

Using the Peak Detector Voltage to Compensate Output Voltage Change over Temperature

This document explains how to use the driver amplifier's peak detector to compensate the amplifier's output voltage over temperature.

Introduction

Many of Microsemi driver amplifier products feature an on-chip diode differential peak detector. This feature can be used with either an external op-amp circuit or DSP/microcontroller to measure the peak detector voltage and adjust the amplifier bias until the peak detector voltage reaches the nominal value.

Output Peak Detector Basics

The block diagram of the on-chip peak detector is shown in Figure 1. The circuitry consists of two diodes, one with the RF signal and a DC offset (V_{det}), and the other with only a DC offset (V_{ref}). This topology allows for common mode cancellation of the diode temperature drift. The peak detector voltage, V_{pk} , is defined as $V_{det} - V_{ref}$.

Most Microsemi driver amplifiers feature this peak detector, but since the nominal DC bias of each amplifier varies, the DC offset voltage will be slightly different from family to family. This application note outline is general and will work for all Microsemi driver amplifiers with a peak detector.

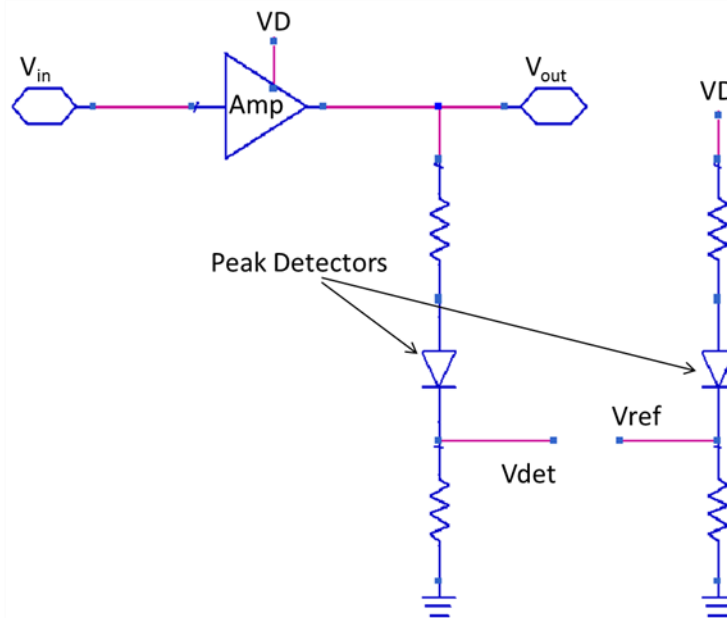


Figure 1: Simplified on-chip peak detector

Operation of the Peak Detector

Figure 2 is an example of the OA3HVQDSL peak detector output measurement plot (V_{ref} and V_{det}). In this example, the V_{ref} (blue trace) and V_{det} (red trace) output voltages are ranging from 4.7 volt to 6.6 volt. This corresponds to the amplifier's output voltage from 2.2 Vpp to 8 Vpp, respectively, at one temperature (e.g., room temperature).

The difference between V_{det} and V_{ref} ($V_{det} - V_{ref}$) is V_{pk} , the calculated peak detector voltage. In Figure 2, V_{pk} (light green trace) ranges from 0.3 V to 1.7 V, corresponding to the amplifier's output voltage from 2.2 Vpp to 8 Vpp.

Please refer to a specific driver amplifier product datasheet for its actual peak detector performance plot.

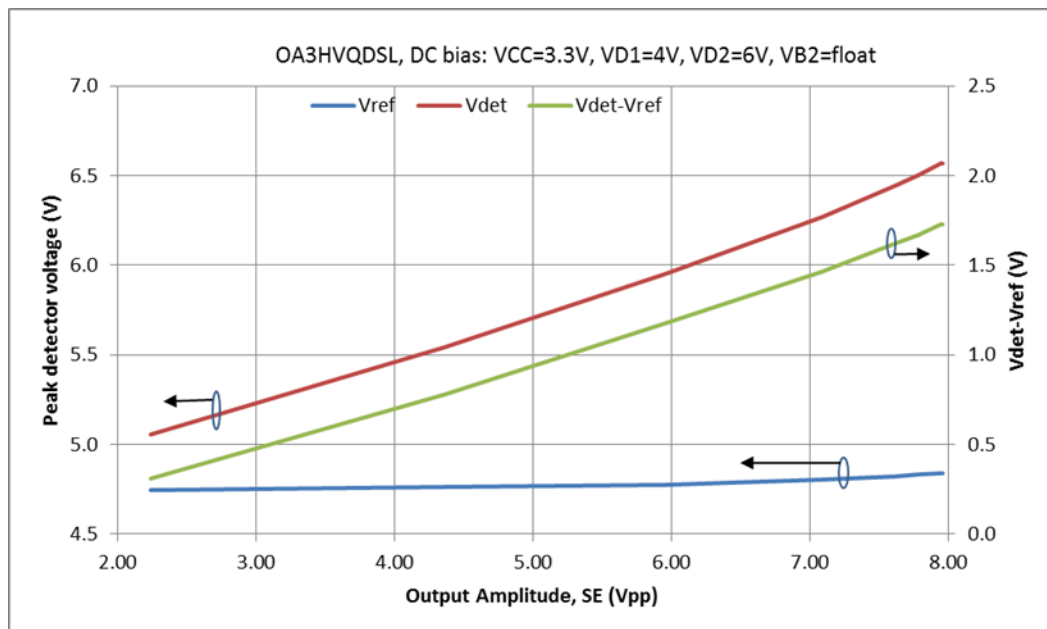


Figure 2: Example of OA3HVQDSL peak detector output voltages and the calculated peak detector voltage ($V_{det} - V_{ref}$)

Application Usage of the Peak Detector Signals

By knowing the relationship characteristics of the calculated peak detector voltage versus the amplifier's output voltage, then one can design a closed-loop system (e.g., DSP/microcontroller adjustment of the bias voltage) to compensate for the change in the output voltage of the amplifier due to temperature. The block diagram example in Figure 3 shows output voltage compensation using peak detect with a digital feedback control loop.

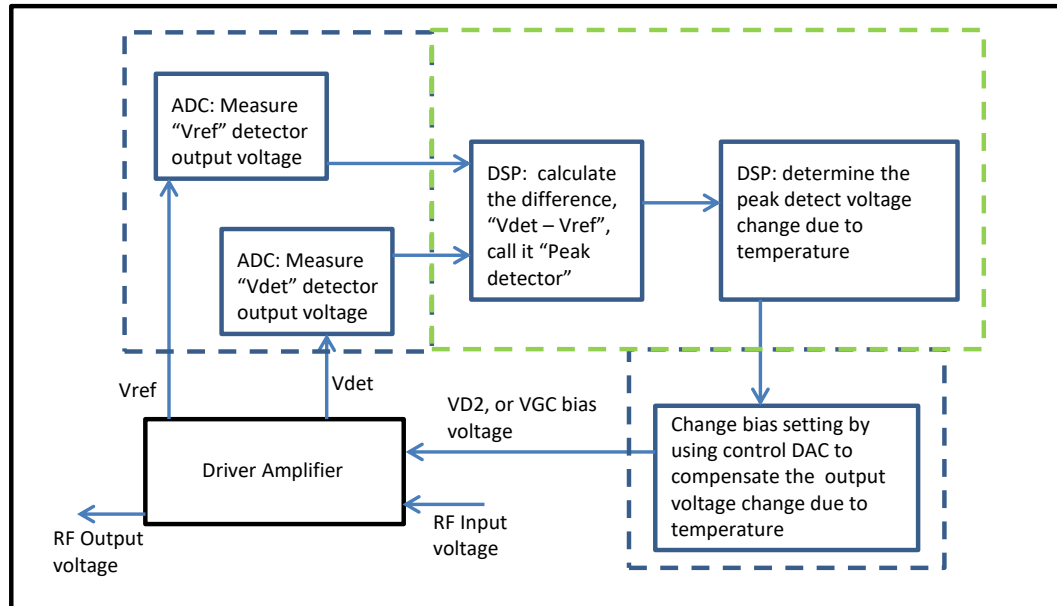


Figure 3: Block diagram of output voltage compensation using peak detect with digital feedback control loop

Linear Operation Mode

During linear mode of operation, the voltage gain control (VGC) input is adjusted to compensate the output swing, based on the value reported by the peak detector. Amplifiers that have a voltage gain control (VGC) bias feature include: OA3HVQDSL, Grizzly32-D1 (OA3HMQDDL), Grizzly32-S1 (MO1105AA), and newer driver amplifier products.

When the amplifier's output voltage is changes over temperature, V_{ref} and V_{det} diode output voltages are measured, and the peak detector voltage ($V_{det} - V_{ref}$) is computed by the DSP/microcontroller. Then, the compensation circuit can adjust the output voltage driving the VGC bias pin, using a DAC or other control mechanism until the desired output voltage level is reached. See Figure 4 for an example of amplifier small signal gain (S_{21}) versus gain control voltage (VGC) plot. The control loop will continue to operate and adjust the VGC voltage until the peak detector voltage reaches the equivalent corresponding desired output voltage level.

Note: Ensure the VGC bias voltage stays within the range specified in the datasheet.

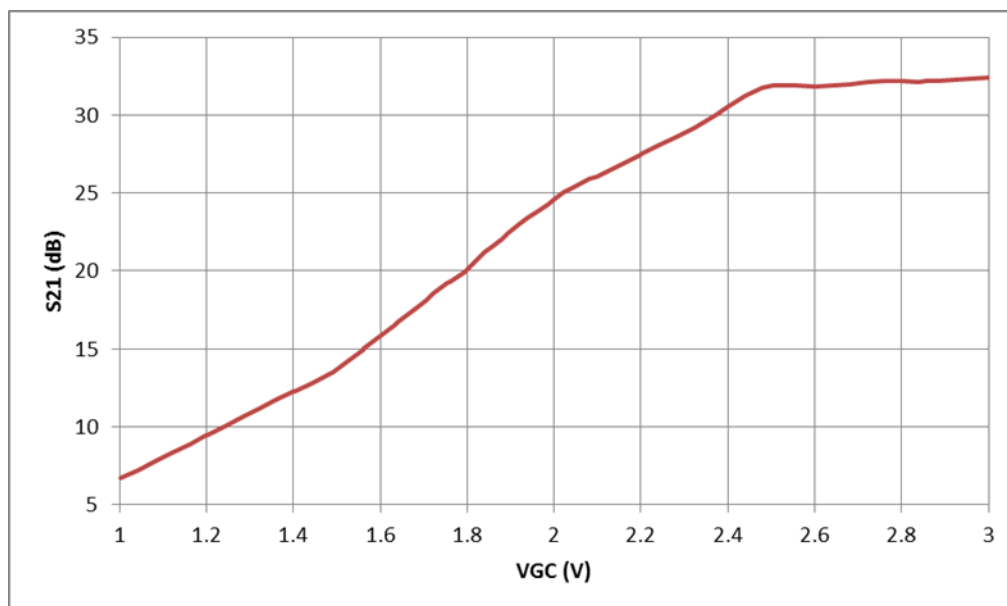


Figure 4: Example of amplifier small signal gain vs. VGC bias control

Limiting Operation Mode

During limiting mode of operation, the voltage gain control (VGC) input is set to maximum to achieve maximum gain and slew rate of the amplifier output, while offering lower power consumption and lower noise than linear mode.

When the amplifier's output voltage changes due to temperature in limiting mode, the control loop operation is like linear mode, except that the DSP/microcontroller of the compensation circuitry will adjust the voltage supplying the drain bias, (power supply of output amplifier stage, the supply name varies by device, refer to Table 1 below for specific pin name for each device), to increase the driver gain.

Note: Ensure the drain bias voltage stays within the range specified in the datasheet.

Alternative Feedback Loop Control Circuit

Another method to compensate for the output voltage change of the amplifier due to temperature is to use an analog feedback loop control circuit, (see the block diagram in Figure 6). It uses an op-amp to measure the delta of the peak detector output voltages, (i.e., $V_{det}-V_{ref}$), and a second op-amp to scale the peak detector voltage.

The feedback voltage to the driver amplifier is applied to the VGC bias voltage, in linear operation mode; or drain bias voltage in limiting operation mode. (Power supply of output amplifier stage, the supply name varies by device; refer to Table 1 below for the specific name for each device).

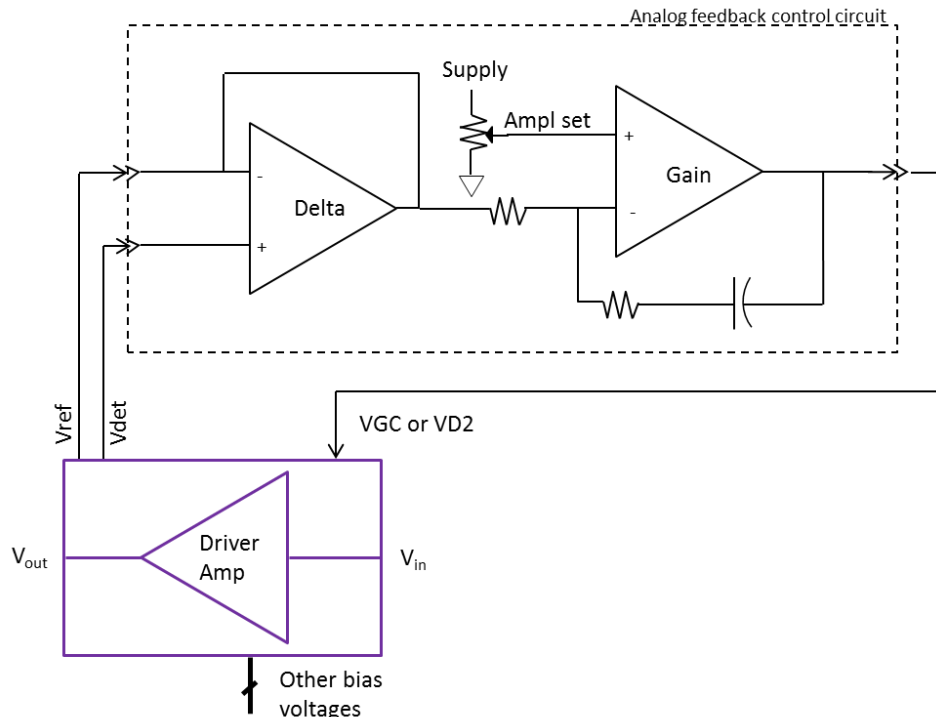


Figure 6: Example of output voltage compensation analog feedback loop block diagram

Note: The peak detector outputs are used to detect the change in the output voltage of the driver amplifier due to temperature. The detector outputs have high response bandwidth (BW), (e.g., in the MHz range). Using a shunt capacitor in the peak detector signal path will lower the BW of the feedback loop to below the amplifier operating frequency. This will help ensure that the feedback control loop works properly. For example, if the low-end operating frequency is 100 kHz, then designs the feedback control loop bandwidth to be 10 kHz. If the feedback control loop BW is within the amplifier operating frequency, the control loop may start to modulate/react at the amplifier operating frequency rate.

Driver Amplifier Pins Identification Usage:

Examples of bias pins usage with the feedback control loop, on the driver amplifiers:

Table 1: Driver amplifiers' bias pins identification and their application usage in the feedback control loop

Product Part Number	Bias Pin Name	Application	Note
OA3HVQDSL	VGC	Linear	Uses VGC bias to compensate the output voltage swing due to temperature.
	VD2	Limiting	Uses VD2 (drain bias on the final output stage) bias to compensate the output voltage swing due to temperature.
Grizzly32-D1 (OA3HMQDDL)	VGC	Linear	Uses VGC bias to compensate the output voltage swing due to temperature.
	VD2_P and VD2_M	Limiting	Use VD2_P and VD2_M (drain bias on the final output stage) biases to compensate the output voltage swing due to temperature.
Grizzly32-S1 (MO1105AA)	VGC	Linear	Uses VGC bias to compensate the output voltage swing due to temperature.
	VD2	Limiting	Uses VD2 (drain bias on the final output stage) bias to compensate the output voltage swing due to temperature.

Summary

This application note outlined two methods, digital feedback control loop and analog feedback control loop, for using the amplifier's peak detector voltages to compensate for the output voltage level change of the driver amplifier due to temperature.

References

1. Application Note, MM-APP-0004, Microsemi MMIC Amplifiers with On-Chip Power Detectors
2. Application Note, MM-APP-0005, Microsemi MMIC Amplifiers with Dynamic Gain Control

The above application notes can be found at Microsemi's website:

- 1) <https://www.microsemi.com/product-directory/rf-microwave-a-millimeter-wave/3538-mmics#resources>
- 2) <https://www.microsemi.com/product-directory/ics/3568-optical-solutions#resources>



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