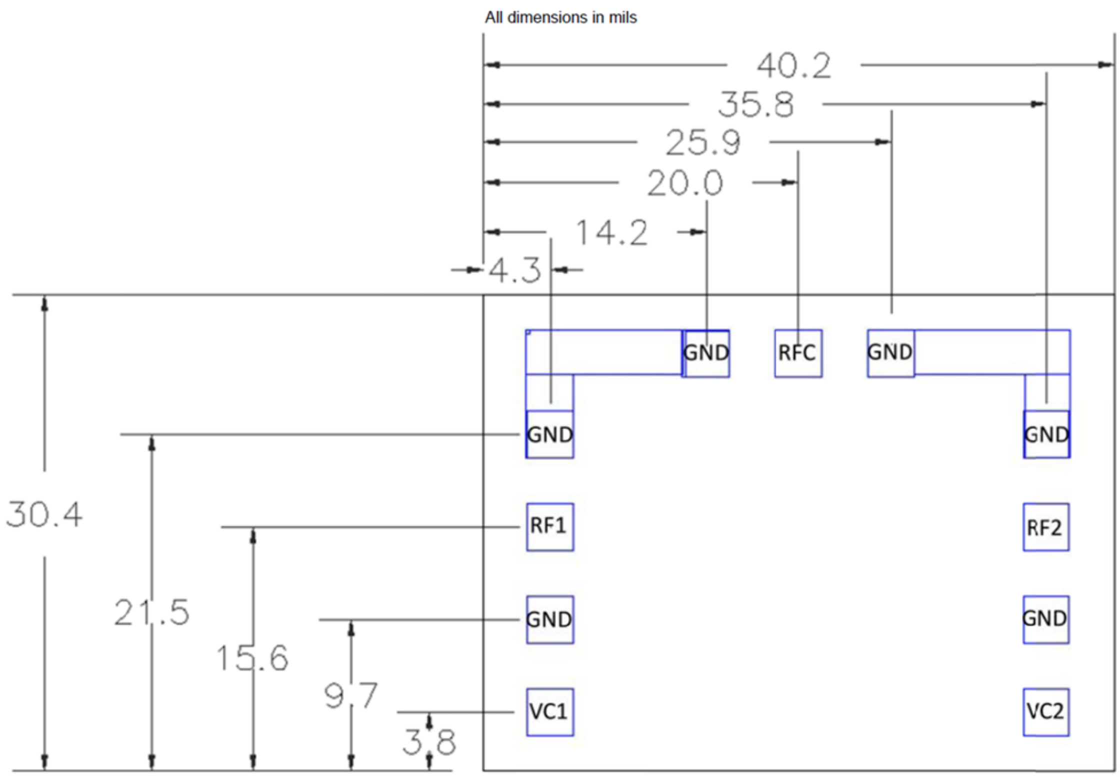


Switching Speed – ON = 40ns
V_{LOW} = 0/-20, Switching frequency= 10kHz, P_{in} = -8dBm



Switching Speed – OFF = 22ns
V_{LOW} = 0/-20, Switching frequency= 10kHz, P_{in} = -8dBm

Die Drawing (Dimensions in millimeters)



Pin Names and Descriptions

Pin	Name	Description
1	GND	Ground connection
2	RF2	RF port 2, internally matched to 50Ω
3	GND	Ground connection
4	V_C1	Logic control for RF1
5	GND	Ground connection
6	V_C2	Logic control for RF2
7	GND	Ground connection
8	RF1	RF port 1, internally matched to 50Ω
9-10	GND	Ground connection
11	RFC	RF common port, internally matched to 50Ω
12	GND	Ground connection

Bias Instruction for RFSW2100D Die

ESD Sensitive Material. Please use proper ESD precautions when handling devices die.
Die must be mounted with minimal die attach voids for proper thermal dissipation and power handling capability. This device uses depletion mode HEMT's and must have recommended gate voltage applied prior to applying RF power.

1. Mount device on carrier or package with minimal die attach voiding and apply proper heat removal techniques.
2. Connect ground to the ground supply terminal.
3. Ensure that all 3 RF ports are connected to external RF connections through dc blocking elements for protection to RF connected devices in case of GaN RF switch failure event.
4. Apply V_{LOW} to appropriate control port, as defined by truth table.
5. Apply V_{HIGH} to appropriate control port, as defined by truth table.
6. Apply RF signal.

Switch Status		Logic Control	
RF1 to RFC	RF2 to RFC	V_C1	V_C2
Off	On	High	Low
On	Off	Low	High

High = 0V
Low = -20V to -40V

Assembly Notes

Die Storage

- Individual bare die should be held in appropriately sized ESD waffle trays or ESD GEL packs.
- Die should be stored in CDA/N2 cabinets and in a controlled temperature and humidity environment.

Die Handling

- Die should only be picked using an automated or semi-automated pick system and an appropriate pick tool.
- Pick parameters will need to be carefully defined so as not to cause damage to either the top or bottom die surface.
- GaN HEMT devices are ESD sensitive materials. Please use proper ESD precautions when handling devices or evaluation boards.
- RFMD does not recommend operating this device with typical drain voltage applied and the gate pinched off in a high humidity, high temperature environment.

Caution: The use of inappropriate or worn-out ejector needle and improper ejection parameter settings can cause die backside tool marks or micro-cracks that can eventually lead to die cracking.

Die Attach

There are two commonly applied die attach processes: adhesive die attach and eutectic die attach. Both processes use special equipment and tooling to mount the die.

EUTECTIC ATTACH

- 80/20 AuSn preform, 0.5mil to 1mil thickness, made from virgin melt gold.
- Pulsed heat or die scrub attach process using automated or semi-automatic equipment.
- Attach process carried out in an inert atmosphere.
- Custom die pick collets are required that match the outline of the die and the specific process employed using either pulsed, fixed heat, or scrub.
- Maximum temperature during die attach should be no greater than 320°C and for less than 30 seconds.
- Key parameters that need to be considered include: die placement force, die scrub profile and heat profile.
- Minimal amount of voiding is desired to ensure maximum heat transfer to the carrier and no voids should be present under the active area of the die.
- Voiding can be measured using X-ray or Acoustic microscopy.
- The acceptable level of voiding should be determined using thermal modeling analysis.

ADHESIVE ATTACH

- High thermal silver filled epoxy is dispensed in a controlled manner and die is placed using an appropriate collet. Assembled parts are cured at temperatures between 150°C and 180°C.
- Always refer to epoxy manufacturer's data sheet.
- Industry recognized standards for epoxy die attach are clearly defined within MIL-883.

Mounting and Thermal Considerations

The thermal resistance provided as R_{TH} (junction to case) represents only the packaged device thermal characteristics. This is measured using IR microscopy capturing the device under test temperature at the hottest spot of the die. At the same time, the package temperature is measured using a thermocouple touching the backside of the die embedded in the device heatsink but sized to prevent the measurement system from impacting the results. Knowing the dissipated power at the time of the measurement, the thermal resistance is calculated.

In order to achieve the advertised MTTF, proper heat removal must be considered to maintain the junction at or below the maximum of 200°C. Proper thermal design includes consideration of ambient temperature and the thermal resistance from ambient to the back of the package including heatsinking systems and air flow mechanisms. Incorporating the dissipated DC power, it is possible to calculate the junction temperature of the device.

DC Bias

The GaN HEMT device is a depletion mode high electron mobility transistor (HEMT). At zero volts V_{GS} the drain of the device is saturated and uncontrolled drain current will destroy the transistor. The gate voltage must be taken to a potential lower than the source voltage to pinch off the device prior to applying the drain voltage, taking care not to exceed the gate voltage maximum limits.