Application Note

Biasing LDMOS and GaN Power Amplifiers With the AMC7908

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ABSTRACT

Systems with RF transmissions often use power amplifiers (PA) to increase the power and range of the signals. PA require constant monitoring and precise gate voltages to control the power going through the PA. To achieve this, discrete designs that include DAC, ADC, and gate switches are often implemented, which is inefficient, costly, and board space intensive. The AMC7908 is highly integrated power amplifier biasing controller that features eight 13-bit DAC outputs, a 16-bit ADC input, and dedicated output switching.

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Trademarks

1 AMC7908 in PA Biasing

Figure 1-1 highlights the typical application of the AMC7908.

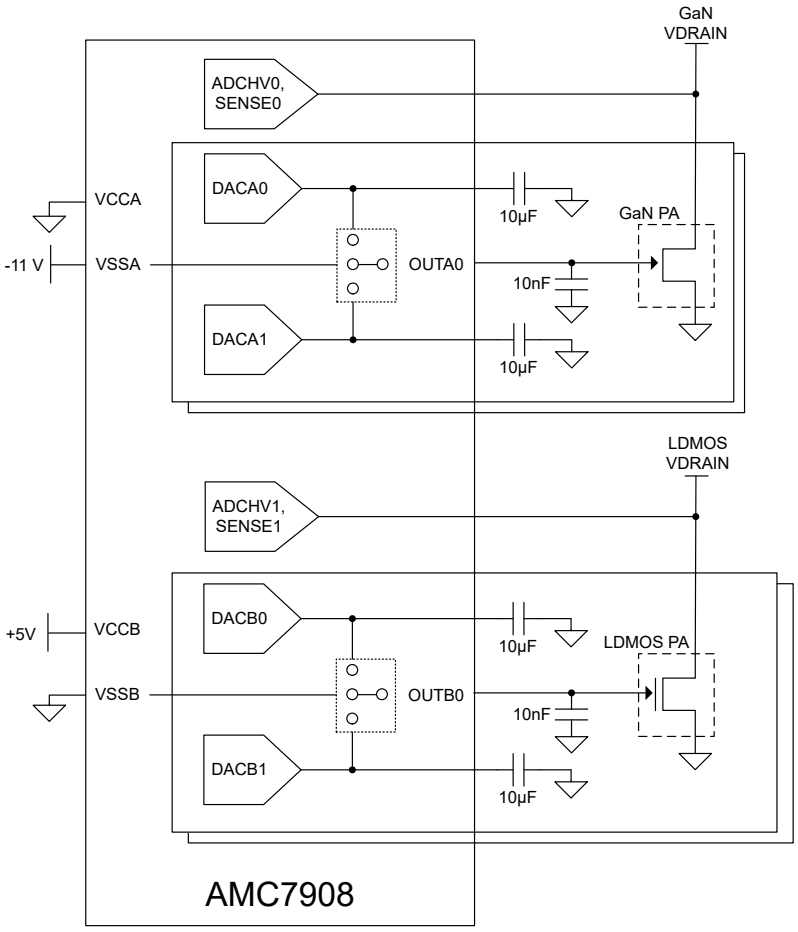

Figure 1-1. AMC7908 Application Figure

The AMC7908 has eight DAC outputs and four OUT outputs. The DAC are grouped in two blocks, each with a separate supply voltage. Each DAC group can operate in a range of 0V to 10V or–10V to 0V, enabling one device to power both LDMOS and GaN PA. The DAC buffers automatically detect the VCC and VSS voltages and set the DAC output range accordingly. At start-up, all DAC are clamped to VSS and the OUT switch is connected to VSS. Each DAC output has a selectable source/sink current maximums: 15mA, 30mA, 90mA, and 120mA

The OUT pins are low on-resistance switched outputs with three connection options: the neighboring even numbered DAC, the neighboring odd numbered DAC, and the VSS supply. While the OUT pins are intended for fast switching the PA gate using the neighboring DAC, this is not required. These switched outputs can also switch from a DAC voltage to VSS, allowing the unused DAC channels to be used for gate biasing that does not require fast switching. The switch between the OUT pin and the DAC pins have a typical resistance of 10Ω, and the switch between OUT and VSS have a typical resistance of 15Ω.

The integrated 16-bit ADC has six inputs: two high-voltage inputs (ADCHV) and two sets of high-side current shunt monitoring inputs (SENSE). The ADCHV channels support up to 85V to monitor the V_{DRAIN} of GaN and GaA PA. The SENSE pins are used to monitor V_{DRAIN} current and require an external shunt resistor. In addition, the AMC7908 has an on-board temperature sensor. The temperature sensor can be used to monitor the temperature of the PA if the AMC7908 is placed close to the PA. The high-voltage inputs, current sense inputs, and temperature sensor have configurable high and low alarm limits. If the ADC detects an alarm condition, the DAC and OUT outputs clamp to VSS to protect the PA.

2 Output Features

The purpose of the OUT pin is to switch the PA gate between an off voltage, also known as the CLAMP, and an on voltage. The on voltage is provided by the even DAC in the OUT group. The CLAMP of the output pin can be set to the odd DAC voltage or the VSS supply. Using the odd DAC for the CLAMP allows for a more precise pinch-off voltage. Using the VSS for the CLAMP frees up the unused DAC to be used for additional gate biasing, allowing for up to 8 bias points on the AMC7908. The switches are toggled with software bits or hardware pins. Figure 2-1 shows how the OUTA0 switches are configured in the AMC7908. The OUT groups are shown in Table 2-1 .

The OUT pins feature fast on and off switching, which is desirable for certain applications such as TDD. The output switches toggle quickly through the use of capacitive charge sharing. To enable this, large capacitors must be externally placed on the DAC outputs and small capacitors on the OUT output. When the switch toggles between different outputs, the small capacitor on the output is quickly charged by the larger DAC capacitor, allowing for fast output switching.

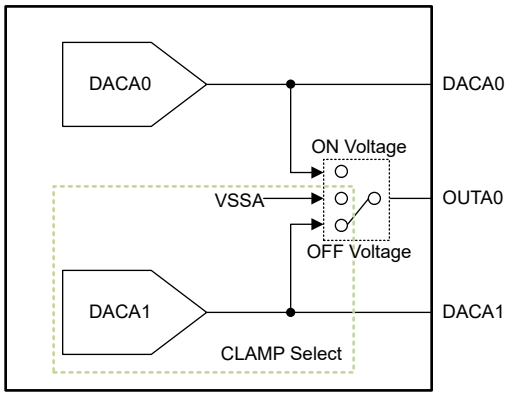

Figure 2-1. Output Switch Configuration

Table 2-1. OUT Groups

OUT Pin	On DAC	Clamp Options
OUTA0	DACA0	DACA1, VSSA
OUTA2	DACA2	DACA3, VSSA
OUTB0	DACB0	DACB1, VSSB
OUTB2	DACB2	DACB3, VSSB

3 PA Monitoring

The AMC7908 has a 16-bit ADC used for voltage, current, and temperature monitoring. Each ADC input has user configurable high and low alarm limits. If the ADC value exceeds these limits, an internal alarm triggers and the device clamps the DAC and OUT outputs to VSS. The user can select which specific DAC and OUT outputs get clamped for each specific alarm. In addition, the ADC also monitors the VCC, VSS, and internal reference and trigger an alarm condition if these voltages are out of range. Figure 3-1 shows the ADC alarm block diagram.

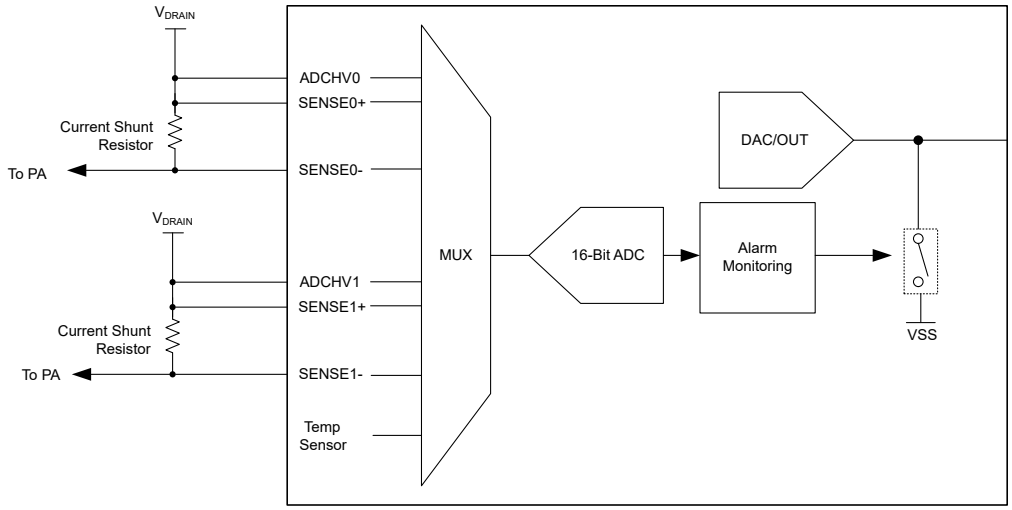

Figure 3-1. ADC Monitoring

4 Power Sequencing

Powering the PA on and off in a controlled routine is necessary to prevent the damage to the PA when V_{DRAIN} is applied. If the gate voltage is too high, the PA can operate in saturation mode and cause thermal damage to the PA or the board the PA is mounted on. After the AMC7908 is powered up, the proper start-up sequencing for the PA requires the following steps:

1. Power on the AMC7908.
2. Configure the gate voltage to the appropriate pinch-off voltage to keep the PA off.
3. Enable the VDRAIN voltage.
4. Now that VDRAIN is applied, the gate bias can be increased to set the desired power output of the PA.
5. Finally, the RF signal can be enabled. This allows the PA to transmit a signal.

The PA can be safely shut down by reversing the power-on steps:

1. Disable the RF signal from the PA.
2. Reduce the DAC outputs to the pinch-off value to turn off the PA.
3. Disable the VDRAIN voltage.
4. Disable the DAC outputs after the PA is fully disabled.
5. Turn off the power to the AMC7908.

5 Summary

The AMC7908 is an all-in-one PA biasing controller. The integrated DAC, ADC, and switches help eliminate a majority of the discrete components often seen in PA controller systems while providing additional benefits. The flexible output switch structure allows for four to eight individual gate biasing points, along with simultaneous LDMOS and GaN gate control. The ADC provides the system with precise PA voltage, current, and temperature monitoring. The integrated nature of the AMC makes sure the PA gates are turned off when the ADC detects an alarm. In addition to the turn on sequencing control, the AMC7908 is a very robust PA controller that can benefit any system that requires a PA.

6 References

- Texas Instruments, *AMC7908 8-channel, 100mA current-drive bipolar power-amplifier monitor and controller with output switches*, product page.
- Texas Instruments, *AMC7908 evaluation module*, product page.

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