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EVALUATION KIT AVAILABLE

MAXIM

Low-Noise Bias Supply in µMAX with Power-OK for GaAsFET PA

MAX881R

General Description

The MAX881R low-noise, inverting power supply is designed for biasing GaAsFET power amplifiers in portable wireless applications. This device is a charge-pump inverter followed by a negative linear regulator. The input voltage range is 2.5V to 5.5V. The output is preset at -2.0V or can be set, using two resistors, to any voltage from -0.5V to (-V_{IN} + 0.6V). It can deliver up to 4mA. The internal linear regulator also filters the output to 1mVp-p ripple and noise.

Other features include a power-OK ($\overline{POK}$) output that signals when the negative voltage is within 7.5% of its set point. It protects the GaAsFET by not allowing power to be applied to the GaAsFET's drain until it is properly biased. The signal can be routed either to a microcontroller or directly to a switch at the GaAsFET drain. The MAX881R is available in a 10-pin µMAX package.

Features

♦ **Small µMAX Package**

♦ **1mVp-p Output Voltage Ripple and Noise**

♦ **Power-OK Signal to Control GaAsFET Drain Switch**

♦ **0.05µA Logic-Controlled Shutdown**

♦ **1ms Guaranteed Startup**

♦ **2.5V to 5.5V Input**

♦ **-0.5V to (-V_{IN} + 0.6V) Output at up to 4mA**

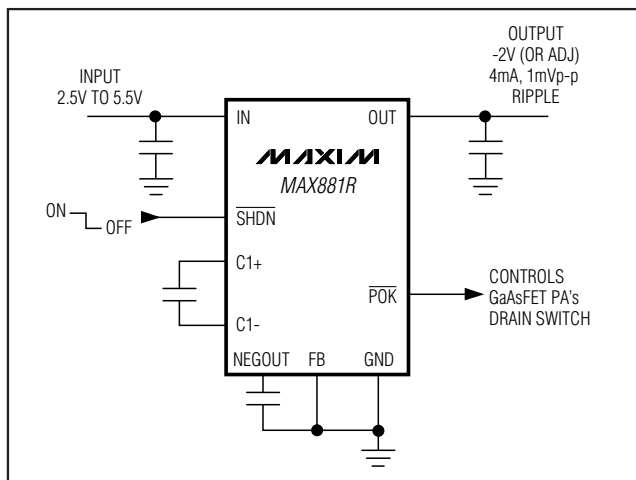♦ **Operates with One 4.7µF and Three 0.22µF Capacitors (no inductors needed)**

Applications

Cell Phones	Wireless Modems
PCS Phones	Two-Way Pagers
PHS Phones	Mobile Radios
Wireless Handsets	Wireless Computers

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX881REUB	-40°C to +85°C	10 µMAX

Typical Operating Circuit

Pin Configuration

TOP VIEW

N.C. = NOT INTERNALLY CONNECTED

MAXIM _____ **Maxim Integrated Products** 1
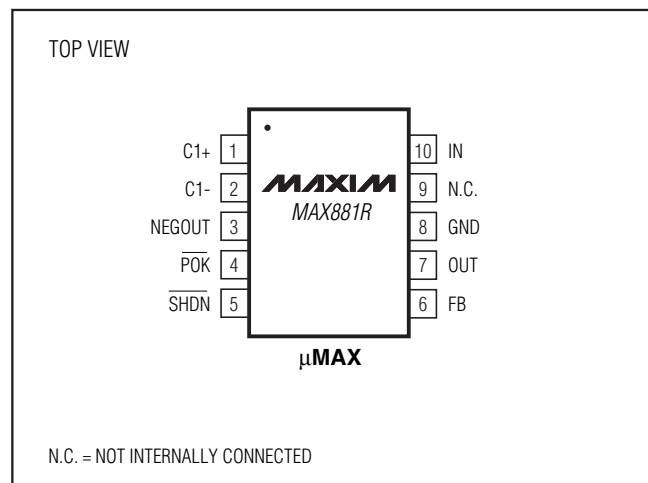
Low-Noise Bias Supply in µMAX
with Power-OK for GaAsFET PA

ABSOLUTE MAXIMUM RATINGS

IN to GND ....-0.3V to +6V
$\overline{SHDN}$ to GND...-0.3V to +6V
$\overline{POK}$ to GND ....-0.3V to +12V
C1+ to GND ....-0.3V to (V_{IN} + 0.3V)
C1-, NEGOUT, OUT, FB to GND ....-6V to (V_{IN} + 0.3V)
Continuous Power Dissipation (T_A = +70°C)
  10-Pin µMAX (derate 5.6mW/°C above +70°C) 444mW

Operating Temperature Range ....-40°C to +85°C
Junction Temperature ....+150°C
Storage Temperature Range ....-65°C to +165°C
Lead Temperature (soldering, 10s) ....+300°C

Note 1: The output may be shorted to NEGOUT or GND if the package power dissipation is not exceeded. Typical short-circuit current is 35mA.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(Circuit of Figure 3, V_{IN} = +3.6V, FB = GND, R_L = ∞, $\overline{SHDN}$ = IN, **T_A = -40°C to +85°C**, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{IN}			2.5		5.5	V
Preset Output Voltage	V_{OUT}	V_{IN} ≥ 2.7V, I_{OUT} = 0 to 4mA		-2.1	-2.0	-1.9	V
Adjustable Output Voltage Range	V_{OUT}	V_{IN} ≥ 2.5V, I_{OUT} = 0 to 4mA		-(V_{IN} - 0.6)		-0.5	V
FB Voltage	V_{FB}	V_{IN} ≥ 2.5V, I_{OUT} = 0 to 4mA	T_A = +25°C	-0.515	-0.5	-0.485	V
			T_A = 0°C to +85°C	-0.525		-0.475	
			T_A = -40°C to +85°C	-0.535		-0.465	
FB Input Current		V_{FB} = -0.5V			-10	-100	nA
Supply Current (Note 3)	I_Q				500	950	µA
Shutdown Supply Current	I_{SHUT}	$\overline{SHDN}$ = GND			0.05	1	µA
Output Load Regulation		V_{IN} ≥ 2.7V, I_{OUT} = 0 to 4mA			2	6	mV/mA
Output Ripple		I_{OUT} = 4mA, circuit of Figure 3b			1		mVp-p
Oscillator Frequency	f_{OSC}			80	100	120	kHz
$\overline{POK}$ Threshold		FB = OUT		90	92.5	95	% of V_{OUT}
$\overline{POK}$ Output Level		V_{IN} ≥ 2.5V, sinking 1mA				100	mV
$\overline{POK}$ Off Leakage Current		$V\overline{POK}$ = 11V				1	µA
$\overline{SHDN}$ Input High Voltage	V_{IH}	V_{IN} = 5.5V		2.2			V
$\overline{SHDN}$ Input Low Voltage	V_{IL}	V_{IN} = 2.5V				0.35	V
$\overline{SHDN}$ Input Current	$I_{\overline{SHDN}}$	Connected to IN or GND				±1	µA
$\overline{SHDN}$ Input Capacitance	C_{IN}				10		pF
Startup Time	t_{START}	V_{IN} = 3V, R_L = 500Ω, $V\overline{SHDN}$ = 0 to V_{IN}, $\overline{POK}$ goes low				1	ms

Note 2: Specifications to -40°C are guaranteed by design, not production tested.
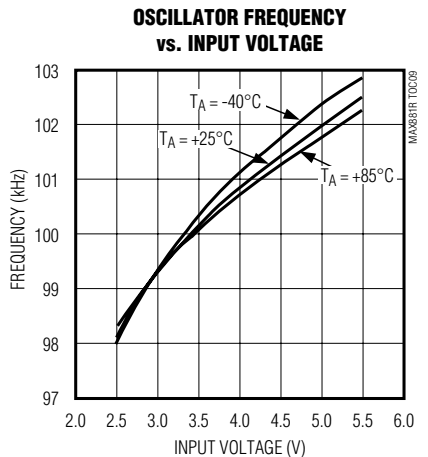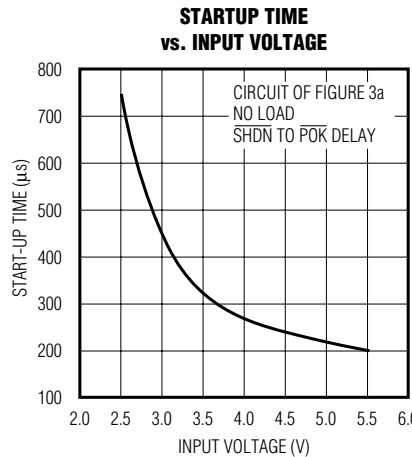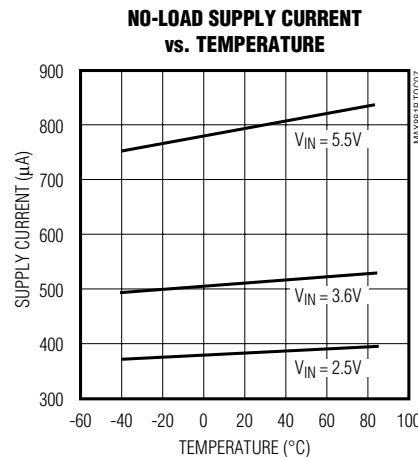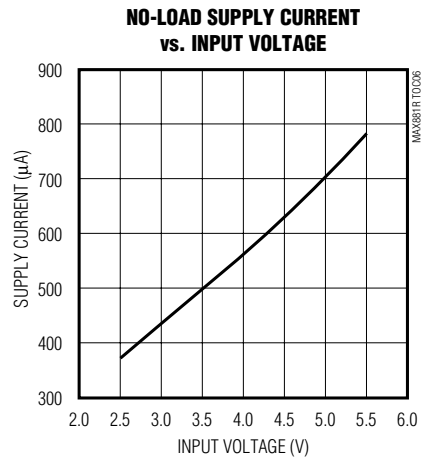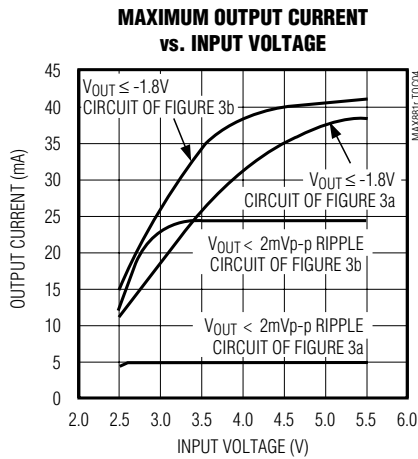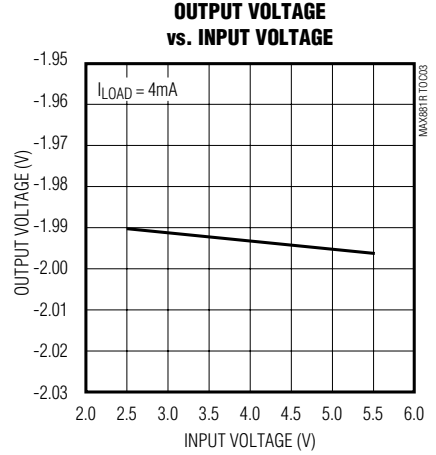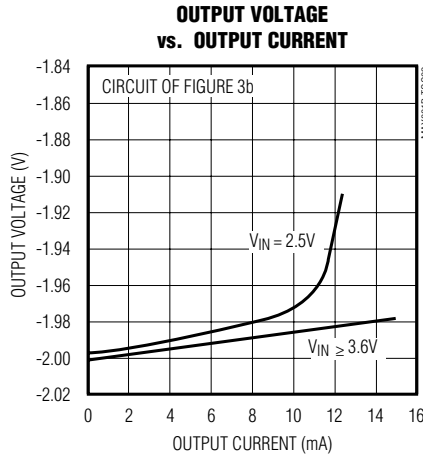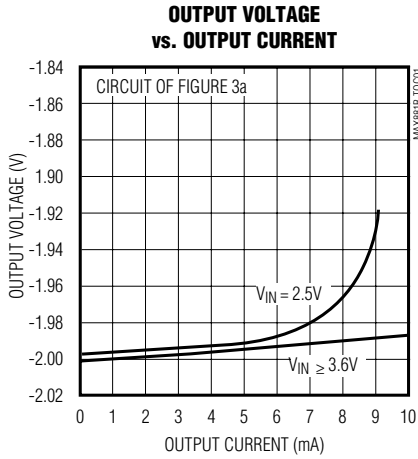**Note 3:** MAX881R may draw high supply current during startup, up to the minimum operating supply voltage. To guarantee proper startup, the input supply must be capable of delivering 90mA more than the maximum load current.

MAX881R

_____Typical Operating Characteristics

(Circuit of Figure 3, V_{IN} = 3.6V, T_A = +25°C, unless otherwise noted.)

OUTPUT VOLTAGE
vs. OUTPUT CURRENT

CIRCUIT OF FIGURE 3a

V_{IN} = 2.5V

$V_{IN} \geq 3.6V$

MAX881R TOC01

OUTPUT VOLTAGE
vs. OUTPUT CURRENT

CIRCUIT OF FIGURE 3b

V_{IN} = 2.5V

$V_{IN} \geq 3.6V$

MAX881R TOC02

OUTPUT VOLTAGE
vs. INPUT VOLTAGE

I_{LOAD} = 4mA

MAX881R TOC03

MAXIMUM OUTPUT CURRENT
vs. INPUT VOLTAGE

$V_{OUT} \leq$ -1.8V
CIRCUIT OF FIGURE 3b

$V_{OUT} \leq$ -1.8V
CIRCUIT OF FIGURE 3a

V_{OUT} < 2mVp-p RIPPLE
CIRCUIT OF FIGURE 3b

V_{OUT} < 2mVp-p RIPPLE
CIRCUIT OF FIGURE 3a

MAX881R TOC04

MAXIMUM NEGOUT CURRENT
vs. INPUT VOLTAGE

V_{NEGOUT} = 0.9 x $V_{NEGOUT(NO LOAD)}$

CIRCUIT OF FIGURE 3b

CIRCUIT OF FIGURE 3a

MAX881R TOC05

NO-LOAD SUPPLY CURRENT
vs. INPUT VOLTAGE

MAX881R TOC06

NO-LOAD SUPPLY CURRENT
vs. TEMPERATURE

V_{IN} = 5.5V

V_{IN} = 3.6V

V_{IN} = 2.5V

MAX881R TOC07

STARTUP TIME
vs. INPUT VOLTAGE

CIRCUIT OF FIGURE 3a
NO LOAD
SHDN TO POK DELAY

MAX881R TOC08

OSCILLATOR FREQUENCY
vs. INPUT VOLTAGE

T_A = -40°C

T_A = +25°C

T_A = +85°C

MAX881R TOC09

MAX881R

Typical Operating Characteristics (continued)

(Circuit of Figure 3, V_{IN} = 3.6V, T_A = +25°C, unless otherwise noted.)

STARTUP FROM SHUTDOWN
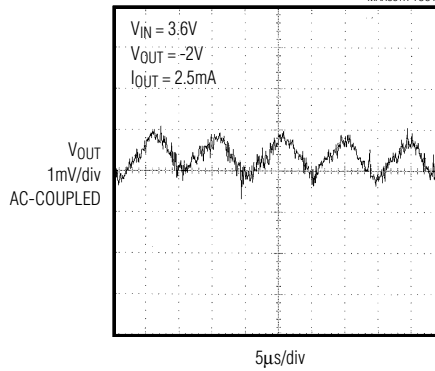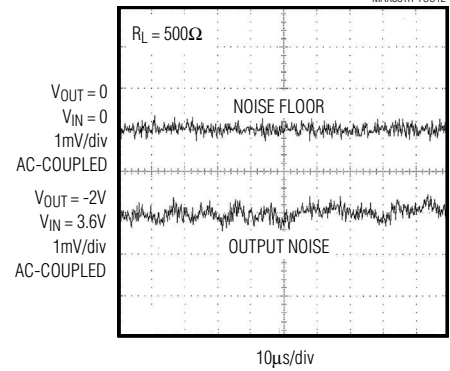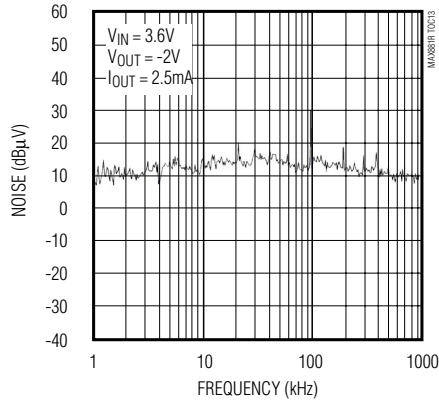**(NO LOAD)**

MAX881R-TOC10

$\overline{SHDN}$ +5V

    0

V_{OUT} 0

    -2V

$\overline{POK}$ V_{IN}

    0

V_{IN} = 3.6V
CIRCUIT OF FIGURE 3b

100µs/div

OUTPUT NOISE AND RIPPLE
(CIRCUIT OF FIGURE 3a)

MAX881R-TOC11

V_{IN} = 3.6V
V_{OUT} = -2V
I_{OUT} = 2.5mA

V_{OUT}
1mV/div
AC-COUPLED

5µs/div

OUTPUT NOISE AND RIPPLE
(CIRCUIT OF FIGURE 3b)

MAX881R-TOC12

R_L = 500Ω

V_{OUT} = 0
V_{IN} = 0
1mV/div
AC-COUPLED

NOISE FLOOR

V_{OUT} = -2V
V_{IN} = 3.6V
1mV/div
AC-COUPLED

OUTPUT NOISE

10µs/div

OUTPUT NOISE SPECTRUM
(CIRCUIT OF FIGURE 3a)

MAX881R-TOC13

V_{IN} = 3.6V
V_{OUT} = -2V
I_{OUT} = 2.5mA

NOISE (dBµV)

60
50
40
30
20
10
0
-10
-20
-30
-40

1   10   100   1000
FREQUENCY (kHz)

OUTPUT NOISE SPECTRUM
(CIRCUIT OF FIGURE 3b)

MAX881R-TOC14

V_{IN} = 3.6V
V_{OUT} = -2V
I_{OUT} = 4mA

NOISE (dBµV)

60
50
40
30
20
10
0
-10
-20
-30
-40

1   10   100   1000
FREQUENCY (kHz)

LINE-TRANSIENT RESPONSE

MAX881R-TOC15

V_{IN} 3.3V

    2.7V

V_{OUT} 10mV/div

I_{LOAD} = 4mA
V_{OUT} = -2V
CIRCUIT OF FIGURE 3b

2ms/div
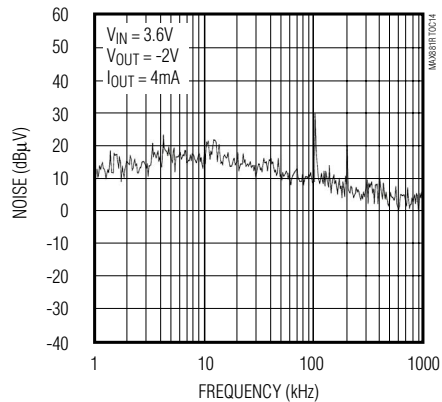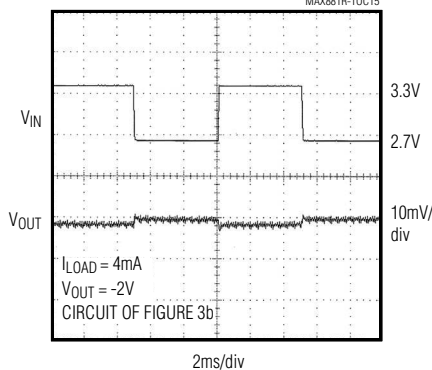
LOAD-TRANSIENT RESPONSE

MAX881R-TOC16

I_{OUT} 4mA

    400µA

V_{OUT} 10mV/div

V_{IN} = 3.6V
V_{OUT} = -2V
CIRCUIT OF FIGURE 3b

100µs/div

MAXIM
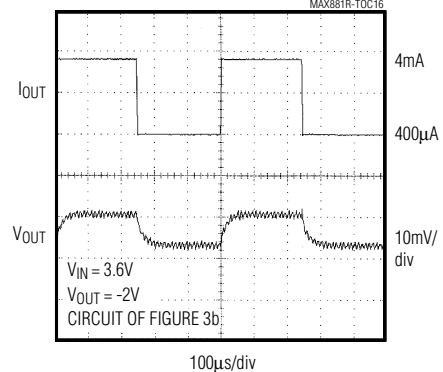
MAX881R

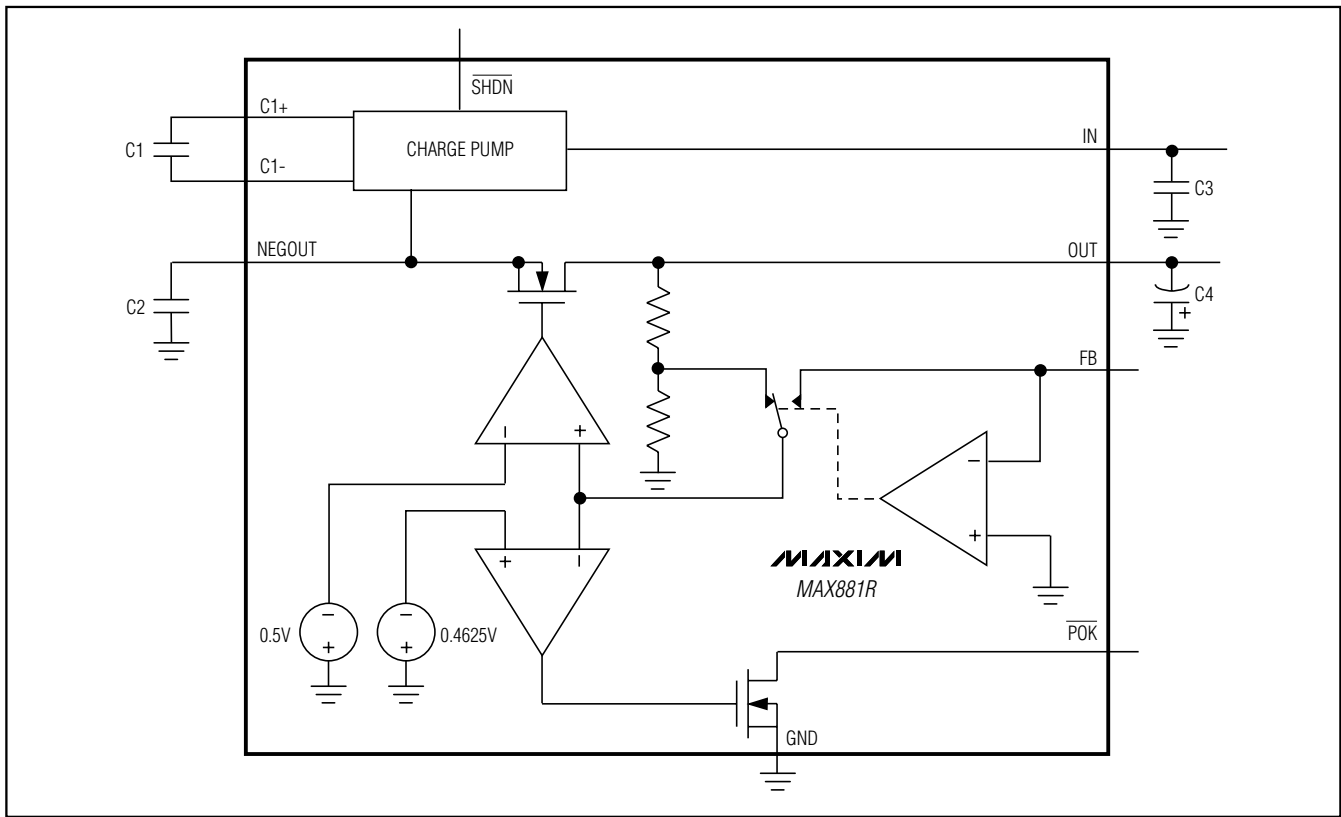| PIN	NAME	FUNCTION
1	C1+	Positive Terminal for C1
2	C1-	Negative Terminal for C1
3	NEGOUT	Negative Output Voltage (unregulated)
4	$\overline{POK}$	Active-Low, Open-Drain Power-OK Output. Goes low when OUT reaches 92.5% of its set value.
5	$\overline{SHDN}$	Active-Low, Logic-Level Shutdown Input. Connect to IN for normal operation. Do not leave this pin unconnected.
6	FB	Dual-Mode™ Feedback Input. When FB is connected to GND, the output is preset to -2V. To select other voltages, connect FB to an external resistor-divider (Figure 4). Do not leave this pin unconnected.
7	OUT	Regulated Negative Output Voltage
8	GND	Ground
9	N.C.	No Connection. Not internally connected.
10	IN	Positive Power-Supply Input

Dual Mode is a trademark of Maxim Integrated Products.

Figure 1. Functional Diagram
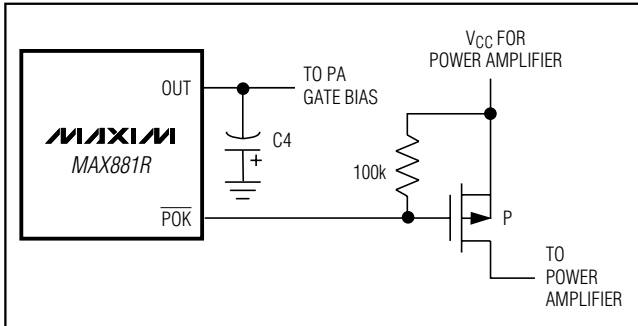
MAX881R

Figure 2. Using the $\overline{POK}$ Function

Figure 3a. Standard Application Circuit for Minimum Capacitor Values
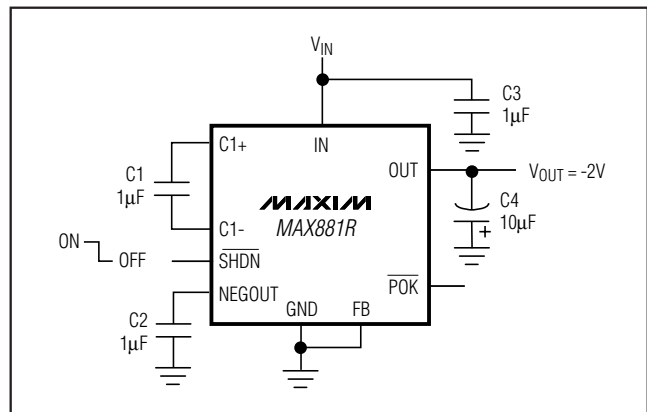
Figure 3b. Standard Application Circuit for Minimum Output Noise

Detailed Description

The MAX881R, a low-noise, inverting, regulated charge-pump power supply, is designed for biasing GaAsFET devices such as power-amplifier modules in cellular handsets.

The applied input voltage (V_{IN}) is inverted to a negative voltage at NEGOUT by a capacitive charge pump. This voltage is regulated by an internal linear regulator at OUT (Figure 1). With FB connected to GND, V_{OUT} is regulated at -2V. Alternatively, use a voltage-divider at FB to adjust the output voltage between -0.5V and -(V_{IN} - 0.6V) (see the section *Setting the Output Voltage*). The internal linear regulator reduces the ripple noise induced by the charge-pump inverter to 1mVp-p at OUT (circuit of Figure 3b). In addition, the excellent AC rejection of the linear regulator attenuates noise from the incoming supply.

Power-OK Signal

The MAX881R has an active-low, open-drain, power-OK ($\overline{POK}$) output. This output goes low when OUT reaches 92.5% of the regulated output voltage. $\overline{POK}$ can be used to drive the gate of a P-MOSFET that switches power to the GaAsFET power amplifier (Figure 2), thereby ensuring that the power amplifier is not powered before the required negative bias voltage is present.

Use a 50kΩ or larger pull-up resistor to signal a logic high when $\overline{POK}$ goes high impedance.

Shutdown Mode

The MAX881R features a shutdown mode that reduces supply current to less than 1µA over temperature. $\overline{SHDN}$ is an active-low, logic-level input. Start-up time coming out of shutdown mode is typically 0.5ms. OUT and NEGOUT are switched to GND in shutdown mode.
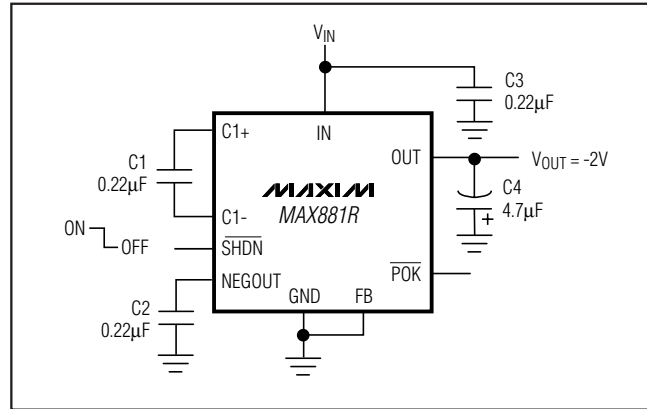
Applications Information

Setting the Output Voltage

Select either a fixed or adjustable output for the MAX881R. Connect FB to GND for a fixed -2V output (Figure 3). Select an alternative output voltage by connecting FB to the midpoint of a resistor-divider from OUT to GND (Figure 4). When operating under full load (4mA), the voltage at IN should be at least 0.6V higher than the absolute voltage required at OUT. Note that the minimum input voltage required for operation is 2.5V, regardless of the desired output voltage. Choose R1 to be between 100kΩ and 400kΩ and calculate R2. For greater accuracy, use resistors with 1% or better tolerance.

$$R2 = R1 \ (2 \times |V_{OUT}| - 1)$$

MAXIM

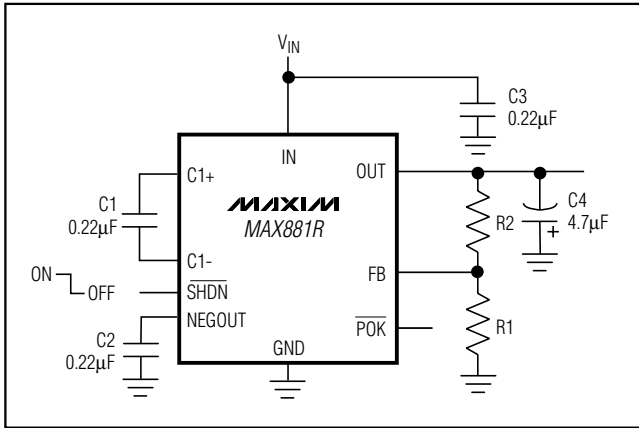# Low-Noise Bias Supply in µMAX with Power-OK for GaAsFET PA

Figure 4. Adjustable Output Configuration

Capacitors

Use capacitors with a low effective series resistance (ESR) to maintain a low dropout voltage ($V_{IN} - |V_{OUT}|$). The overall dropout voltage is a function of the output resistance of the charge pump and the voltage drop across the linear regulator (N-channel pass transistor). At the 100kHz charge-pump switching frequency, output resistance is a function of the value of C1 and the ESR of C1 and C2. Therefore, increasing C1 and minimizing the ESR of the charge-pump capacitors minimizes dropout voltage.

The output resistance of the entire circuit (in dropout) is approximately:

$$R_{OUT} = R_O + 4 \times ESR_{C1} + ESR_{C2} + 1 / (f_S \times C1) + R_{(linear\ regulator)}$$

Where $R_{(linear\ regulator)}$ (the output impedance of the linear regulator) is approximately 2Ω and R_O (the resistance of the internal switches) is typically 10Ω. When regulating, the output resistance of the circuit is simply the linear-regulator load regulation (2mV/mA).

C1, C2, and C3 should be 0.22µF capacitors with less than 0.4Ω ESR. C4 should be a 4.7µF capacitor with less than 0.1Ω ESR. Larger capacitor values can be used (C1 = C2 = C3 = 1µF, C4 = 10µF) to reduce output noise and ripple (1mVp-p), at the expense of cost and board space. All capacitors should be either ceramic or surface-mount chip tantalum (Figures 3a and 3b).

Layout and Grounding

Good layout is important for good noise performance. To optimize the layout:

1) Mount all components as close together as possible.

2) Keep traces short to minimize parasitic inductance and capacitance, especially connections to FB.

3) Use a ground plane.

Noise and Ripple Measurement

Accurately measuring the output noise and ripple is a challenge. Slight momentary differences in ground potential between the circuit and the oscilloscope (which result from the charge pump's switching action) cause ground currents in the probes' wires, inducing sharp voltage spikes. For best results, measure directly across the output capacitor (C4). Do not use the ground lead of the probe; instead, remove the probe's tip cover and touch the ground ring on the probe directly to C4's ground terminal. This direct connection gives the most accurate noise and ripple measurement.
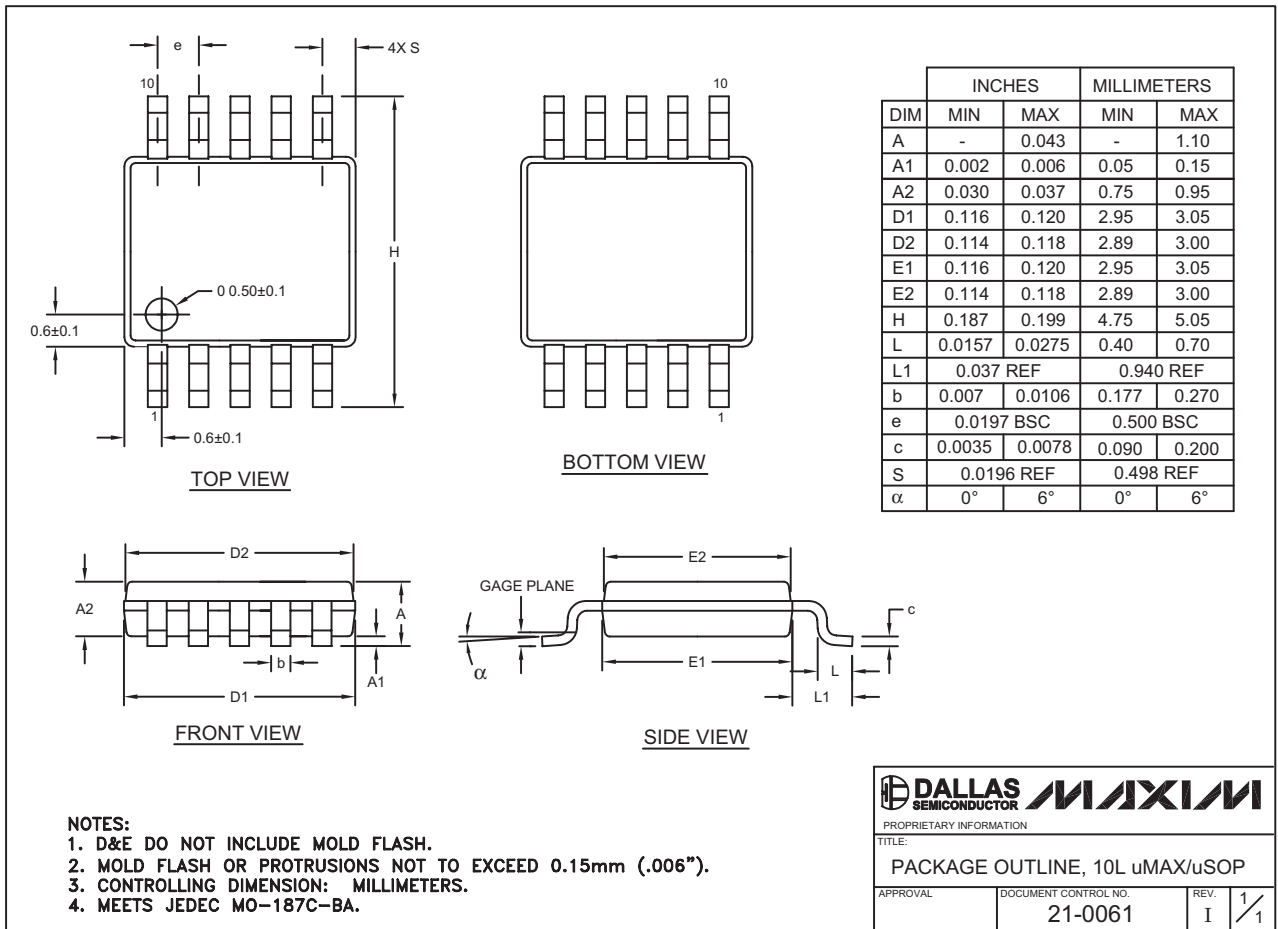
Chip Information

TRANSISTOR COUNT: 413

Low-Noise Bias Supply in µMAX
with Power-OK for GaAsFET PA

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

10LUMAX.EPS

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
D1	0.116	0.120	2.95	3.05
D2	0.114	0.118	2.89	3.00
E1	0.116	0.120	2.95	3.05
E2	0.114	0.118	2.89	3.00
H	0.187	0.199	4.75	5.05
L	0.0157	0.0275	0.40	0.70
L1	0.037 REF		0.940 REF	
b	0.007	0.0106	0.177	0.270
e	0.0197 BSC		0.500 BSC	
c	0.0035	0.0078	0.090	0.200
S	0.0196 REF		0.498 REF	
α	0°	6°	0°	6°

TOP VIEW

BOTTOM VIEW

FRONT VIEW

SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO−187C−BA.

DALLAS SEMICONDUCTOR **/VI/IXI/VI**

PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, 10L uMAX/uSOP

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0061	I	1/1