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MOTOROLA

MC33169

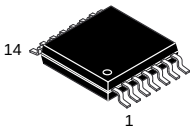
GaAs Power Amplifier Support IC

The MC33169 is a support IC for GaAs Power Amplifier Enhanced FETs used in hand–held telephones such as GSM and PCS. This device provides negative voltages for full depletion of Enhanced MESFETs as well as a priority management system of drain switching, ensuring that the negative voltage is always present before turning “on” the Power Amplifier. Additional features include an idle mode input and a direct drive of the N–Channel drain switch transistor. This product is available in a 4.0 V version intended for control of the RF Power Amplifier in GSM, DCS1800 and PCS applications.

- Negative Regulated Output for Full Depletion of GaAs MESFETs
- Drain Switch Priority Management Circuit
- CMOS Compatible Inputs
- Idle Mode Input (Standby Mode) for Very Low Current Consumption
- Output Signal Directly Drives N–Channel FET
- Low Startup and Operating Current

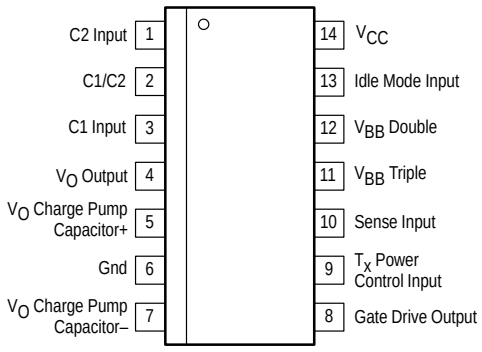
GaAs POWER AMPLIFIER SUPPORT IC

SEMICONDUCTOR TECHNICAL DATA



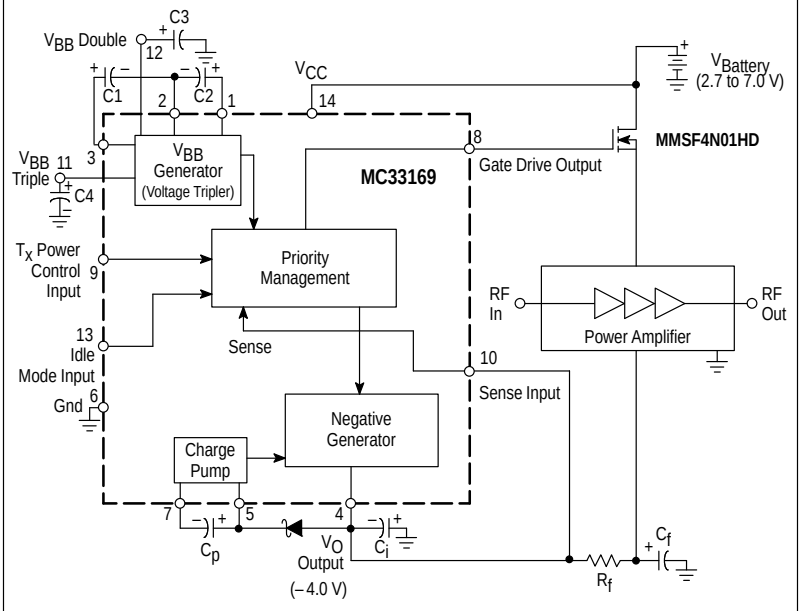
DTB SUFFIX
PLASTIC PACKAGE
CASE 948G
(TSSOP–14)

PIN CONNECTIONS



(Top View)

Simplified Block Diagram



This device contains 148 active transistors.

ORDERING INFORMATION

Device	Operating Temperature Range	Package
MC33169DTB–4.0	T_A = –40° to +85°C	TSSOP–14

MAXIMUM RATINGS

Rating	Pin	Symbol	Value	Unit
Power Supply Voltage	14	V_{CC}	9.5	V
T_X Power Control Input	9	VT_X	V_{CC}	V
Idle Mode Input	13	V_i	V_{CC}	V
Sense Input	10	V_{Sense}	–5.0 to 0	V
Negative Generator Output Source Current	4	I_{SS}	20	mA
Charge Pump Capacitor Current	–	I_{max}	60	mA
Diode Forward Current	–	I_{Fmax}	60	mA
Gate Drive Output Current	8	I_{GO}	5.0	mA
Power Dissipation and Thermal Characteristics Maximum Power Dissipation @ T_A = 50°C Thermal Resistance, Junction–to–Air Operating Junction Temperature	–	 P_D $R_{\theta JA}$ T_J	 417 240 +150	 mW °C/W °C
Operating Ambient Temperature	–	T_A	–40 to +85	°C
Storage Temperature Range	–	T_{stg}	–60 to +150	°C

NOTE: ESD data available upon request.

MC33169–4.0

ELECTRICAL CHARACTERISTICS (V_{CC} = 4.8 V. For typical values T_A = 25°C, for min/max values T_A is the operating ambient temperature range that applies, unless otherwise noted.)

Characteristic	Pin	Symbol	Min	Typ	Max	Unit
V_{BB} GENERATOR (VOLTAGE TRIPLER)						
Oscillator Frequency	–	f_{osc}	90	100	110	kHz
Oscillator Duty Cycle	–	DC	35	50	65	%
Output Voltage (V_{CC} = 3.0 V, I_O = 3.0 mA) Double Voltage Triple Voltage (V_{CC} = 7.2 V, I_O = 3.0 mA) Triple Voltage	12 11 11	V_{BBD} V_{BBT} V_{BBT}	4.6 6.1 –	5.0 7.0 11.2	– – –	V
NEGATIVE GENERATOR OUTPUT						
Output Voltage (I_O = 3.0 mA)	4	V_O	–3.75	–4.0	–4.25	V
Output Voltage Ripple with Filter (R_f = 33 Ω, C_f = 4.7 μF) (I_O = 0 to 5.0 mA)	4	V_r	 –	 2.0	 –	mVpp
PRIORITY MANAGEMENT SECTION						
Idle Mode Input Input Voltage High State (Logic 1) Input Voltage Low State (Logic 0) Input Current High State (Logic 1) Input Current Low State (Logic 0), i.e. Standby Mode	13	 V_{IH} V_{IL} I_{IH} I_{IL}	 2.0 0 10 –	 – – – –	 V_{CC}+0.2 0.5 80 1.0	 V V μA μA
T_X Power Control Input Input Voltage Range Input Voltage “Off” State (Zero RF Output Level) Input Voltage “On” State (Maximum RF Output Level) Input Resistance Bandwidth (–3.0 dB)	9	 VT_X $VT_{X(off)}$ $VT_{X(on)}$ R_{in} B	 0 – – – –	 – 0.7 2.7 90 1.0	 3.1 – – – –	 V V V kΩ MHz
Gate Drive Output Voltage (VT_X = 0 V) (VT_X = 3.0 V) Peak Current (Source and Sink) (VT_X = 3.0 V)	8	 V_{GO} I_{GO}	 – V_{CC}+2.7 –	 – – 3.0	 0.5 – –	 V mA
Undervoltage Lockout Voltage on Sense Input (Magnitude)	10	V_{sense}	–3.0	–3.2	–	V
TOTAL DEVICE POWER CONSUMPTION						
I_{CC} Operating (VT_X = 3.0 V, I_O = 3.0 mA)	–	I_{CC}	–	10	15	mA
I_{CC} Operating (VT_X = 0 V, I_O = 3.0 mA) (VT_X = 0 V, I_O = 0 mA)	–	I_{CC}	– –	12 4.0	15 5.0	mA
Standby Mode (Idle Mode Input = 0 V)	–	I_{CC}	–	–	1.0	μA

MC33169–4.0

ELECTRICAL CHARACTERISTICS (V_{CC} = 2.7 V. For typical values T_A = 25°C, for min/max values T_A is the operating ambient temperature range that applies, unless otherwise noted.)

Characteristic	Pin	Symbol	Min	Typ	Max	Unit
V_{BB} GENERATOR (VOLTAGE TRIPLER)						
Oscillator Frequency	–	f_{osc}	90	100	110	kHz
Oscillator Duty Cycle	–	DC	35	50	65	%
Output Voltage (V_{CC} = 3.0 V, I_O = 3.0 mA)						V
Double Voltage	12	V_{BBD}	4.6	5.0	–	
Triple Voltage	11	V_{BBT}	6.1	7.0	–	
Triple Voltage (V_{CC} = 7.2 V, I_O = 3.0 mA)	11	V_{BBT}	–	11.2	–	
NEGATIVE GENERATOR OUTPUT						
Output Voltage (I_O = 1.0 mA)	4	V_O	–3.75	–4.0	–4.25	V
Output Voltage Ripple with Filter (R_f = 33 Ω, C_f = 4.7 μF) (I_O = 0 to 5.0 mA)	4	V_r	–	2.0	–	mVpp
PRIORITY MANAGEMENT SECTION						
Idle Mode Input	13					
Input Voltage High State (Logic 1)		V_{IH}	2.0	–	V_{CC}+0.2	V
Input Voltage Low State (Logic 0)		V_{IL}	0	–	0.5	V
Input Current High State (Logic 1)		I_{IH}	10	–	80	μA
Input Current Low State (Logic 0), i.e. Standby Mode		I_{IL}	–	–	1.0	μA
T_X Power Control Input	9					
Input Voltage Range		VT_X	0	–	3.0	V
Input Voltage “Off” State (Zero RF Output Level)		$VT_{X(off)}$	–	0.7	–	V
Input Voltage “On” State (Maximum RF Output Level)		$VT_{X(on)}$	–	2.7	–	V
Input Resistance		R_{in}	–	90	–	kΩ
Bandwidth (–3.0 dB)		B	–	1.0	–	MHz
Gate Drive Output	8					
Voltage (VT_X = 0 V)		V_{GO}	–	–	0.5	V
(VT_X = 3.0 V)			V_{CC}+2.7	–	–	
Peak Current (Source and Sink) (VT_X = 3.0 V)		I_{GO}	–	3.0	–	mA
Undervoltage Lockout Voltage on Sense Input (Magnitude)	10	V_{sense}	–3.0	–3.2	–	V
TOTAL DEVICE POWER CONSUMPTION						
I_{CC} Operating (VT_X = 3.0 V)	14	I_{CC}				mA
(I_O = 3.0 mA)			–	–	15	
(I_O = 1.0 mA)			–	–	9.0	
I_{CC} Operating (VT_X = 0 V)	14	I_{CC}				mA
(I_O = 3.0 mA)			–	–	13	
(I_O = 1.0 mA)			–	–	9.0	
(I_O = 0 mA)			–	4.5	6.0	
Standby Mode (Idle Mode Input = 0 V)	14	I_{CC}	–	–	1.0	μA

PRIORITY MANAGEMENT TRUTH TABLE

Control Inputs		Outputs	
Idle Mode	T_X Power Control	V_O	Gate Drive
0	0	Off	0.5 V max
1	0	–4.0 V	0.5 V max
0	1	Off	0.5 V max
1	1	–4.0 V	V_{CC} + 2.7 V min

PIN FUNCTION DESCRIPTION

Pin	Name	Description
1	C2 Input	This is the positive pin for the charge pump capacitor in the voltage doubler.
2	C1/C2	This is the negative pin for the charge pump capacitors.
3	C1 Input	This is the positive pin for the charge pump capacitor in the voltage tripler.
4	V_O Output	It delivers a regulated negative voltage of –4.0 V. It can source an output current in excess of 5.0 mA.
5	V_O Charge Pump Capacitor +	This is the positive pin for the capacitor in the inverting charge pump.
6	Gnd	This pin is Ground for both signal and power circuitry.
7	V_O Charge Pump Capacitor –	This is the negative pin for the capacitor in the inverting charge pump.
8	Gate Drive Output	This is the output of the gate amplifier which directly drives the gate of an N–Channel MOSFET. It can sink and source peak currents up to 3.0 mA.
9	T_X Power Control Input	The input signal applied on this pin controls the N–Channel switching MOSFET in follower mode and therefore, linearly controls the RF output voltage.
10	Sense Input Pin	It senses the negative voltage directly on the Power Amplifier. It is also the input pin of an internal Undervoltage Lockout circuit which blocks the switching of the N–Channel MOSFET if the sensed voltage is more positive than –3.0 V.
11	V_{BB} Triple	This is the positive pin of the output filter capacitor in the voltage tripler. The triple voltage at that pin is used internally to supply the inverting charge pump and the gate amplifier.
12	V_{BB} Double	This is the positive pin of the output filter capacitor in the voltage doubler.
13	Idle Mode Input	This pin is used to set the circuit in Low Power Consumption Standby mode. It is CMOS compatible, i.e. a voltage lower than 0.5 V applied on this pin makes the device go into Standby mode in which the current consumption is lower than 1.0 μA. The MC33169 is then awakened by a voltage higher than 2.0 V applied on that pin.
14	V_{CC}	This is the supply input pin for the MC33169, V_{CC} voltage ranges from 2.7 V to 7.2 V.

Figure 1. MC33169 Representative Block Diagram

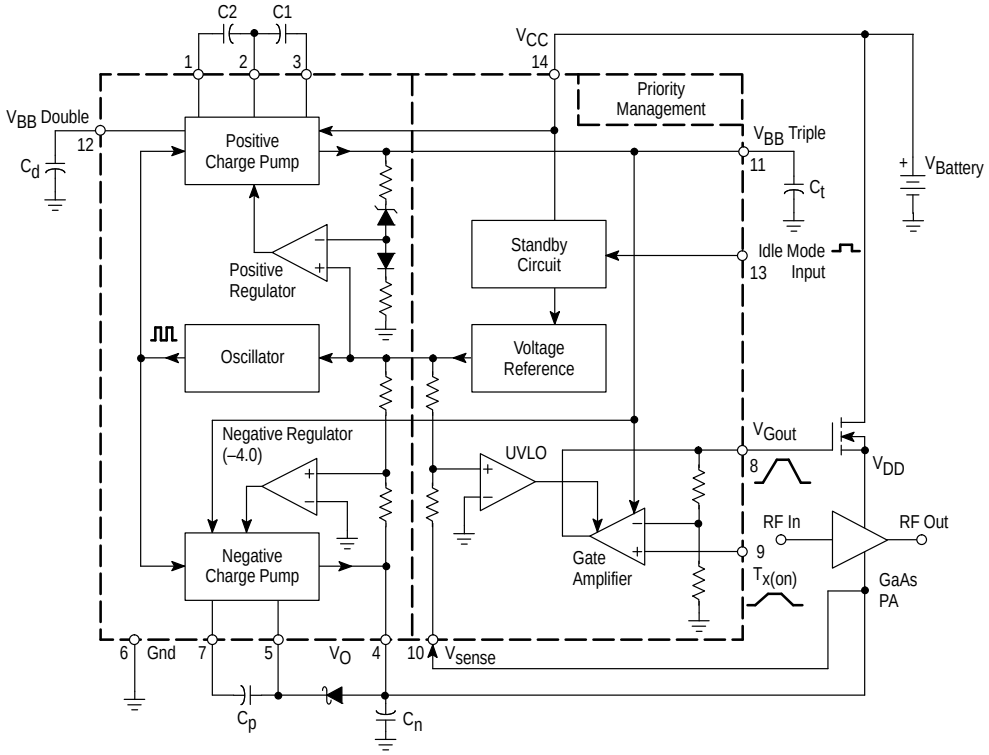


Figure 2. Operating Current versus Temperature

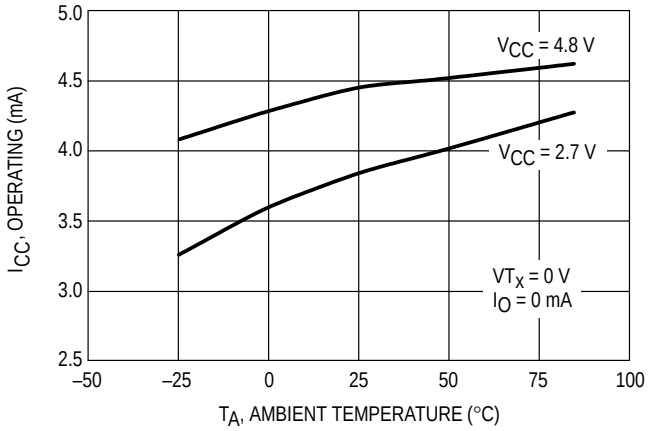


Figure 3. Operating Current versus Temperature

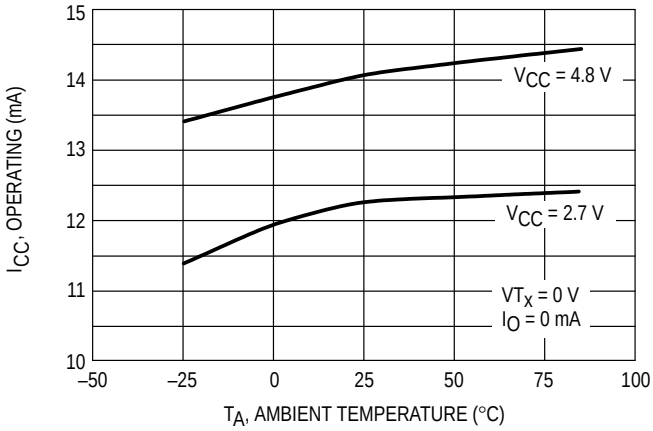


Figure 4. Operating Current versus Temperature

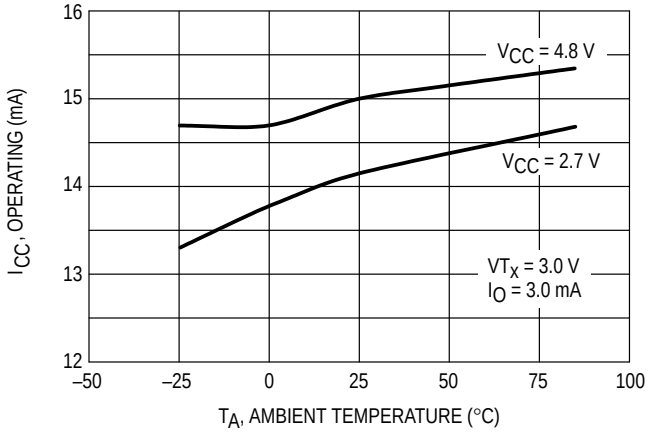


Figure 5. Operating Current versus Temperature

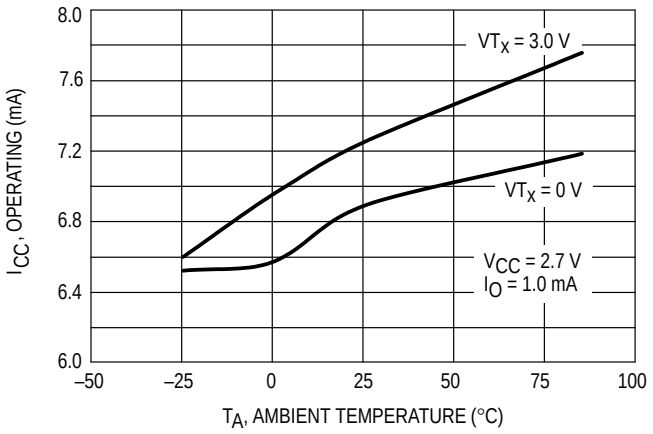


Figure 6. Output Voltage versus Temperature

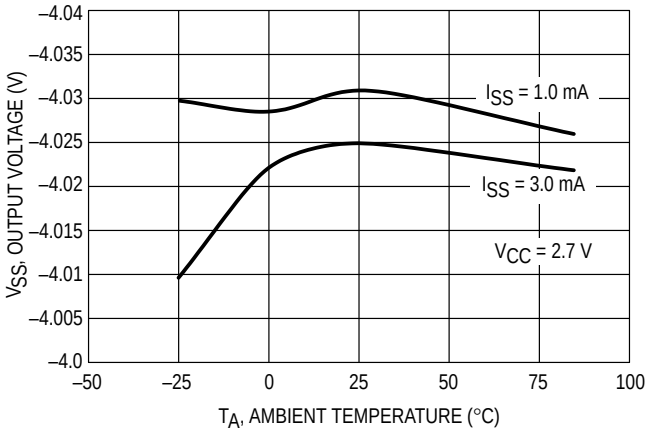


Figure 7. Output Voltage versus Temperature

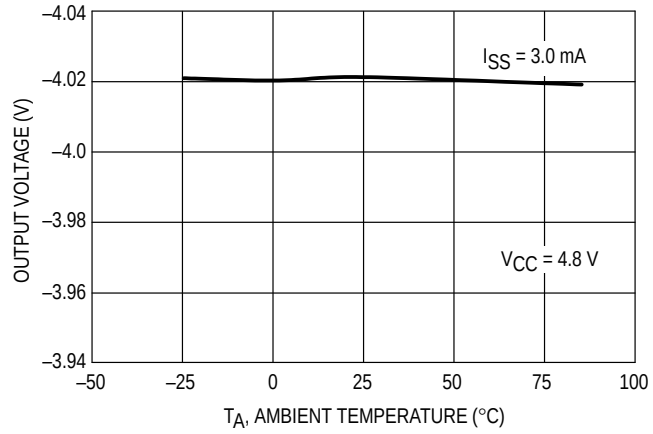


Figure 8. Output Voltage versus Load Current

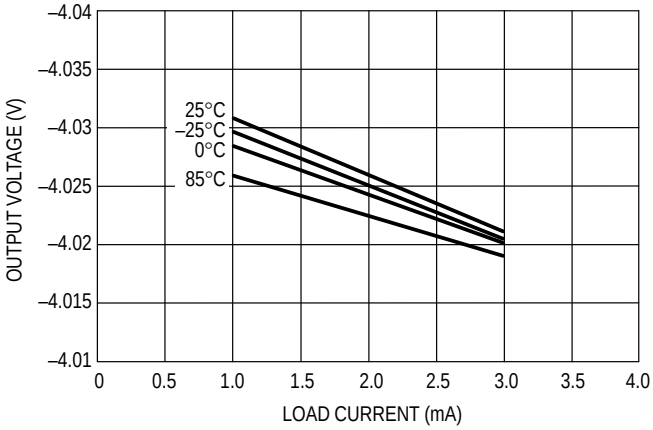
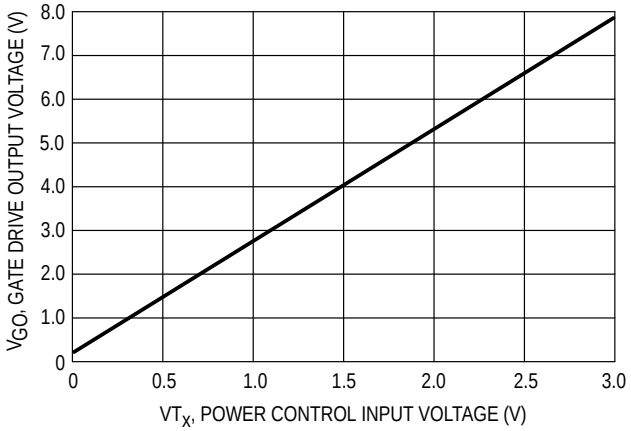


Figure 9. VT_X Control Voltage versus Gate Drive Output Voltage



OPERATING DESCRIPTION

The MC33169 is a power amplifier support IC that is designed to properly switch “on” or “off” a MESFET Power Amplifier either manually or by microprocessor. Controlling the power drain of the RF Amplifier extends operating battery life in many portable systems.

Outputs

The IC is designed to provide a –4.0 V bias to the gate of the RF Ampllifier MESFET devices prior to application of a positive battery voltage to the drain. The negative output voltage can provide up to 5.0 mA of current. The positive voltage control requires an external N–Channel logic level MOSFET, connected as a source follower. The Gate Drive Output, Pin 8, can source or sink 3.0 mA to the external MOSFET. The low drive current slows the MOSFET switching speed, thereby minimizing voltage glitches on the V_{CC} line which could cause disturbances to other circuitry.

Inputs

A Sense Input, Pin 10, protects the Power Amplifier load by monitoring the level of the negative output voltage. If the negative voltage magnitude falls below a preset level, 3.2 V typical, an undervoltage lockout circuit disables the external MOSFET gate drive.

The T_X Power Control Input controls the N–Channel external switching MOSFET in source follower mode, which allows linear control of the RF Output voltage level.

The Idle mode input is CMOS compatible, allowing the RF Amplifier to be placed in a standby mode, drawing less than 1.0 μA from the power source.

Figure 10. Class 4 GSM with a Two–Stage Integrated Power Amplifier (I.P.A.)

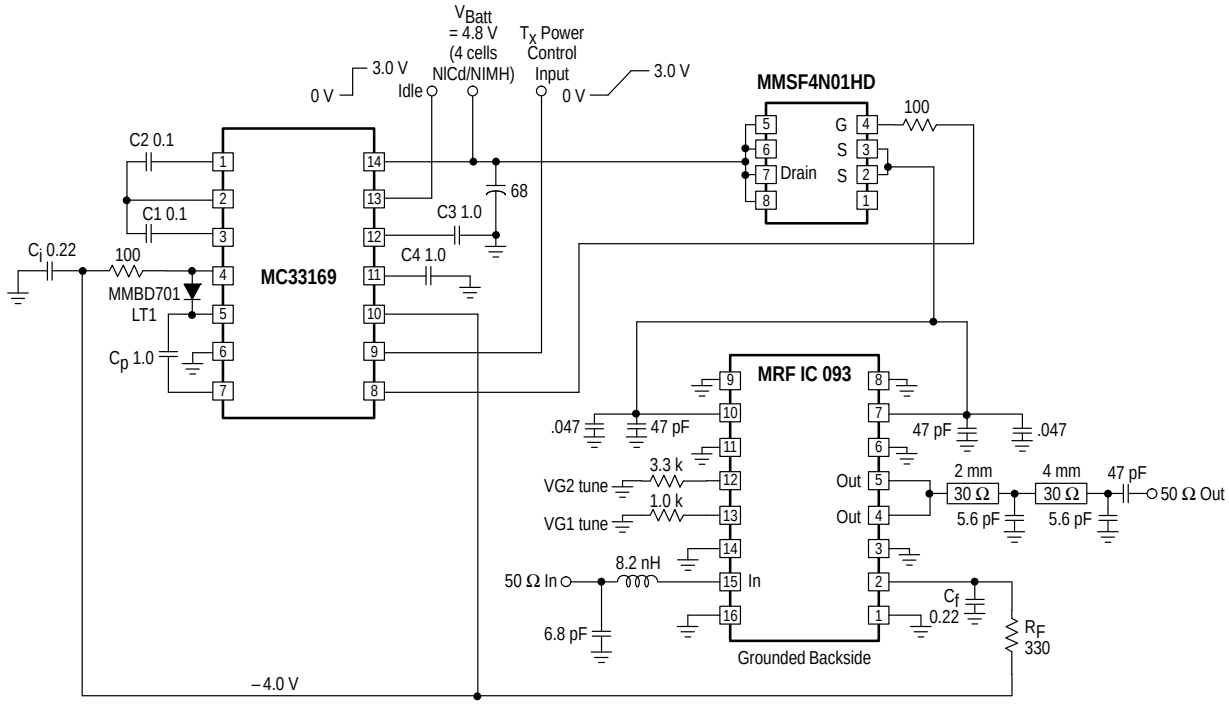
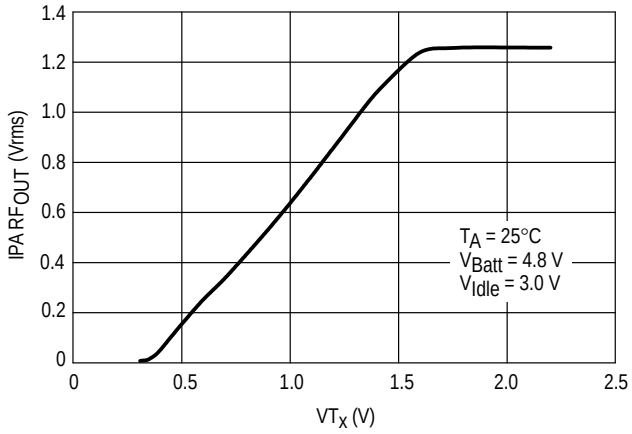


Figure 11. Transfer Characteristic for Gate Drive Output



V_{Batt} = 4.8 V
P_{in} = 10 dBm
V_{Idle} = 3.0 V

V_{ramp}: 40 Hz sinusoidal voltage set for 95% AM depth on RF

Peak output power: 34.6 dBm

CURVES RELATED TO APPLICATION GSM CLASS 4

Figure 12. RF Output Voltage (40 Hz/95% AM) and VT_X Driving Voltage

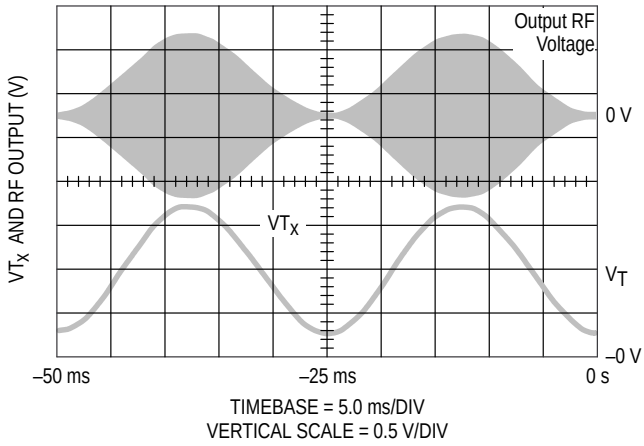


Figure 13. Idle, PA Drain, RF Output and V_O Voltages During a Burst Period

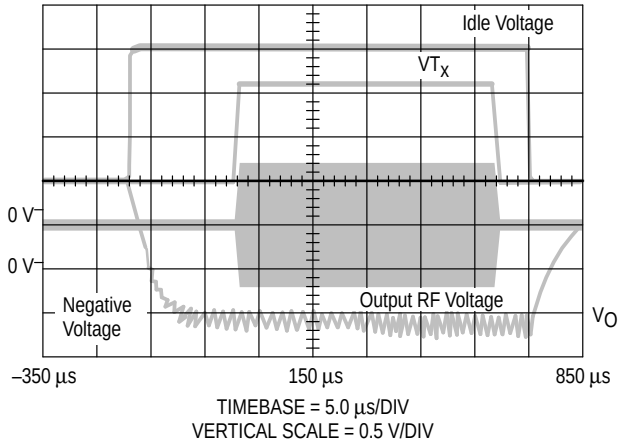


Figure 14. RF Output Voltage, PA Drain Voltage and VT_X Driving Voltage, During Fall Time

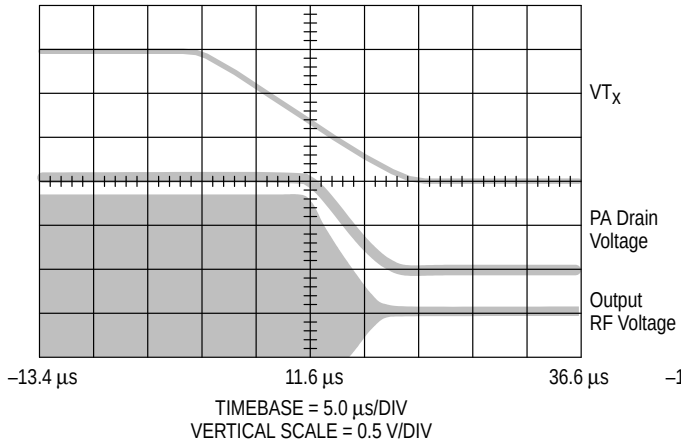


Figure 15. RF Output Voltage, PA Drain Voltage and VT_X Driving Voltage, During Rise Time

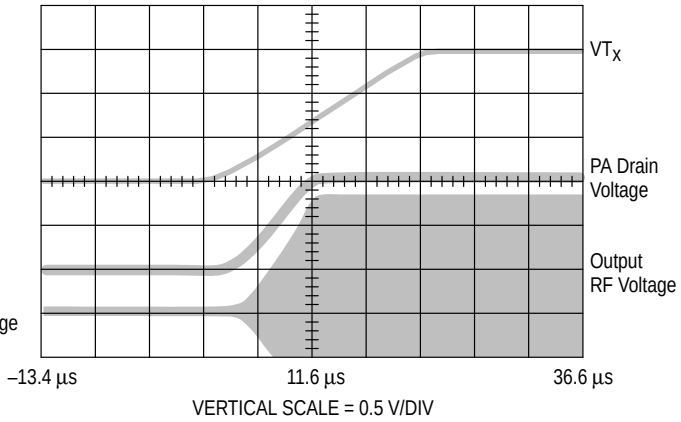


Figure 16. AMPS version with MRFIC0913, Integrated Power Amplifier (I.P.A.)

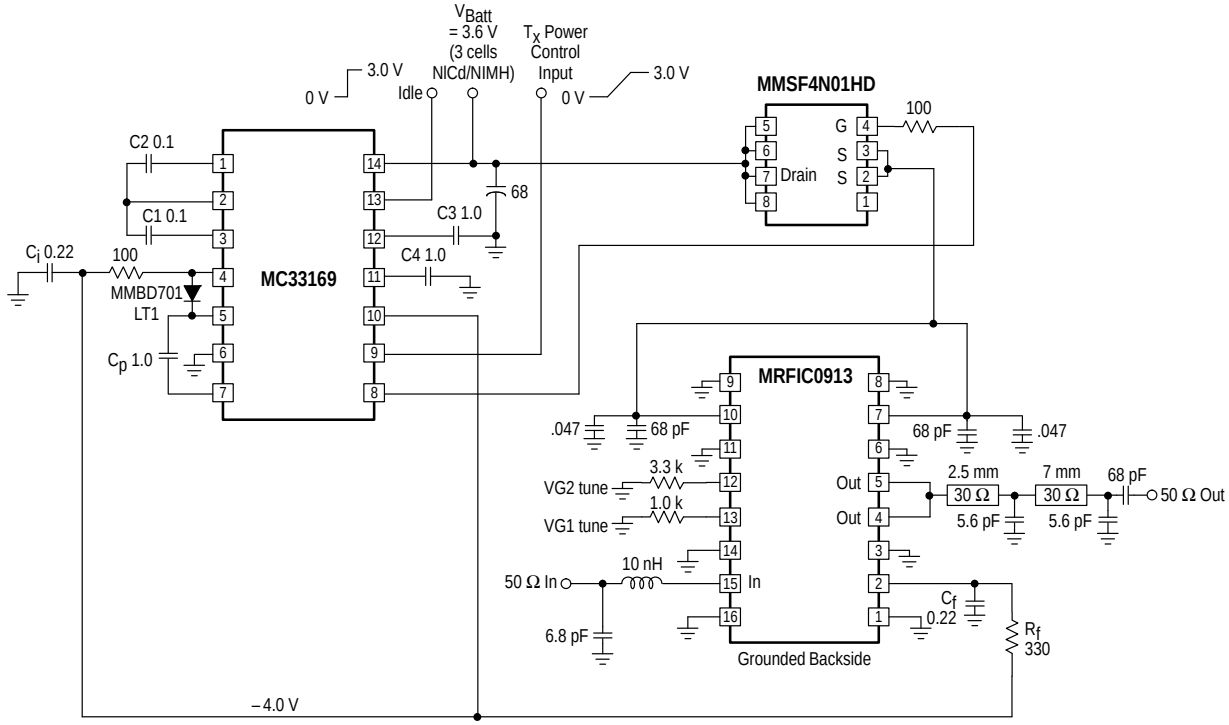
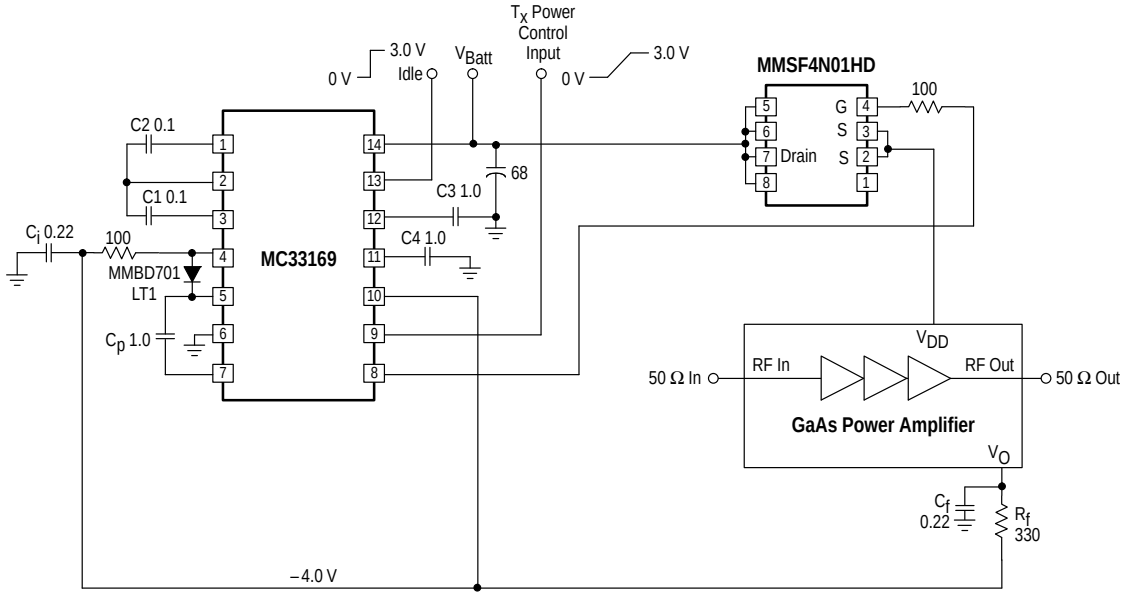
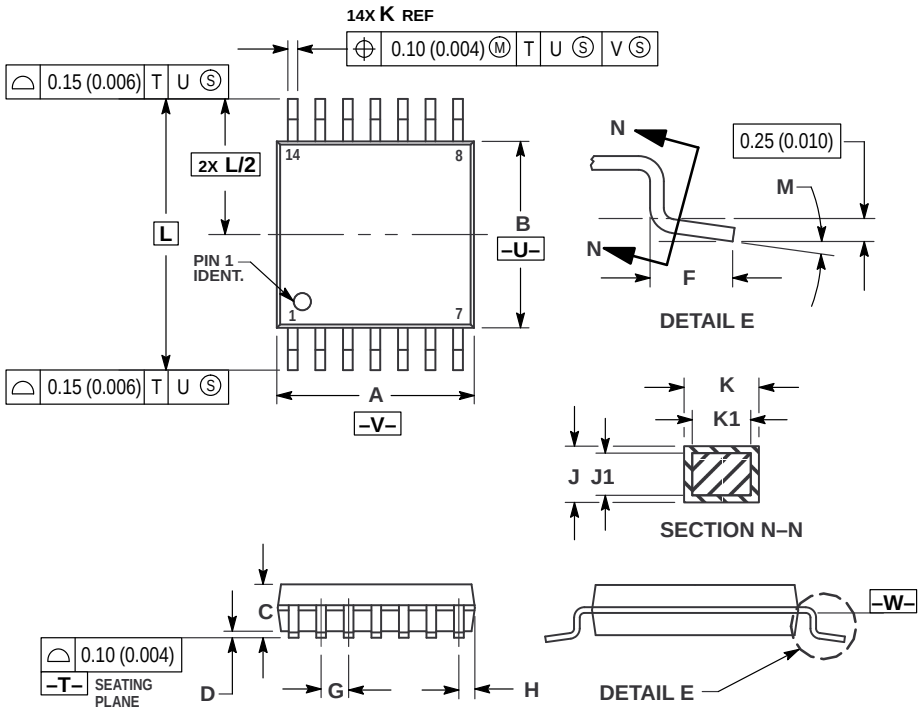


Figure 17. MC33169 with GaAs RF Power Amplifier



OUTLINE DIMENSIONS

DTB SUFFIX
PLASTIC PACKAGE
CASE 948G–01
(TSSOP–14)
ISSUE O



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE –W–.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.90	5.10	0.193	0.200
B	4.30	4.50	0.169	0.177
C	—	1.20	—	0.047
D	0.05	0.15	0.002	0.006
F	0.50	0.75	0.020	0.030
G	0.65 BSC		0.026 BSC	
H	0.50	0.60	0.020	0.024
J	0.09	0.20	0.004	0.008
J1	0.09	0.16	0.004	0.006
K	0.19	0.30	0.007	0.012
K1	0.19	0.25	0.007	0.010
L	6.40 BSC		0.252 BSC	
M	0°	8°	0°	8°

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