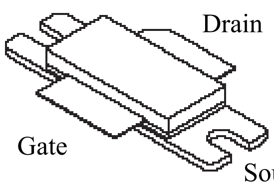
BIASING THE GaN HEMT DEVICE

The biasing of high power RF devices, especially GaN devices, requires special attention. The concerns are mainly for preventing instabilities/oscillations, maintaining large drain current with a small voltage drop, and bias decoupling circuits to reduce interference with the RF matching circuit and limiting its influence on the linearity of the device. This application note will be an attempt to address these issues of biasing a Nitronex GaN HEMT.

GaN HEMTs are depletion mode device which requires a negative voltage applied to the gate. By switching between a ground node and a positive voltage node, a standard power supply can be used to provide negative voltages.

For GaN HEMT devices, the first and most important issue is the biasing sequence. The goal is to stay away from areas that are sensitive to the potential instability of the device: the area where V_{DS} is low and Ids is high, for instance. Assuming that the device are properly connected to regulated power supplies, that drain and gate are sufficiently DC decoupled and connected to 50 Ohm terminations.



Packaged device lead identification for Nitronex's GaN HEMT device.

Recommended biasing sequence:

- Set V_{GS} = 0V (gate), and V_{DS} = 0V (drain).
- Decrease V_{GS} to the Pinch-off voltage (V_P), typically -1.8 to -2.2V for Nitronex's GaN devices.
- Increase V_{DS} up to the nominal voltage.
- Increase V_{GS} until the required quiescent current is reached.
- Apply the RF power.
- Similarly, the turn-off sequence is as follows:
- Turn off the RF power.
- Decrease V_{GS} down to V_P.
- Decrease V_{DS} down to 0V.
- Set V_{GS} to 0V.

GATE POWER SUPPLY ISSUES

One needs to pay attention to how to deal with a positive gate current which will arise when the device is driven hard. Many commercial power supplies are not able to source and sink DC current through the same connector. One way to overcome this limitation is to use a resistor connected across the power supply terminals, this resistor will enable the power supply to always provide a negative current while allowing the device to source or sink current. The maximum value for this resistor is determined by the gate voltage and the amount of gate current required by the device. This can be calculated by the following:

$$R_{MAX} = \frac{-V_{GSMAX}}{I_{GSMAX}}$$

A 50W Nitronex device has nominal V_{GSQ} between -1.2V and -1.6V, and an I_{GSMAX} = 20mA. moreover, the resistor's power rating also needs to be considered when selecting a gate resistor. For instance, with $V_{GSQ,MIN}$=-2 V, and 20 mA current a 100 Ohm gate resistor dissipates 0.04 W; therefore at 0.10 W resistor can be safely used.

To accommodate the high drain current, and to achieve the lowest voltage drop and lowest cost, a microstrip line feed is recommended. A quarter-wave line shorted at one end will provide an RF open at the other end to prevent RF leakage. If we use a resistor at the gate feed line to suppress oscillation, its value should be properly selected to keep I_{DS} constant versus RF_{IN}. The reason for this is I_{GS} can change from negative to positive and cause V_{GS} variation. To limit V_{GS} variation to a small level the maximum value of the gate resistor should be limited to; R_G=- V_{GS} / $I_{GS,MAX.}$

Lumped capacitors can be used for DC blocking for applications at S band and below to isolate the source and load from V_{GS} and V_{DS}. DC blocking capacitors are selected to have the series resonant frequencies in the bandwidth of interest to achieve low impedance as much as possible for these capacitors. They are also selected to have high Q's to have minimum insertion loss. The breakdown voltage of these DC blocking capacitors needs to cover the maximum voltage (DC + RF) they will be subjected to.