

Improving Power Amplifier Efficiency with Current Monitors

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This tech note addresses a few of the current shunt monitor (CSM) implementations used with power amplifier stages in wireless infrastructure. With each particular implementation, this note presents the trade-offs as well as recommends a device relevant for the approach.

PA Feedback

Delving past the abstraction of antennas, transmitters, and receivers of an active antenna system (AAS) or remote radio unit (RRU) can yield systems of amplifiers, microprocessors, multiplexors, DACs, and sensors. Of these elements, one of the crucial elements impacting power consumption is the power amplifier stage transmitting out to the users on the network. This power amplifier stage may consist of a Doherty amplifier with a pre-driver, which could be further reduced down to some LDMOS or GaN transistors configured into class B, AB, and C amplifiers.

Controlling the bias point of the transistors in a PA stage improves the efficiency of the system. An open-loop, fixed-control voltage for the bias neglects the impact of supply variations on the drain side, device aging, and transconductance fluctuations due to temperature changes from heat dissipation and ambient temperature swings. Consequently, feedback facilitating dynamic control to adjust the PA transistors bias points is needed like in [Figure 1](#). Depending on the designer's constraints in board space, cost, precision, number of antennas, and so forth, the optimal method for the dynamic control may vary. Many approaches include a current shunt monitor (CSM) to serve as part of the feedback chain to adjust the bias and thereby improve efficiency. This note presents three general approaches, with each subsequent implementation having greater control on the bias point and related efficiency of the PA stage.

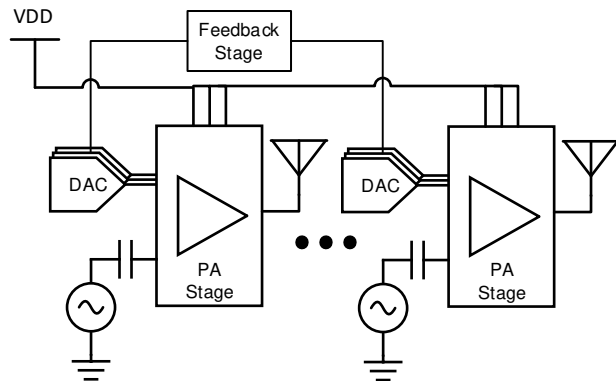


Figure 1. PA Stages with Feedback

Factory Calibration

A single factory calibration with a generated look-table is one way to control a PA stage. During calibration, a PA is subjected to a range of bias voltages or temperatures, while an on or off board CSM, as in [Figure 2](#), monitors the load. From the load measurements, a bias value or group of bias values can be programmed into a look-up table that a DAC later uses to control the bias. This process is then extended to each individual PA in the system. Consequently, the number of CSMs depends on how much calibration time in production can be afforded, as well as by BOM cost. After production, an off-board or shorted sensor saves power otherwise lost across the shunt. Additionally, if temperature sensors are included in the feedback with the look-up table, regions of PA stages can be adjusted relatively quickly according to the temperature drift, thereby improving efficiency. As the factory calibration emphasizes cost for a relatively high common-mode, high-side measurement, devices such as the [INA186](#) and [LMP8480](#) should be considered.

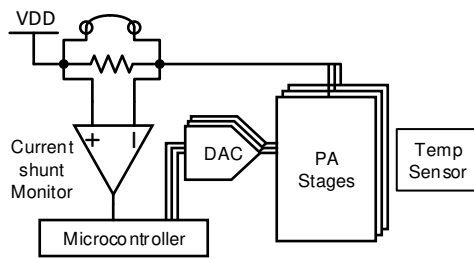


Figure 2. Current Sense Feedback

Periodic Calibration

Although the factory calibration approach improves efficiency over a fixed-bias voltage, it neglects supply variation, which can immediately affect the bias and device aging, which gradually affects the bias. To overcome these shortcomings, the system can be designed to periodically power off and recalibrate. From periodic calibration, adjustments are made to the look-up table as the PAs age, the system switches between batteries and solar power, or when the supply begins to droop. With this tighter control is the option of current monitoring and voltage monitoring all integrated into one package, such as in the [INA226](#). Periodic calibration requires the shunt to be permanently fixed on the board, resulting in constant losses across the shunt. To minimize the losses, a part with low input offset like the [INA190](#) or [INA290-Q1](#) can be used, as the lower offset permits a smaller shunt for as good or better accuracy. Alternatively, a monitor like the [TMCS1100](#) with an isolated hall sensor allows for a very high common-mode with minimal losses across the 1.8-mΩ lead frame. Aside from the shunt dissipation, the other concern for periodic calibration is the compromise between added programming and monitor count needed to provide minimal transmission interruption.

Real-time Sensing

While the periodic calibration does address known issues with aging and temperature that a designer can anticipate, it does not have immediate dynamic response for unexpected conditions. For critical applications in which tighter control is required, continuous current monitoring may be needed. This method allows for quick adjustments to any PA stage for any possible changes in operating conditions. As continuous monitoring requires CSMs for all PA stages, a multichannel device such as the [INA4181](#)

might be considered to save board space. Also for further integration, board savings, and added system protection, devices such as [INA381](#) and [INA200](#) with integrated comparators can be used for overcurrent conditions.

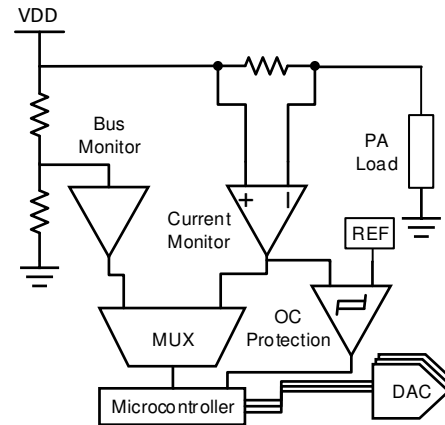


Figure 3. Bus Voltage, Current, and OC Feedback

Table 1. CSM Method Comparison

Approach	BOM Count	Control	Integrate Bus Monitor	Integrate OC	Shunt Loss
Factory Calibration	Low	Loose	No	No	Never
Periodic Calibration	Medium	Tighter	Yes	No	Periodic
Real-time Sensing	High	Tightest	Yes	Yes	Always

Table 2. Alternative Device Recommendations

Device	Characteristics
INA200	Common mode range –16 V to 80 V; Comparator
INA226	Common mode range –0.3 V to 36 V; 16-bit delta sigma ADC
INA290-Q1	Common mode range Vs to 110 V

Table 3. Related TI Tech Notes

SBOA366	Current Sensing Applications in Communication Infrastructure Equipment
SLPA013	Hybrid Battery Charger With Load Control for Telecom Equipment

(1)

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