

2 Watt RF Power Amplifier for 10 GHz

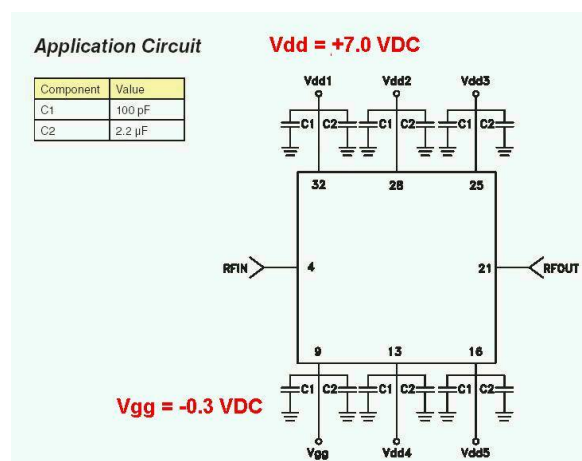
Overview

Generating RF power above a few milliwatts in the 10 GHz band used to be very difficult. Thankfully, Hittite Microwave Corp. has the HMC487, which is an easy-to-use X-band amplifier chip that requires no complicated external RF circuitry or weird voltage biasing. The HMC487 costs around \$60 in single quantities and the evaluation board – which is *highly* recommended – is a couple hundred dollars. The project shown here will be based around the HMC487 evaluation board to help make construction of the final amplifier very easy, even for a beginner microwave experimenter.

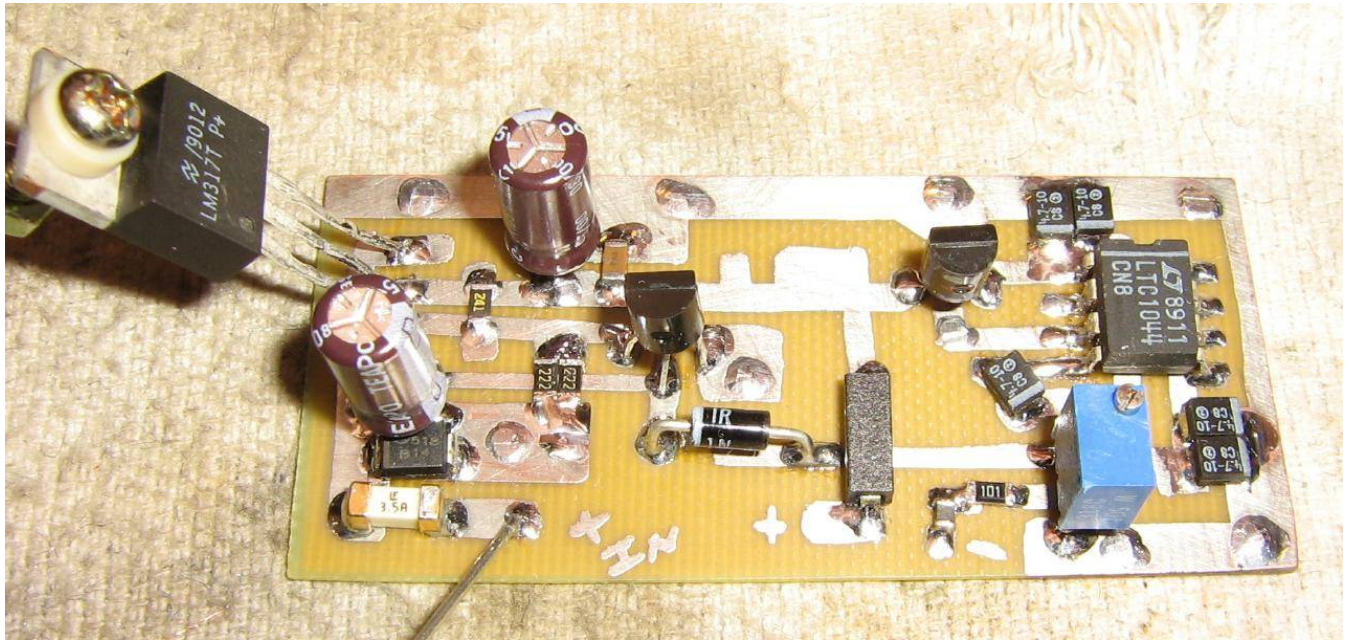
The Hittite HMC487 is a remarkable little chip. It has around 20 dB of gain from 9 to 12 GHz and is internally matched to 50 ohms on both the RF input and output. This means no fussing with complex tuning lines or sliding solder flakes! It will do an easy 1 watt (+30 dBm) RF output with a 10 mW (+10 dBm) RF input over most of the X-band. It saturates at around 2 watts (+33 dBm) and I've heard it can reach 3 watts (+35 dBm) if you run it with a little higher drain voltage and fiddle with the input return loss matching a bit. The only real drawback to the HMC487 is the large amount of heat it needs to dissipate. Its RF efficiency is only around 20% and the rest of this energy will need to be dissipated as heat. To properly do this, a small block of aluminum will need to be milled out in order to securely hold the HMC487 evaluation board. This new aluminum block can act as a heatsink alone, or it can be further attached to a larger heatsink in order to improve cooling. This entire process may be difficult to accomplish if you don't have access to a milling machine, but some type of additional heatsinking, or probably even fan cooling, for the HMC487 evaluation board will be *required*. This is especially true if you plan on operating the amplifier for an extended period of time.

To power the HMC487, a +12 VDC input will be regulated down to +7 volts using a LM317 adjustable voltage regulator. The HMC487 does require a small negative voltage for its gate bias which will be generated with a LTC1044 negative voltage converter and controlled via a 500 ohm multturn potentiometer. A simple 4.7 volt Zener diode / 2N3904 transistor circuit will "power down" the LM317 voltage regulator until the negative gate voltage is applied to the HMC487. This little Zener voltage pre-conditioning circuit is a requirement to protect the HMC487 when voltage is first applied. When the HMC487's negative gate bias is set (at around -0.3 VDC), the amplifier's supply current (1.3A) will not change whether RF input power is applied or removed.

HMC487 Application Circuit



Pictures & Construction Notes



Overview of the Hittite HMC487 evaluation board power supply circuit.

Nothing too complicated is required, but try to have a good ground plane on the PC board.

The +12 VDC input is from the lower-left and goes through a little surface-mount 3 amp fuse. The LM317's tab will need to be isolated from the project box with a mica washer or thermal pad and a plastic feed-through on the mounting screw. High-quality capacitors can be salvaged from old computer motherboards.

The blackish rectangle thing in the middle is a high-current surface-mount ferrite bead.

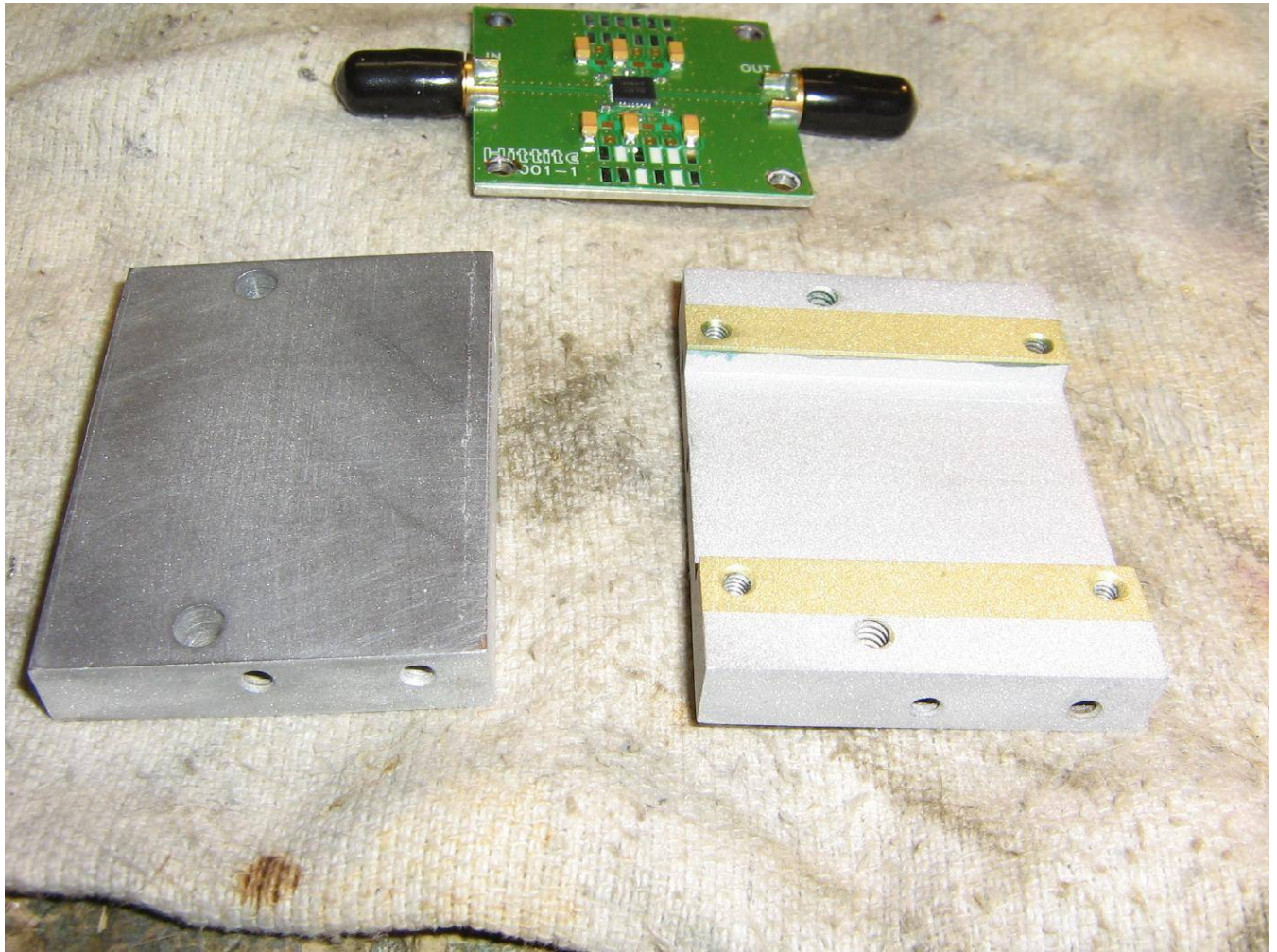
The LTC1044 negative voltage converter is on the upper-right and takes its input from a 78L05 voltage regulator. The -5 VDC output of the LTC1044 is then fed to a multiturn 500 ohm potentiometer. This is used to adjust the HMC487's gate bias for a final quiescent current draw of 1.3 amps. The negative voltage going to the HMC487 should never exceed -2.0 volts.

For additional protection, the +12 VDC power supply feeding this circuit should be current-limited to around 2 amps.



Installing the power supply circuit in the project box.

This old project box was found at a hamfest and already had a bunch of holes drilled in it, so it may look a little funny and is probably a tad too small to house everything.



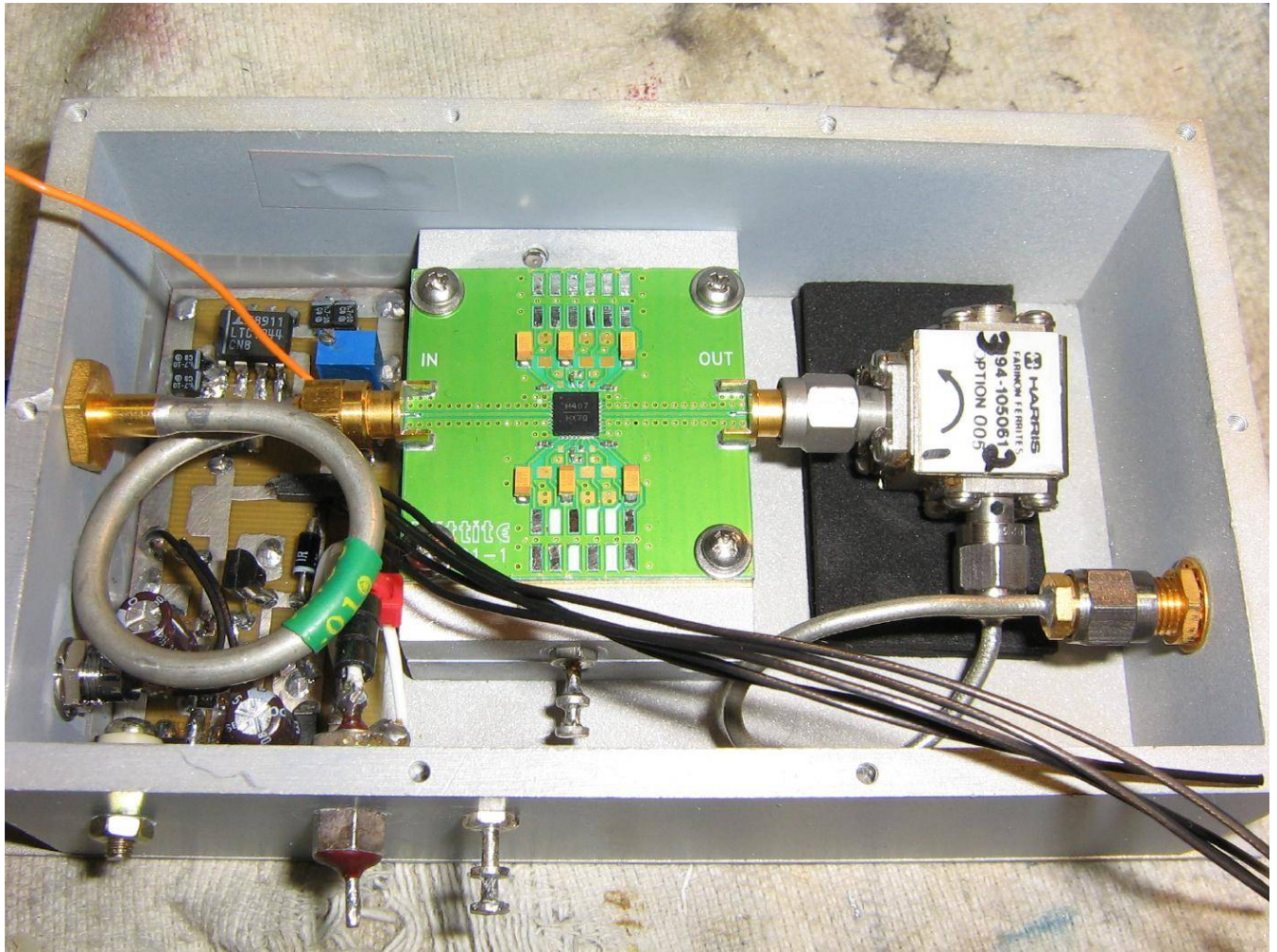
Overview of the Hittite HMC487 evaluation board and the milled aluminum mounting block.

The aluminum blocks were salvaged from other projects, hence the holes in the sides. Two were used in order to make room for an optional RF isolator attached to the RF output of the HMC487.

The block on the right-side has a slot milled to accept the little heatsink on the bottom of the HMC487 evaluation board. Thermal grease was lightly applied to each piece and then the entire assembly is bolted to the bottom of project box.

The brass inserts on that one aluminum block were added when I machined the aluminum down a little too much.

The HMC487 evaluation board has a little 1/4-inch thick aluminum square attached to its bottom to act as a makeshift heatsink, but it's far too small for continuous operation. The idea here is to mill out a slot for this stock heatsink to fit in, then mount this entire assembly to a larger heatsink.



Mounting the evaluation board in the project box.

Four holes were also drilled in the HMC487 evaluation board and the top aluminum block. The holes in the aluminum block were then tapped with #3–48 threads and the evaluation board was secured to the aluminum blocks with #3–48 hardware.

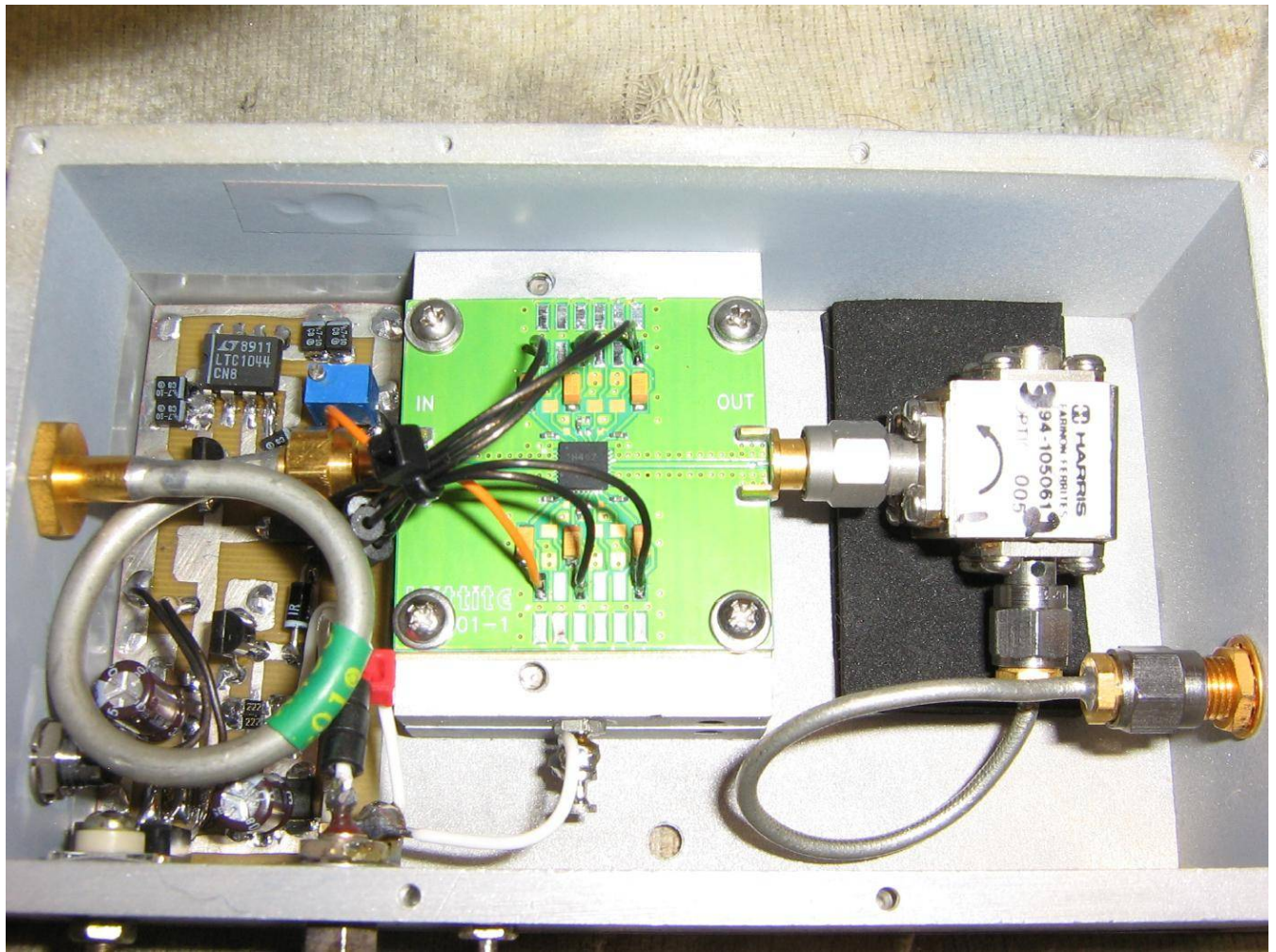
Two #6–32 screws come up from the bottom and secure two aluminum blocks together.

The pin headers were removed from the HMC487 evaluation board to allow the drain and gate wires to be soldered directly to the board. A solder terminal was added to one of the aluminum blocks for the ground.

The +12 VDC input is via the feed-through capacitor on the lower-left. Ground is the solder terminal to the right. There are a couple extra ferrite beads on the incoming +12 VDC wire.

The RF input is on the left-side and comes in via a panel-mounted SMA connector on a salvaged piece of UT-141 coax. The RF output goes through an optional 10 GHz RF isolator (Harris/Farinon 94-105061) to protect the HMC487 in the event of an impedance mismatch downline. The final RF output is via a panel-mounted SMA bulkhead.

The RF connectors and conformable coax were all hamfest finds, so it may look a little rough, but everything checked out fine.



Finished overview.

The **BROWN** wires carry the +7 VDC drain voltage. The **ORANGE** wire carries the approximately -0.3 VDC gate bias. The **WHITE** wire is a common ground for everything.

A few pieces of art foam are underneath the 10 GHz isolator to relieve any strain.

Extra ferrite beads were slipped over the wires carrying the drain and gate bias voltages.



Setting the HMC487's negative gate bias and drain quiescent current.

First, attach good 50 ohm loads to the RF input and output of the amplifier.

Then power the amplifier with a quality current meter inline with the incoming +12 VDC power line. Slowly adjust the 500 ohm gate bias potentiometer until the quiescent current reads around 1.3 amps.

The final gate voltage will be around -0.3 VDC. The meter in the above picture is reading -0.256 VDC. Don't exceed -2.0 volts on the gate bias line or the HMC487 will be damaged.



Finished case overview.

RF input is via the SMA connector on the left side.

RF output in on the right side. It passes through an optional 10 dB directional coupler for power monitoring or local oscillator drive on an external mixer.

+12 VDC power is applied via the feed-through capacitor.

For linear operations, you'll want to avoid running the amplifier into compression but for FM, or other constant-envelope modulations, you can let this amplifier hit 2 watts (+33 dBm) of RF output.

Doing this, when combined with a simple 18-inch DSS satellite dish, will make your ERP at least 2,000 watts – at 10 GHz!



v01.0705

HMC487LP5 / 487LP5E

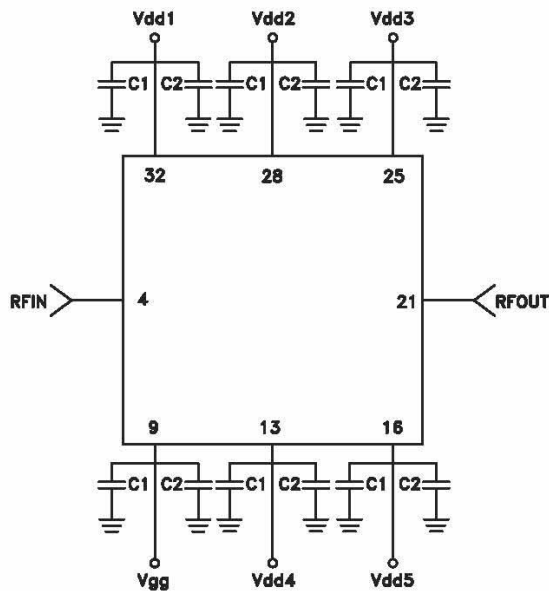
SURFACE MOUNT PHEMT 2 WATT POWER AMPLIFIER, 9 - 12 GHz

Pin Descriptions

Pin Number	Function	Description	Interface Schematic
1-3, 5-8, 10-12, 14, 15, 17-20, 22-24, 26, 27, 29-31	N/C	No connection required. These pins may be connected to RF/DC ground without affecting performance.	
4	RFIN	This pin is AC coupled and matched to 50 Ohms from 9 - 12 GHz.	
9	Vgg	Gate control for amplifier. Adjust to achieve I _{dd} of 1300 mA. Please follow "MMIC Amplifier Biasing Procedure" Application Note. External bypass capacitors of 100 pF and 2.2 μF are required.	
21	RFOUT	This pin is AC coupled and matched to 50 Ohms from 9 - 12 GHz.	
32, 28, 25, 13, 16	Vdd1, Vdd2, Vdd3, Vdd4, Vdd5	Power Supply Voltage for the amplifier. External bypass capacitors of 100 pF and 2.2 μF are required.	
	GND	Ground: Backside of package has exposed metal ground slug that must be connected to ground through a short path. Vias under the device are required.	

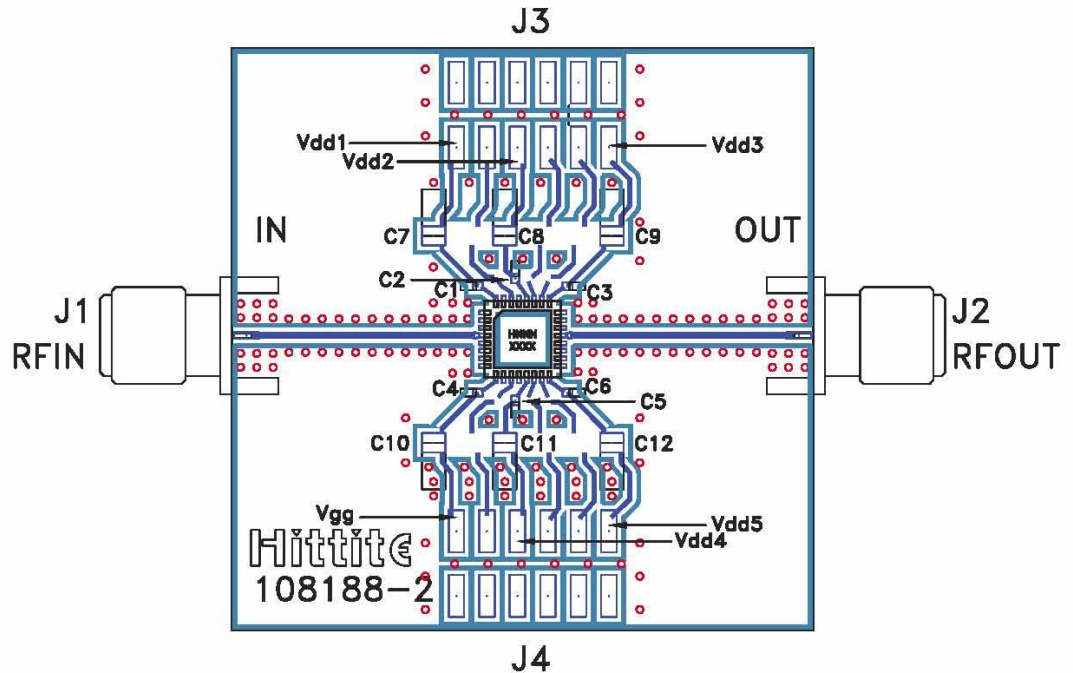
Application Circuit

Component	Value
C1	100 pF
C2	2.2 μF



For price, delivery, and to place orders, please contact Hittite Microwave Corporation:
 20 Alpha Road, Chelmsford, MA 01824 Phone: 978-250-3343 Fax: 978-250-3373
 Order On-line at www.hittite.com

Evaluation PCB



List of Materials for Evaluation PCB 108190 [1]

Item	Description
J1, J2	SRI PC Mount SMA Connector
J3, J4	2mm DC Header
C1 - C6	100 pF capacitor, 0402 pkg.
C7 - C12	2.2µF Capacitor, Tantalum
U1	HMC487LP5 / HMC487LP5E Amplifier
PCB [2]	108188 Evaluation PCB

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Rogers 4350.

The circuit board used in this application should use RF circuit design techniques. Signal lines should have 50 ohm impedance while the package ground leads and exposed paddle should be connected directly to the ground plane similar to that shown. A sufficient number of via holes should be used to connect the top and bottom ground planes. Copper filled vias under the device are recommended. The evaluation board should be mounted to an appropriate heat sink. The evaluation circuit board shown is available from Hittite upon request.

HMC487 Power Supply Circuits

