A Multi-Band GSM/GPRS Power Amplifier Controller

Application Brief 122

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Highlights

- Multi-band GSM/GPRS PAC
- 1.5 mm x 1.5 mm micro SMD Package
- High-dynamic Range Log Detector
- Control GaAs/InGaP HBT Power Amplifier

Global System for Mobile Communications (GSM) is the most popular cellular phone system in the world. In a GSM cellular phone or DCS/PCS phone network, Time Division Multiple Access (TDMA) scheme is used in the same cell to provide duplex communication. The Gaussian Minimum Shift Keying (GMSK) modulation scheme is used in both forward and reverse link.

Because GMSK modulation has a constant envelope, a class C RF power amplifier is used to maximize power efficiency. The output RF power is tightly controlled to minimize power consumption and reduce interference to other users in the network. The European Telecommunications Standards Institute (ETSI) has specified cellular phone output power requirements. All cellular phones have to meet the requirement of transmit time mask, spectral mask, harmonics distortion, and output power level, output noise, etc. (Refer to www.etsi.org, for detailed performance requirements.) To control a class C power amplifier to meet all the above specifications is not straightforward, thus, National Semiconductor has a GSM/GPRS Power Amplifier Controller (PAC), the LMV243, to resolve this difficult problem. Together with a baseband ramping signal and directional coupler, the LMV243 can set a GSM/GPRS power amplifier delivering correct RF energy to the antenna and then meet the ETSI specifications. In a subscriber unit, the transmitter requires a power amplifier, directional coupler, and a PAC like the LMV243.

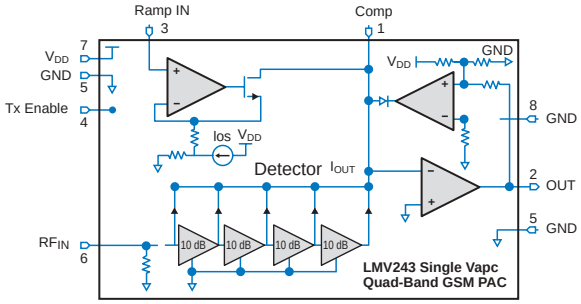

Figure 1: Block Diagram of the LMV243 PAC

As shown in *Figure 1*, the LMV243 consists of a 45 dB log amp detector for sensing the RF output power level of a PA and an error amplifier to close the control loop as in a servo control.

Advantage Of Using 45 dB Log Amp Detector

Typically, a GSM/GPRS PA requires a control voltage Vapc from 0.1+ to 2.0+ Volts for power levels from 0 dBm to 35 dBm. The baseband chip can usually provide a DC pulse voltage of 100 mV to 2V through a Digital-to-Analog Converter (DAC). The resolution of the profile and min./max. range depends on the firmware and performance of the DAC. With a 45 dB detection range, the LMV243 can detect RF power from about 0 dBm down to -45 dBm. For a GSM band, it requires a coupling factor of 35 dB or higher. This loosely-coupled coupler can easily be implemented by a resistive divider or a microstrip line.

Equations For Calculating The Attenuation

On the other hand, if an off-the-shelf LTCC coupler is used, an additional attenuation, L in dB, between the RF input of the LMV243 and the output of the LTCC coupler is needed. Depending on PCB layout constraints and personal preference of RF engineers, either the T- or π-networks (*Figure 2*) can be used to add the additional attenuation.

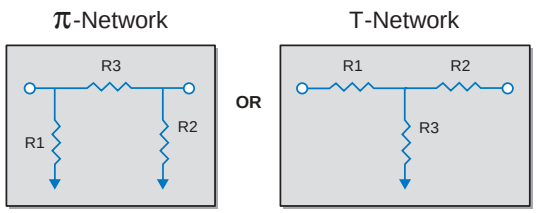

Figure 2: Attenuator Circuits

Following are the equations for calculating the necessary resistors for the π-network:

$$R_3 = \frac{50}{2}(10^{L/10}-1)\sqrt{\frac{1}{10^{L/10}}} \quad \text{and} \quad R_1 = R_2 \frac{1}{\frac{10^{L/10}+1}{50(10^{L/10}-1)} - \frac{1}{R_3}}$$

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Following are the equations for calculating the necessary resistors for the T-network, and where L is the attenuator loss in dB and is a positive number:

$$R_3 = \frac{100\sqrt{10^{L/10}}}{10^{L/10}-1} \quad \text{and} \quad R_1 = R_2 = 50\,\frac{10^{L/10}+1}{10^{L/10}-1} - R_3$$

Choose The Right R_F, C_F To Match The Performance Of Different PA

After choosing the right coupling factor (-35 dB or even more), you must then choose the feedback capacitor C_F to close the control loop. Typically, you can choose the C_F between 22 pF to 100+ pF depending on the performance of individual power amplifiers and the voltage profile of Vramp. Sometimes, a small R_F may be needed to compensate the stability of the servo loop. A small C_F will have a fast response in the envelope and may cause overshoot in the time mask and a big C_F may cause delay. So an optimized C_F and R_F should be chosen together with a set of Vramp profiles to meet the GSM specification. A recommended application circuit is shown in *Figure 3*.

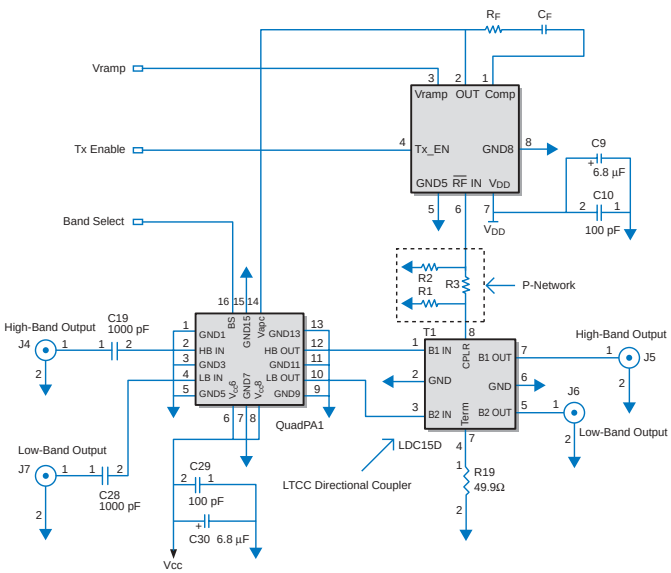

Figure 3: LMV243 GSM/GPRS PAC Application Circuit

LMV243 Evaluation Board Meets GSM Spec

National has developed an LMV243 demoboard for multi-band GSM/GPRS power amplifiers with a single Vapc pin. The LMV243 has been tested in the demoboard to control the GSM/GPRS power amplifier. A picture of the demoboard can be seen in *Figure 4*, and *Figure 5* shows how the LMV243 passes the GSM transmit time mask at a high-output power level.

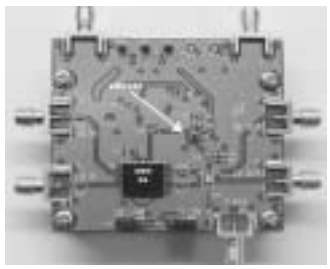

Figure 4: Demoboard

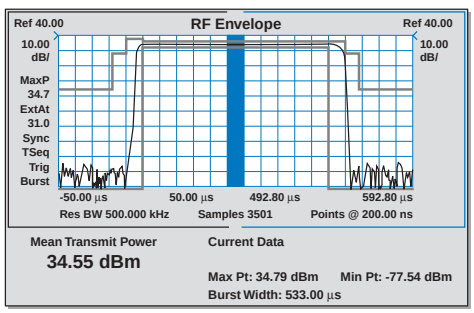

Figure 5: GSM Transmit Time Mask at Full Output Power

Additional Information

amplifiers.national.com
www.national.com/pf/LM/LMV243.html
www.national.com/nationaledge/aug02/LMV243.html
www.national.com/appinfo/amps/lmv243.html

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