

LMV243 Single-Channel, Quad-Band GSM Power Controller in DSBGA

Check for Samples: [LMV243](#)

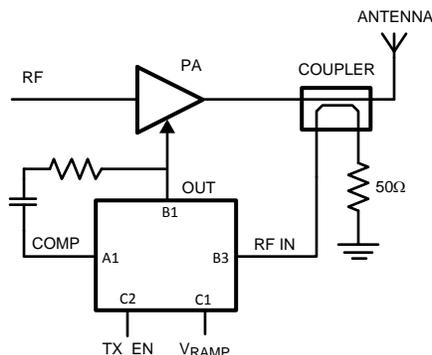
FEATURES

- (Typical Unless Otherwise Noted)
- 50dB RF Detection Range (Typical)
- Support of GaAs HBT, Bipolar Technology
- Quad-Band Operation
- Shutdown Mode for Power Save in Rx Slot
- GPRS Compliant
- External Loop Compensation Option
- Accurate Temperature Compensation
- Frequency Range is 450MHz to 2GHz
- DSBGA Package: 1.5mm x 1.5mm x .995mm

APPLICATIONS

- GSM Mobile Phone
- AGC for Digital Audio
- TDMA RF Control
- Wireless LAN

TYPICAL APPLICATION



DESCRIPTION

The device is intended for use within an RF transmit power control loop in GSM mobile phones and supports GaAs HBT and bipolar RF single supply power amplifiers. The circuit operates with a single supply from 2.7V to 3.3V.

The LMV243 contains an RF detector, error amplifier, ramp V/I converter and output driver. The LMV243 input interface consists of the RF input, Ramp voltage, and a digital input to perform the function "Shutdown/Transmit Enable". The device will be active in the case TX_EN = HI, otherwise, the device goes into a low power consumption shutdown mode. During shutdown the output will be in high impedance (tri-state).

A single external RC combination is used to provide stable operations that accommodates individual PA characteristics.

The LMV243 is offered in a 8-bump DSBGA 1.5mm x 1.5mm package. This space saving package supports flexible product placement almost anywhere in the circuitboard.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS ⁽¹⁾⁽²⁾

Supply Voltage	V _{DD} - GND	4V Max
ESD Tolerance ⁽³⁾	Human Body Model	2000V
	Machine Model	200V
Storage Temperature Range		-65°C to 150°C
Junction Temperature ⁽⁴⁾		150°C Max
Mounting Temperature	Infrared or convection (20 sec)	235°C

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not ensured. For ensured specifications and the test conditions, see the Electrical Characteristics.
- (2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.
- (3) Human body model: 1.5kΩ in series with 100pF. Machine model, 0Ω in series with 100pF.
- (4) The maximum power dissipation is a function of T_{J(MAX)}, θ_{JA} and T_A. The maximum allowable power dissipation at any ambient temperature is P_D = (T_{J(MAX)} - T_A)/θ_{JA}. All numbers apply for packages soldered directly into a PC board

OPERATING RATINGS ⁽¹⁾

Nominal Supply Voltage	2.7V to 3.3V
Temperature Range	-40°C to +85°C
V _{RAMP} Voltage Range	0V to 2V
RF Frequency Range	450MHz to 2GHz

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not ensured. For ensured specifications and the test conditions, see the Electrical Characteristics.

ELECTRICAL CHARACTERISTICS ⁽¹⁾

Unless otherwise specified, all limits are specified to T_J = 25°C. V_{DD} = 2.8V. **Boldface** limits apply at temperature extremes.

Symbol	Parameter	Condition	Min	Typ	Max	Units
I _{DD}	Supply Current	V _{OUT} = (V _{DD} - GND)/2		8.7	10.5 12.5	mA
		In Shutdown (TX_EN = 0.8V) V _{OUT} = (V _{DD} - GND)/2		4.6	30	μA
V _{HIGH}	Logic Level to Enable Power	See ⁽²⁾	1.8			V
V _{LOW}	Logic Level to Disable Power	See ⁽²⁾			0.8	V
T _{ON}	Turn-on- Time from Shutdown			3.7	6.5 7.5	μs
I _{EN}	Current into TX_EN Pin			0.108	5	μA
RAMP Amplifier						
V _{RD}	V _{RAMP} Deadband		170 150	210	250 270	mV
1/R _{RAMP}	Transconductance	See ⁽³⁾		78		μa/V
I _{OUT RAMP}	Ramp Amplifier Output Current	V _{RAMP} = 2V	100	140		μA
RF Input						
P _{IN}	RF Input Power Range ⁽⁴⁾	20kΩ // 27pF between V _{OUT} and V _{COMP}		-50 +5		dBm
				-63 -7		dBV

- (1) Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that T_J = T_A. No specification of parametric performance is indicated in the electrical tables under conditions of internal self-heating where T_J > T_A.
- (2) All limits are specified by design or statistical analysis
- (3) Typical values represent the most likely parametric norm.
- (4) Power in dBV = dBm + 13 when the impedance is 50Ω.

ELECTRICAL CHARACTERISTICS⁽¹⁾ (continued)

Unless otherwise specified, all limits are specified to $T_J = 25^{\circ}\text{C}$. $V_{DD} = 2.8\text{V}$. **Boldface** limits apply at temperature extremes.

Symbol	Parameter	Condition	Min	Typ	Max	Units
	Logarithmic Slope ⁽⁵⁾	@ 900MHz, 20k Ω // 27pF between V_{OUT} and V_{COMP}		-1.79		$\mu\text{a/dB}$
		@ 1800MHz, 20k Ω // 27pF between V_{OUT} and V_{COMP}		-1.89		
		@ 1900MHz, 20k Ω // 27pF between V_{OUT} and V_{COMP}		-1.89		
	Logarithmic Intercept ⁽⁵⁾	@ 900MHz, 20k Ω // 27pF between V_{OUT} and V_{COMP}		-50.5		dBm
		@ 1800MHz, 20k Ω // 27pF between V_{OUT} and V_{COMP}		-46.9		
		@ 1900MHz, 20k Ω // 27pF between V_{OUT} and V_{COMP}		-45.9		
R_{IN}	DC Resistance	See ⁽³⁾		50		Ω
C_{IN}	Input Capacitance	See ⁽³⁾		0.5		pF
Error Amplifier						
GBW	Gain-Bandwidth Product	See ⁽³⁾		7.6		MHz
V_O	Output Swing from Rail	Sourcing, $I_O = 5\text{mA}$		55	85 105	mV
		Sinking, $I_O = -5\text{mA}$		45	75 95	
I_O	Output Short Circuit Current ⁽⁶⁾	Sourcing, $V_O = 0\text{V}$	25	145		mA
		Sinking, $V_O = 2.8\text{V}$	25	180		
e_n	Output Referred Noise	RF input = 1800 MHz, -10dBm, 20k Ω // 27pF between V_{OUT} and V_{COMP} , $V_{OUT} = 1.4\text{V}$, set by V_{RAMP} , ⁽⁷⁾		700		$\text{nV}/\sqrt{\text{Hz}}$
SR	Slew Rate		8 5	11		$\text{V}/\mu\text{s}$

- (5) Slope and intercept are calculated from graphs " V_{OUT} vs. RF input Power" where the current is obtained by division of the voltage by 20k Ω .
- (6) Shorting circuit output to either V^+ or V^- will adversely affect reliability.
- (7) Typical values represent the most likely parametric norm.

CONNECTION DIAGRAM

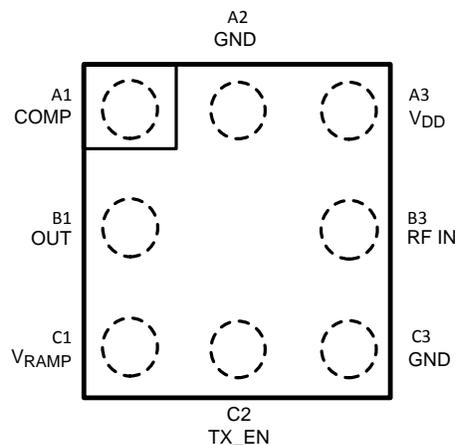


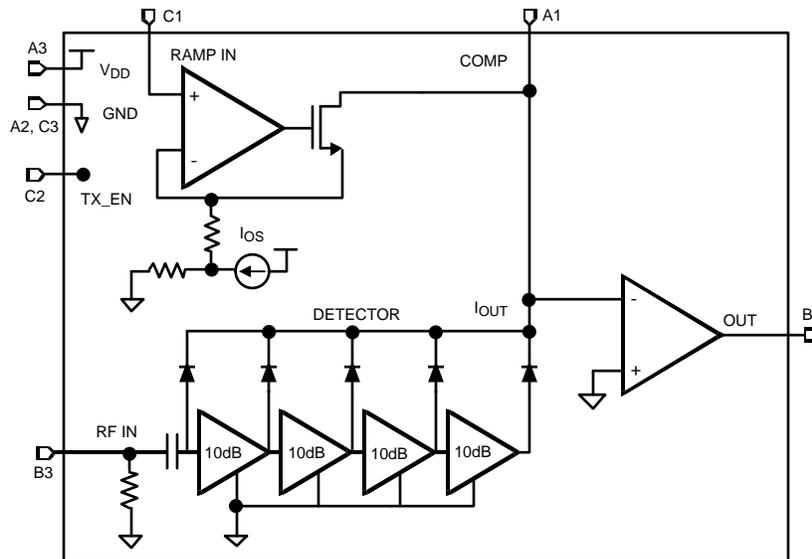
Figure 1. 8-Bump DSBGA Top View

PIN DESCRIPTIONS⁽¹⁾

	Pin	Name	Description
Power Supply	A3	V _{DD}	Supply Voltage
	A2, C3	GND	Power Ground. Operation requires both pins be grounded.
Digital Inputs	C2	TX_EN	A Logic High to enable device.
Analog Inputs	B3	RF IN	RF Input connected to the Coupler output with optional attenuation to measure the Power Amplifier (PA) / Antenna RF power levels.
	C1	RAMP IN	Sets the RF output power level. The useful input voltage range is from 0.2V to 1.8V, although voltages from 0V to V _{DD} are allowed.
Compensation	A1	Comp	Connects an external RC network between the Comp pin and the Output pin for an overall loop compensation and to control the closed loop frequency response. Conventional loop stability techniques can be used in selecting this network, such as Bode plots. A good starting value for the RC combination will be C = 68pF and R = 0Ω.
Output	B1	Out	A rail-to-rail output capable of sourcing 25mA and sinking 25mA, with less than 200mV total voltage drop over the specified temperature. The output is free from glitches when enabled by TX_EN. When TX_EN is low, the output voltage is near GND.

- (1) 1. All inputs and outputs are referenced to GND (pin A2, C3).
 2. For the digital inputs, a LOW is < 0.8V and a HIGH is > 1.8V.
 3. RF power detection is performed internally in the LMV243 and only an RF power coupler with optional extra attenuation has to be used.

BLOCK DIAGRAM



TYPICAL PERFORMANCE CHARACTERISTICS

Unless otherwise specified, $V_{DD} = +2.8V$, $T_J = 25^\circ C$.

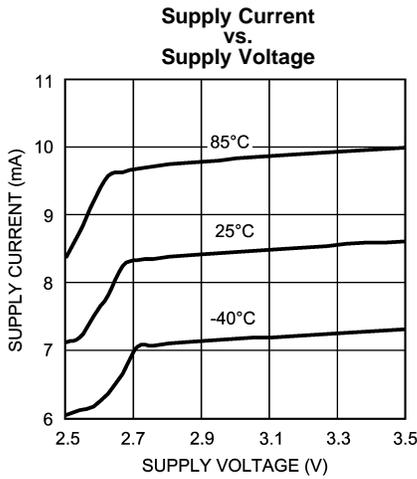


Figure 2.

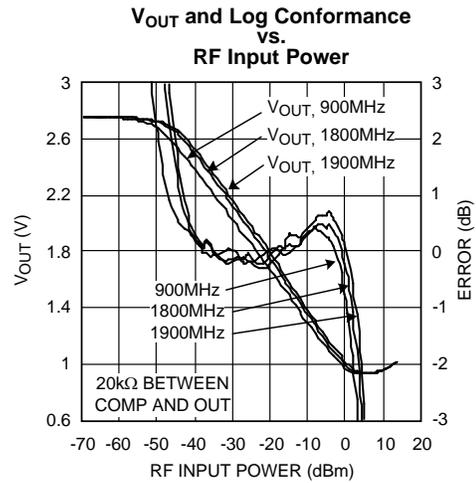


Figure 3.

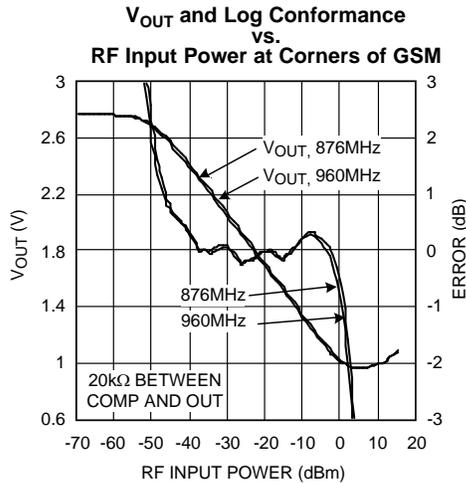


Figure 4.

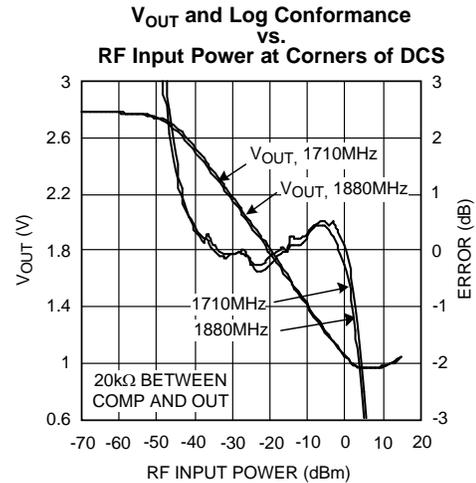


Figure 5.

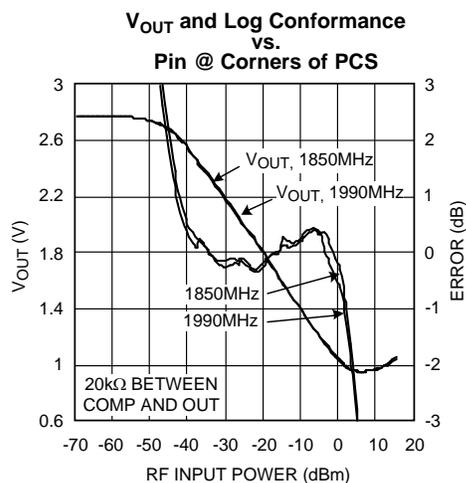


Figure 6.

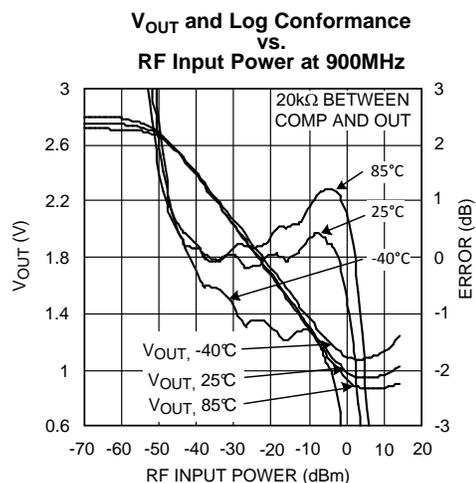


Figure 7.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, $V_{DD} = +2.8V$, $T_J = 25^\circ C$.

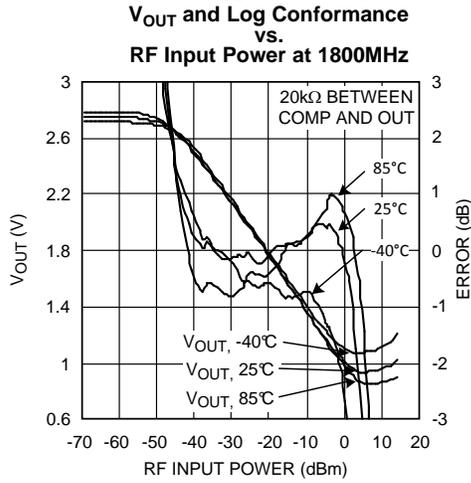


Figure 8.

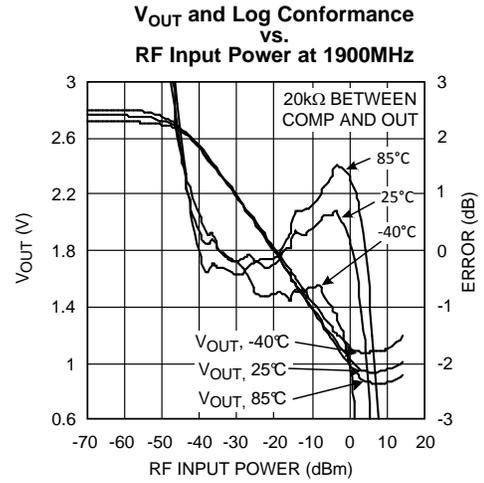


Figure 9.

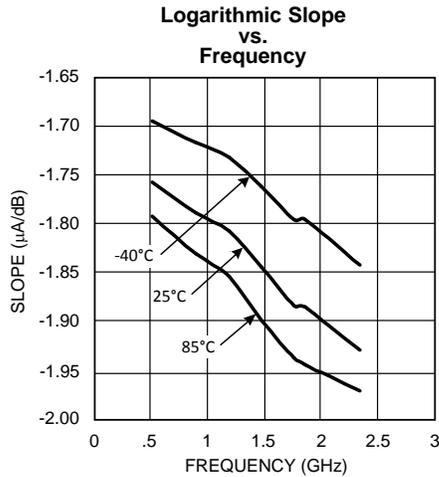


Figure 10.

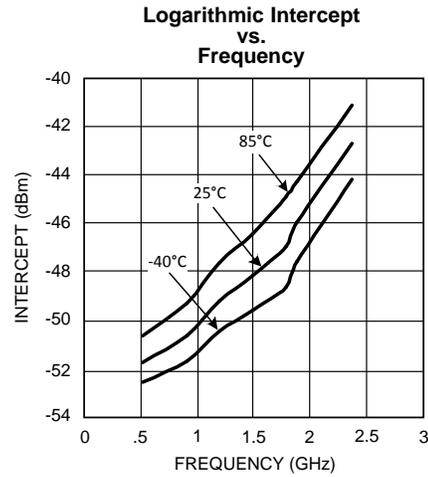


Figure 11.

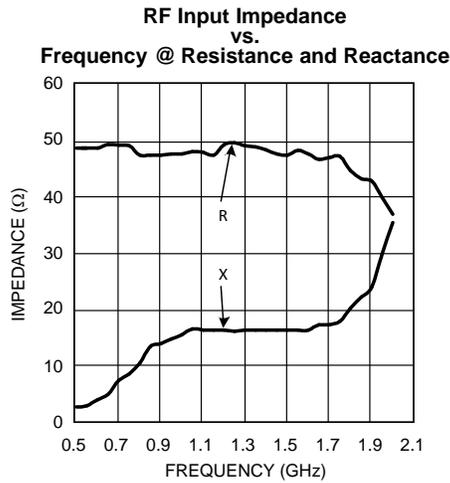


Figure 12.

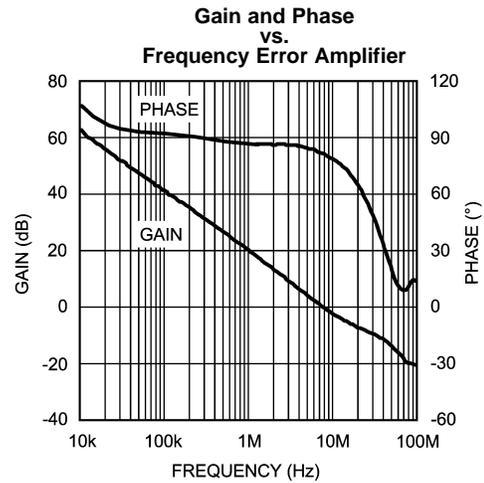


Figure 13.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, $V_{DD} = +2.8V$, $T_J = 25^\circ C$.

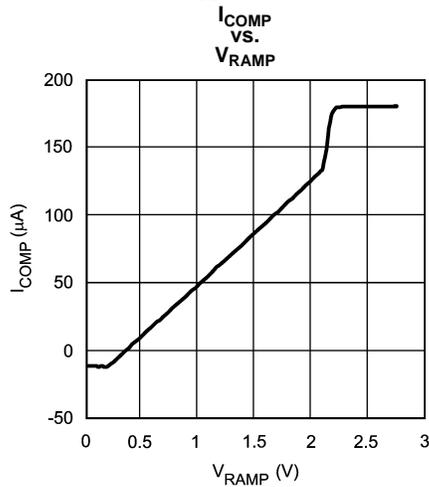


Figure 14.

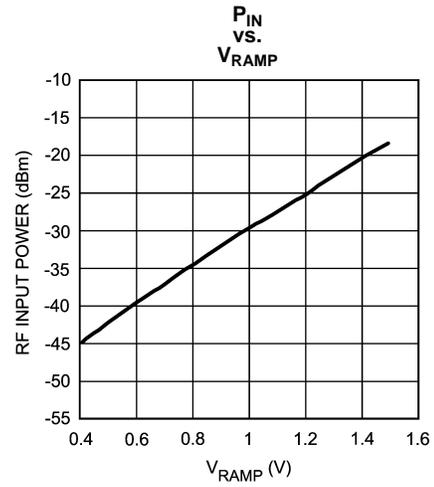


Figure 15.

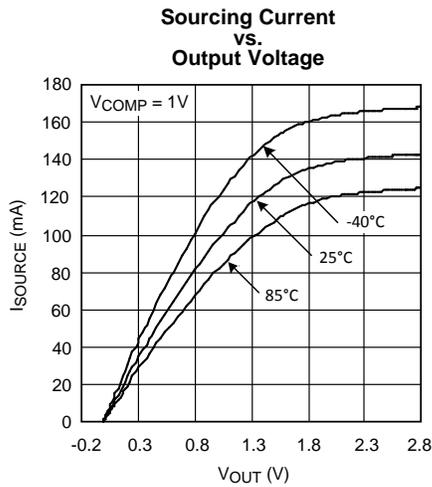


Figure 16.

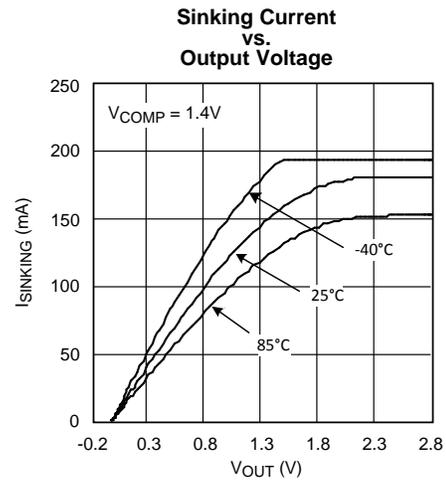


Figure 17.

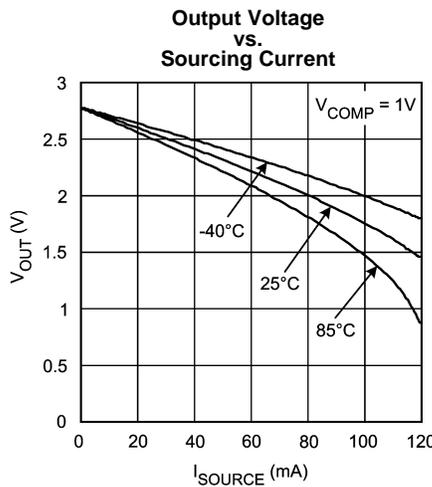


Figure 18.

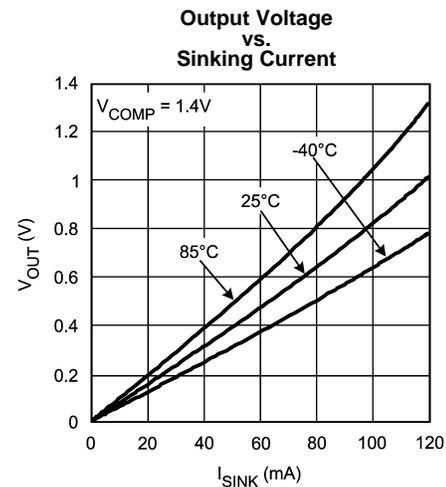


Figure 19.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, $V_{DD} = +2.8V$, $T_J = 25^\circ C$.

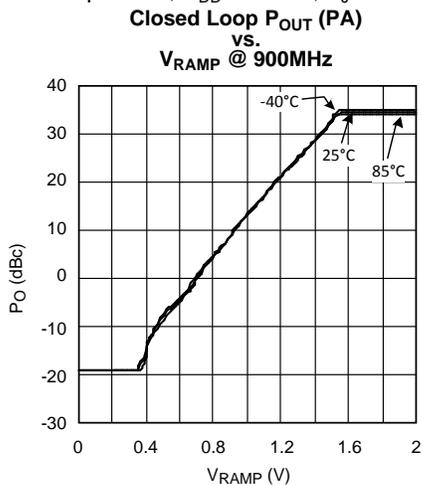


Figure 20.

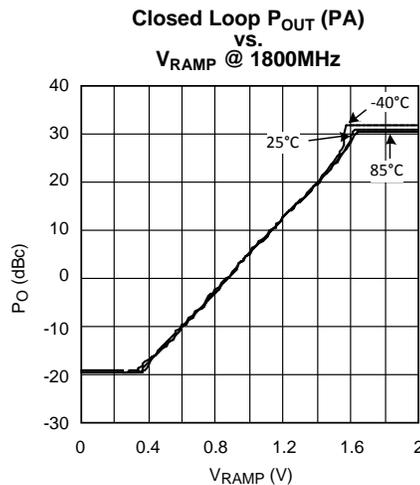


Figure 21.

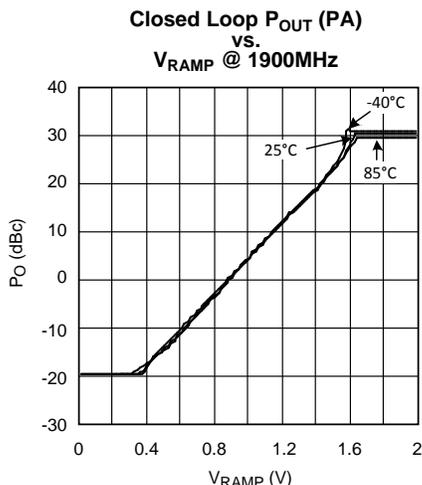


Figure 22.

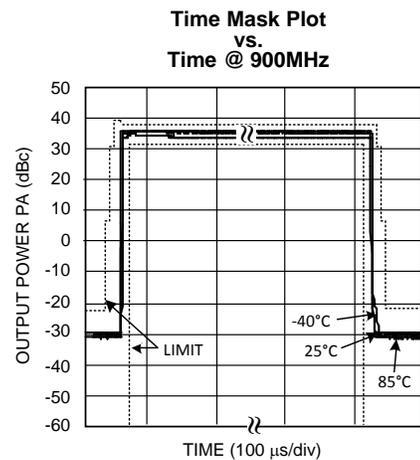


Figure 23.

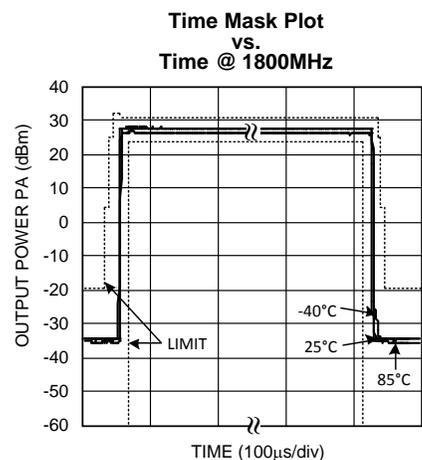


Figure 24.

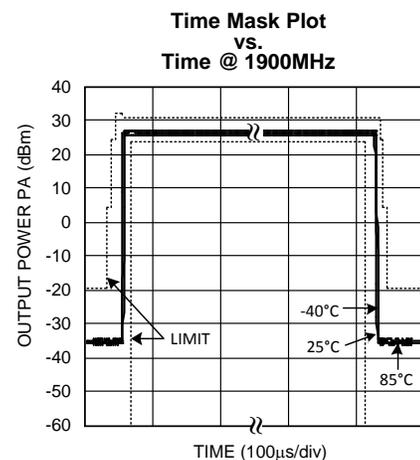


Figure 25.

APPLICATION INFORMATION

THE LMV243 AS AN RF POWER AMPLIFIER (PA) CONTROLLER

The LMV243 is a member of the power loop controller family of TI, for a quad-band TDMA/GSM solution. The [typical application diagram](#) demonstrates a basic approach for implementing the quad-band solution around the RF Power Amplifier. The LMV243 contains a 50 dB Logamp detector and interfaces directly with the directional coupler.

The LMV243 Base Band (control) interface consists of 2 signals: TX_EN to bring the device out of shutdown status within $5\mu s$, and V_{RAMP} for the transmit burst characteristic determining the desired Output Power level. The LMV243 gives maximum flexibility to meet GSM frequency and time mask criteria for many different single supply Power Amplifier types like HBT or, MesFET in GaAs, SiGe or Si technology. This is accomplished by the Programmable Ramp characteristic from the Base Band and the TX_EN signal along with the external compensation capacitor.

Power consumption requirements are supported by the TX_EN function which puts the entire chip into a Power Saving Mode to enable maximum standby and talk time while ensuring the output does not glitch excessively during Power-up and Power-down.

A TYPICAL GSM POWER AMPLIFIER CONTROLLED LOOP

This section should give a general overview and understanding of how a typical Power Amplifier control loop works and how to get rid of some of the most common problems confronted in the design. [Figure 26](#) shows the generic components of such a loop. Beginning at the output of the GSM Power Amplifier (PA), this signal is fed, usually via a directional coupler, to a detector. The output current of the detector I_{DET} drives the inverting input of an op amp, configured as an integrator. A reference voltage drives the non-inverting input of the op amp. Finally the output of the op amp integrator drives the gain control input of the power amplifier. Now to examine how this circuit works, we will assume initially that the output of the PA is at some low level and that the V_{RAMP} voltage is at 1V. The V/I converter converts the V_{RAMP} voltage to a sinking current I_{RAMP} . This current can only come from the integrator capacitor C . Current flow in this direction increases the output voltage of the integrator. This voltage, which drives the PA, increases the gain (we assume that the PA's gain control input has a positive sense, that is, increasing voltage increases gain). The gain will increase, thereby increasing the amplifier's output level until the detector output current equals the ramp current I_{RAMP} . At that point, the current through the capacitor will decrease to zero and the integrator output will be held steady, thereby settling the loop. If capacitor charge is lost over time, the gain will decrease. However, this leakage will quickly be corrected by additional integrator current from the newly reduced detector current.

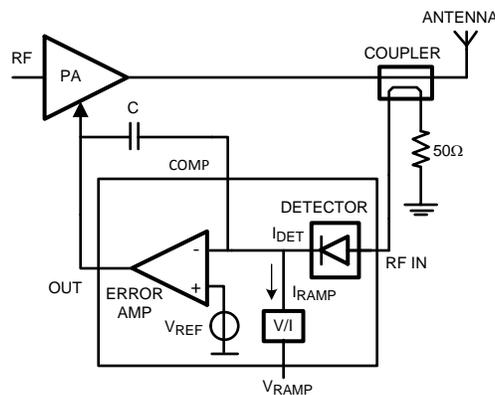


Figure 26. PA Control Loop

The key usefulness of this circuit lies in its immunity to changes in the PA gain control function. From a static perspective at least, the relationship between gain and gain control voltage is of no consequence to the overall transfer function. Based upon the value of V_{RAMP} , the integrator will set the gain control voltage to whatever level is necessary to produce the desired output level. Any temperature dependency in the gain control function will be eliminated. Also, non-linearity's in the gain transfer function of the PA do not appear in the overall transfer function (V_{OUT} vs. V_{RAMP}). The only requirement is that the gain control function of the PA be monotonic. It is crucial, however, that the detector is temperature stable.

The circuit as described so far, has been designed to produce a constant output level for varying input levels. The only requirement is for it to be temperature stable for input levels that correspond to the setpoint voltage V_{RAMP} . If the detector used has a higher dynamic range, the circuit to precisely set PA output levels over a wide dynamic range. To do this, the integrator reference voltage, V_{RAMP} , is varied. The voltage range on V_{RAMP} follows directly from the detector's transfer function. For example, if the detector delivers 0.5V for an input of -7dBm , a reference voltage of 0.5V will cause the loop to settle when the detector input is -7dBm (the PA output will be greater than this amount by whatever coupling factor exists between PA and detector). The dynamic range for the variable RF P_{OUT} case will be determined by the device in the circuit with the least dynamic range (i.e. the gain control range PA or linear dynamic of detector).

The response time of this loop can be controlled by varying the RC time constant of the integrator. Setting this at a low level will result in fast output settling but can result in ringing in the output envelope. Settling the RC time constant high will give the loop good stability but will increase settling time.

Figure 27 shows a typical RF power control loop realized by using TI's LMV243 with integrated RF detector. The RF signal from the PA passes through a directional coupler on its way to the antenna. Directional couplers are characterized by their coupling factor which is in the 10dB to 30dB range, typical 20dB. Because the coupled output must in its own right deliver some power (in this case to the detector), the coupling process takes some power from the main output. This manifests itself as insertion loss, the insertion loss being higher for lower coupling factors.

ATTENUATION BETWEEN COUPLER AND LMV273 DETECTOR

It is very important to choose the right attenuation between PA output and detector input, i.e. the total of coupling factor and extra attenuation, in order to achieve power control over the full output power range of the PA. A typical value for the output power of the PA is $+35.5\text{ dBm}$ for GSM and $+30\text{ dBm}$ for PCS/DCS. In order to accommodate these levels into the LMV243 detection range the minimum required total attenuation is about 35 dBm (please refer to [typical performance characteristics](#) in the datasheet). A typical coupler factor is 20dB. An extra attenuation of about 15 dB should be inserted.

Extra attenuation Z between the coupler and the RF input of the LMV243 can be achieved by 2 resistors R_X and R_Y according to Figure 27, where

$$Z = 20 \log [R_{IN} / (R_{IN} + R_Y)] \quad (1)$$

e.g. $R_Y = 300\Omega$ results in an attenuation of 16.9dB.

To prevent reflection back to the coupler the impedance seen by the coupler should be 50Ω . The impedance R_O consists of $R_X // (R_Y, R_O, + R_{IN})$. R_X can be calculated with the formula:

$$R_X = [R_O * (R_Y + R_{IN})] / R_Y \quad (2)$$

$$R_X = 50 * [1 + (50/R_Y)] \quad (3)$$

e.g. with $R_Y = 300\Omega$, $R_{IN} = 50\Omega \rightarrow R_X = 58\Omega$.

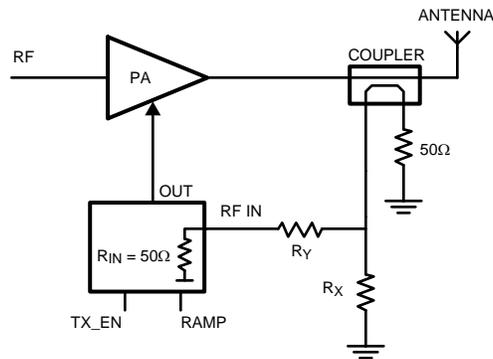


Figure 27. PA Control Loop With Extra Attenuation

COMPONENTS OF A POWER AMPLIFIER LOOP

Figure 27 shows the basics of a typical LMV243 quad-band application.

The key components are:

- The LMV243
- One power amplifier, usually for the GSM and PCS/DCS bands
- A single two channel RF coupler is used instead of the two RF couplers
- A dual or quad-band antenna.

BLOCK DIAGRAM shows the LMV243's internal architecture. The LMV243 contains an RF detector, error amplifier, a ramp V/I converter and an output driver. The LMV243 input interface consists of an RF input, Ramp voltage, and a digital input to perform the function "Shutdown/Transmit Enable".

ANALOG AND DIGITAL INPUT SIGNALS OF THE LMV243

The LMV243 has the following inputs:

- V_{RAMP} is an analog signal (Base band DAC ramp signal)
- TX_EN is a digital signal (performs the function 'Shutdown/Transmit Enable').

V_{RAMP} in Signal

The actual V_{RAMP} input value sets the RF output power. By applying a certain mask shape to the 'Ramp in' pin, the output voltage level of the LMV243 adjusts the PA control voltage to get a power level (P_{OUT}/dBm) out of the PA which is proportional to the single ramp voltage steps. The recommended V_{RAMP} voltage range for RF power control is 0.2V to 2.0V. The V_{RAMP} input will tolerate voltages from 0V to V_{DD} without malfunction or damage. The V_{RAMP} input does not change the output level until the level reaches about 200mV, so offset voltages in the DAC or amplifier supplying the Ramp signal will not cause excess RF signal output and increased power consumption.

ANALOG OUTPUT

The Output is driven by a rail-to-rail amplifier capable of both sourcing and sinking. It is able to source and sink 25mA with less than 200mV voltage drop from either rail over recommended operating conditions. Please refer to the [typical performance characteristics](#). The output voltage vs. Sourcing/Sinking current show the typical voltage drop from the rail over temperature. The Sourcing/Sinking current vs. output voltage characteristics show the typical charging/discharging current, which the output is capable of delivering at a current voltage. The output is free from glitches when enabled by TX_EN. When TX_EN is low, the selected output voltage is fixed or near GND.

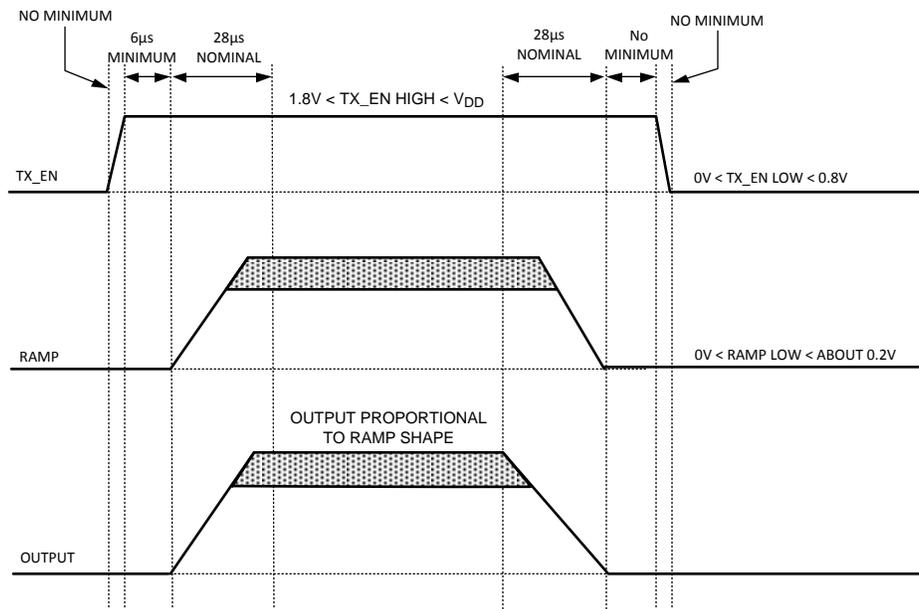
BANDWIDTH COMPENSATION

To compensate and prevent the closed loop arrangement from oscillations and overshoots at the output of the RF detector/error amplifier LMV243, the system can be adjusted by means of external RC components connected between Comp and Out . Exact values heavily depend on PA characteristics. A good starting point is $R = 0\Omega$ and $C = 68\text{pF}$. The vast combinations of PA's and couplers available preclude a generalized formula for choosing these component. Please contact TI for additional assistance.

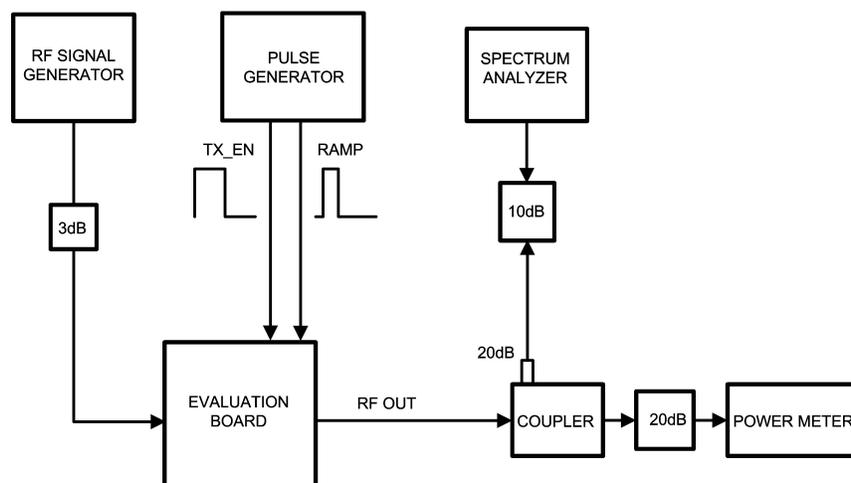
EVALUATION BOARD

An evaluation board is available for the LMV243. Please contact your local distributor or TI sales office.

Typical Timing Diagram



Typical Test Setup Diagram



EQUIPMENT LIST:**RF Signal Generator**

Pulse Generator

Spectrum Analyzer

Power Meter

Coupler

Rohde & Schwarz SMIQ 03B

Tektronix AFG2020

Rohde & Schwarz FSP

HP E4418B, with Powersensor HP E4413A

Pasternack PE 2208-10

REVISION HISTORY

Changes from Revision B (May 2013) to Revision C	Page
• Changed layout of National Data Sheet to TI format	13

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com