19-2145; Rev 1; 8/03

MAXIM

# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands



## General Description

The MAX2900–MAX2904 complete single-chip 200mW transmitters are designed for use in the 868MHz/915MHz frequency bands. The MAX2900/MAX2901/MAX2902 are compliant with the FCC CFR47 part 15.247 902MHz to 928MHz ISM-band specifications. MAX2903/MAX2904 are compliant with the ETSI EN330-220 specification for the European 868MHz ISM band.

These transmitter ICs offer a high level of integration while minimizing the number of external components. This is achieved by full integration of the transmit modulator, power amplifier, RF VCO, 8-channel frequency synthesizer, and baseband PN sequence lowpass filter. By filtering the BPSK modulation, the spurious emissions are reduced, enabling up to eight independent transmit channels in the U.S. ISM band. Inputs are provided for spread-spectrum BPSK, ASK, and OOK. FM can be achieved by directly modulating the VCO. The devices are intended primarily for use with an external differential antenna.

## Applications

Automatic Meter Reading
Wireless Security Systems/Alarms
Wireless Sensors
Wireless Data Networks
Wireless Building Control

## Features

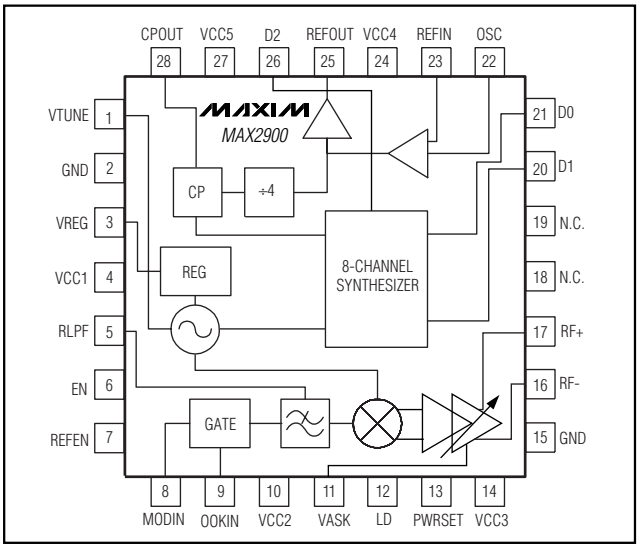
- **Versions for U.S. 902MHz to 928MHz Band and European 868MHz Band**
- **-7dBm to +23dBm Adjustable Differential RF Output Power**
- **+23dBm Output Power at 4.5V, +20dBm Output Power at 3.0V**
- **Support BPSK, OOK, ASK, and FM Modulations**
- **Modulation Filter for Direct Sequence BPSK up to 8Mchips/s**
- **Fully Integrated VCO with On-Chip Tank**
- **Extremely Low Frequency Pulling for OOK Modulation (typ 60kHz peak, 5kHz RMS)**
- **Integrated Frequency Synthesizer for up to 8 Channels (MAX2900)**
- **+2.7V to +4.5V Supply Operation**
- **Small 28-Pin QFN Package with Exposed Pad (5mm × 5mm)**

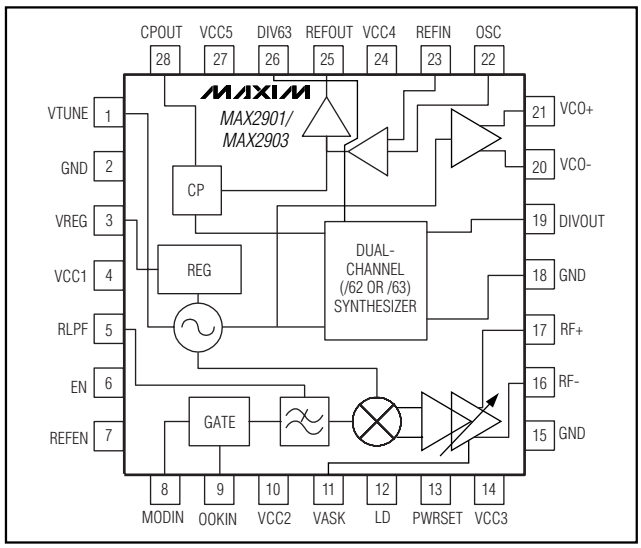
## Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE |
|---|---|---|
| **MAX2900**EGI | -40°C to +85°C | 28 QFN-EP* |
| **MAX2901**EGI | -40°C to +85°C | 28 QFN-EP* |
| **MAX2902**EGI | -40°C to +85°C | 28 QFN-EP* |
| **MAX2903**EGI | -40°C to +85°C | 28 QFN-EP* |
| **MAX2904**EGI | -40°C to +85°C | 28 QFN-EP* |

*Exposed pad

## Functional Diagrams/Pin Configurations




***Functional Diagrams/Pin Configurations are continued at end of data sheet.***

# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands

## ABSOLUTE MAXIMUM RATINGS

$V_{CC}$ to GND .....-0.3V to +5.0V
Analog/Digital Input Voltage to GND.....-0.3V to ($V_{CC}$ + 0.3V)
Analog/Digital Input Current .....±10µA
Continuous Power Dissipation ($T_A$ = +70°C)
28-Pin QFN-EP (derate 28.5mW/°C above +70°C).....2W
Operating Temperature Range .....-40°C to +85°C
Junction Temperature .....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C

*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.*

**CAUTION!** ESD SENSITIVE DEVICE

## Part Selection Information

Five different versions are available. The versions differ by their frequency band of operation, and by the synthesizer's mode of operation. The MAX2900 has an internal 8-channel synthesizer.

The MAX2901 and MAX2903 are dual-channel versions with a selectable internal synthesizer division ratio of 62 or 63. The MAX2901 operates in the 902MHz to 928MHz ISM band and the MAX2903 operates in the 867MHz to 870MHz European ISM band.

The MAX2902 and MAX2904 require an off-chip frequency synthesizer. The MAX2902 operates in the 902MHz– 928MHz ISM band and MAX2904 operates in the 867MHz–870MHz European ISM band.

The MAX2901–MAX2904 provide LO outputs to drive a receiver and/or an external synthesizer.

| PART | FREQUENCY RANGE (MHz) | SYNTHESIZER | LO OUTPUTS |
|---|---|---|---|
| MAX2900EGI | 902 to 928 | Internal 8 selectable channels | No |
| MAX2901EGI | 902 to 928 | Internal 2 selectable channels | Yes |
| MAX2902EGI | 902 to 928 | Off-chip | Yes |
| MAX2903EGI | 867 to 870 | Internal 2 selectable channels | Yes |
| MAX2904EGI | 867 to 870 | Off-chip | Yes |

## DC ELECTRICAL CHARACTERISTICS

($V_{CC}$ = +2.7V to +4.5V, EN = OOKIN = REFEN = high, $T_A$ = -40°C to +85°C. Typical values are at $V_{CC}$ = +4.5V, $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | CONDITIONS | | MIN | -3σ | TYP | +3σ | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|
| Supply Voltage | | | 2.7 | | 4.5 | | 4.5 | V |
| Supply Current | Shutdown mode: EN = REFEN = low | $V_{CC}$ = +4.0V | | | 0.7 | | 10 | µA |
| | | $V_{CC}$ = +4.5V | | | 60 | | 200 | |
| | Synth mode: OOKIN = low (MAX2900/MAX2901/MAX2903 only) | | | | 32 | | 40 | mA |
| | Transmit mode with output matching optimized for +23dBm at +4.5V: PWRSET loaded with 22kΩ resistor | $T_A$ = -40°C to +85°C | | | 150 | 200 | | |
| | Transmit mode with output matching optimized for +20dBm at +3.0V: PWRSET loaded with 22kΩ resistor | $T_A$ = -40°C to +85°C | | | 110 | 135 | | |

## DC ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = +2.7V to +4.5V, EN = OOKIN = REFEN = high, $T_A$ = -40°C to +85°C. Typical values are at $V_{CC}$ = +4.5V, $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | CONDITIONS | | MIN | -3σ | TYP | +3σ | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|
| Supply Current (continued) | Transmit mode with output matching optimized for +17dBm at +3.0V: PWRSET loaded with 36kΩ resistor | $T_A$ = +25°C | | | 75 | | | mA |
| | Transmit mode with output matching optimized for +14dBm at +3.0V: PWRSET loaded with 51kΩ resistor | $T_A$ = +25°C | | | 57 | | | |
| | Reference-only mode: EN = low | | | | 2 | | 3 | |
| | PA standby mode: OOKIN = low (MAX2902/MAX2904 only) | | | | 29 | | 33 | |
| VCO Input Tuning Pin Current | VTUNE = +4.5V, $T_A$ = +25°C | | | | 0.02 | | 2 | µA |
| VREG VCO Regulator Voltage | | | | | 2.0 | | | V |
| **DIGITAL INPUT/OUTPUTS** (PINS EN, REFEN, D0, D1, D2, MODIN, OOKIN, LD) | | | | | | | | |
| Input Level High | | | $V_{CC}$ - 0.5V | | | | | V |
| Input Level Low | | | | | | | 0.5 | V |
| Input Bias Current | | | -10 | | | | 10 | µA |
| Output Level High | | | $V_{CC}$ - 0.4 | | | | | V |
| Output Level Low | | | | | | | 0.4 | V |
| Output Current | | | -100 | | | | 100 | µA |
| **ANALOG CONTROL INPUTS** (PINS PWRSET, RLPF, VASK) | | | | | | | | |
| PWRSET Voltage | | | | | 1.2 | | | V |
| RLPF Voltage | | | | | 1.2 | | | V |
| VASK Input Impedance | | | 100 | | 220 | | 400 | kΩ |

# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands

## AC ELECTRICAL CHARACTERISTICS

(MAX290_ EV kits. $V_{CC}$ = +2.7V to +4.5V, $R_{RLPF}$ = 68kΩ, $R_{PWRSET}$ = 22kΩ, $f_{RF}$ = 917.28MHz (MAX2900/MAX2901/MAX2902) or $f_{RF}$ = 868MHz (MAX2903/MAX2904), VASK = VREG, $f_{REF}$ = 14.56MHz (MAX2900/MAX2901/MAX2902) or $f_{REF}$ = 13.62MHz (MAX2903/MAX2904), chip rate on MODIN = 1.22Mbps, $P_{OUT}$ = +23dBm, $T_A$ = -40°C to +85°C. Typical values are at $V_{CC}$ = +4.5V, $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | CONDITIONS | MIN | -3σ | TYP | +3σ | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **ANALOG INPUT PINS** | | | | | | | |
| VTUNE Input Capacitance | VTUNE = +1.35V | | | 15 | | | pF |
| **DIGITAL INPUT PINS** | | | | | | | |
| Digital Input Pin Capacitance | | | | 3 | | | pF |
| **VCO AND SYNTHESIZERS SECTION** | | | | | | | |
| RFOUT Frequency Range | (MAX2900/MAX2901/MAX2902) | 902 | | 917.28 | | 928 | MHz |
| | (MAX2903/MAX2904) | 867 | | 868 | | 870 | |
| REFIN Reference Frequency Range | (MAX2900/MAX2901/MAX2902) | 14 | | 14.56 | | 15 | MHz |
| | (MAX2903/MAX2904) | 13 | | 13.78 | | 14.5 | |
| REFDIV Fixed Reference Divider Ratio | (MAX2900) | 4 | | 4 | | 4 | |
| Main Divider Ratios | Table 4 (MAX2900) | 249 | | | | 256 | |
| | (MAX2901/MAX2903) | 62 | | | | 63 | |
| PLL Comparison Frequency | (MAX2900) | 3.5 | | 3.64 | | 3.75 | MHz |
| | (MAX2901/MAX2903) | 13 | | | | 15 | |
| VCO Buffer Output Power | 300Ω differential load (MAX2901–MAX2904) | | | -12 | | | dBm |
| REFDIV Fixed Reference Divider Ratio | (MAX2901/MAX2903) | 1 | | 1 | | 1 | |
| VCO Phase Noise | At 100kHz offset, measured at RFOUT, PLL loop BW = 5kHz | | | -101 | | | dBc/Hz |
| VCO Tuning Gain | VTUNE = +1.35V | 44 | | 65 | | 86 | MHz/V |
| VCO Frequency Pulling with OOK Modulation | OOKIN clocked at 19kHz, internal (crystal) or external reference frequency | | | 5 | | | kHz RMS |
| | | | | 60 | | | kHz peak |
| PLL Phase Noise | Measured at RFOUT, 5kHz offset, PLL loop BW = 50kHz | | | -96 | | | dBc/Hz |
| REFOUT Voltage Swing | | 100 | | | | | mVp-p |
| CPOUT Charge Pump Current | | | | 500 | | | µA |
| Reference Spurs | | | | -62 | | | dBc |
| Reference Input Voltage for Nominal Operation | Using an external frequency reference | 200 | | 300 | | | mV |
| **BPSK, OOK MODULATOR, AND PA** | | | | | | | |
| MODIN Frequency Range | | | | 1.2 | | 8 | Mb/s |
| Modulation Filter Nominal 3dB Bandwidth | | | | 1 | | | MHz |
| Modulation Filter Final Attenuation | Measured at 30MHz | 28 | | 41 | | | dB |
| Carrier Suppression | | | | 28 | | | dB |
| Noise Power Density | At 960MHz (measured at RFOUT at +23dBm output power) | | | -150 | | | dBc/Hz |

## AC ELECTRICAL CHARACTERISTICS (continued)

(MAX290_ EV kits. $V_{CC}$ = +2.7V to +4.5V, $R_{RLPF}$ = 68kΩ, $R_{PWRSET}$ = 22kΩ, $f_{RF}$ = 917.28MHz (MAX2900/MAX2901/MAX2902) or $f_{RF}$ = 868MHz (MAX2903/MAX2904), VASK = VREG, $f_{REF}$ = 14.56MHz (MAX2900/MAX2901/MAX2902) or $f_{REF}$ = 13.62MHz (MAX2903/MAX2904), chip rate on MODIN = 1.22Mbps, $P_{OUT}$ = +23dBm, $T_A$ = -40°C to +85°C. Typical values are at $V_{CC}$ = +4.5V, $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | CONDITIONS | | MIN | -3σ | TYP | +3σ | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|
| RF Output Power | PWRSET = 22kΩ, $V_{CC}$ = +4.5V, $T_A$ = +25°C | | | 21 | 23.5 | 25 | | dBm |
| | PWRSET = 22kΩ, $V_{CC}$ = +4.5V, $T_A$ = -40°C to +85°C | | | 20.5 | | 25 | | |
| | PWRSET = 22kΩ, $V_{CC}$ = +3.0V, $T_A$ = +25°C | | | 18 | 20 | 21 | | |
| RF Output Power Flatness | $f_{RF}$ = 900MHz to 930MHz (MAX2900/MAX2901/MAX2902) | | | | 0.3 | | | dB |
| | $f_{RF}$ = 867MHz to 870MHz | | | | 0.1 | | | |
| Adjacent Channel Power Ratio | PN sequence at 1.22MHz | | | | -17 | | | dBc |
| Alternate Channel Power Ratio | PN sequence at 1.22MHz | | | | -26 | | | dBc |
| OOK Control Range | | | 40 | | 80 | | | dB |
| ASK Output Power Adjustment Range | ASK output power back-off relative to max power | OOKIN = high, VASK = 0 | | | 41 | | | dB |
| | | OOKIN = high, VASK = 1V | | | 16 | | | |
| RFOUT Rise and Fall Time | Square-wave signal applied on OOK | | | | 1 | | | µs |
| Spurious Emissions | At 2nd harmonic of RF output frequency with external matching network | | | | -50 | | | dBc |
| | At 3rd harmonic of RF output frequency with external matching network | | | | -51 | | | |
| | At 4th harmonic of RF output frequency with external matching network | | | | -63 | | | |
| | Out of 902MHz to 928MHz band other than harmonics with external matching network (MAX2900/MAX2901/MAX2902) | | | | < -70 | | | |
| | Out of 867MHz to 870MHz band other than harmonics with external matching network (MAX2903/MAX2904) | | | | < -70 | | | |
| Unlocked, Out-of-Band Spurious Output Level | Any condition when synthesizer unlocked (pin LD low) | | | | < -50 | | | dBm |
| Noise Level Out of Band | Modulation off, measured at 960MHz, any gain setting (MAX2900/MAX2901/MAX2902) | | | | -126 | | -120 | dBm/Hz |
| | Modulation off, measured at 900MHz, any gain setting (MAX2903/MAX2904) | | | | -126 | | -120 | |
| Output VSWR for Guaranteed Stability | | | | | 2:1 | | | |
| Maximum Allowable Output VSWR | | | | | 2:1 | | | |

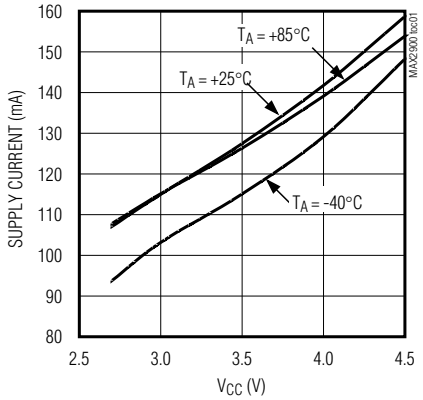
**Note 1:** Devices are production tested at $T_A$ = +25°C and +85°C. Min/Max values are guaranteed by design and characterization over temperature and supply voltage.

# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands

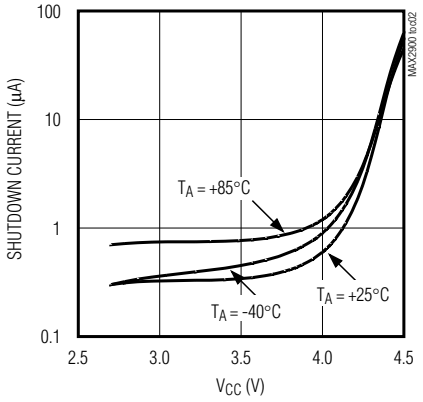
## Typical Operating Characteristics

(MAX290_ EV kits. $V_{CC}$ = +4.5V, $f_{RF}$ = 917.28MHz (MAX2900/MAX2901/MAX2902) or $f_{RF}$ = 868MHz (MAX2903/MAX2904), $R_{RLPF}$ = 68kΩ, $R_{PWRSET}$ = 22kΩ, VASK = VREG, $f_{REF}$ = 14.56MHz (MAX2900/MAX2901/MAX2902) or $f_{REF}$ = 13.78MHz (MAX2903/MAX2904), chip rate on MODIN = 1.22 Mbps, RF output matching network optimized for +23dBm, $V_{CC}$ = 4.5V, $T_A$ = +25°C, unless otherwise noted.)

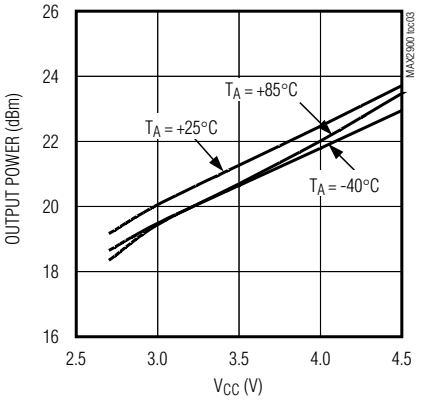
**SUPPLY CURRENT vs. $V_{CC}$**



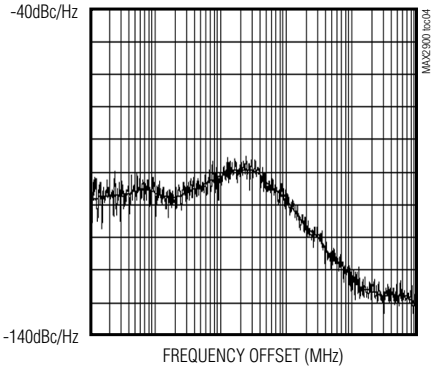

**SHUTDOWN CURRENT vs. $V_{CC}$**



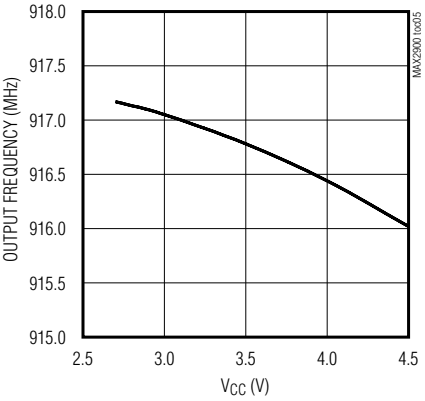

**OUTPUT POWER vs. $V_{CC}$**



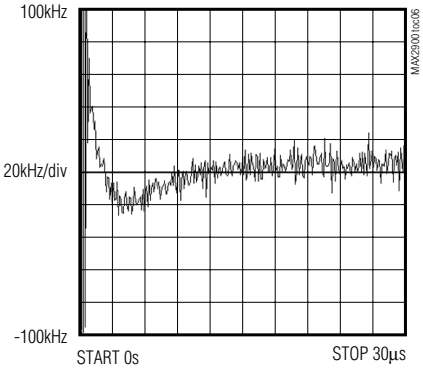

**VCO PHASE NOISE AT 917.28MHz**



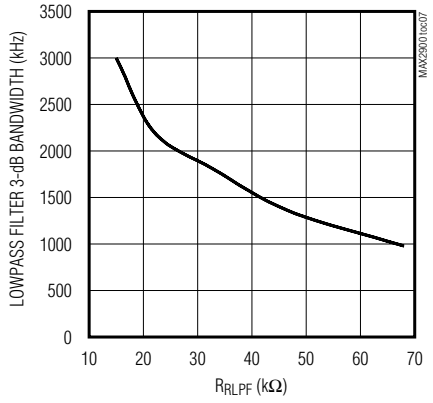

**VCO SUPPLY PUSHING vs. $V_{CC}$**



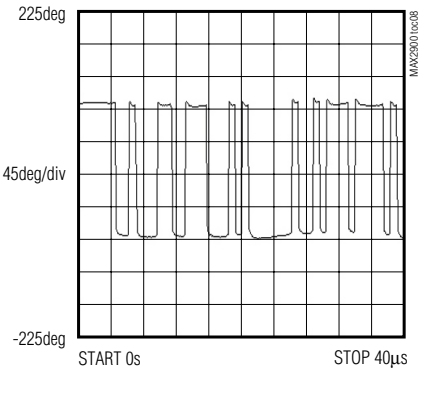

**PLL LOCK TIME**



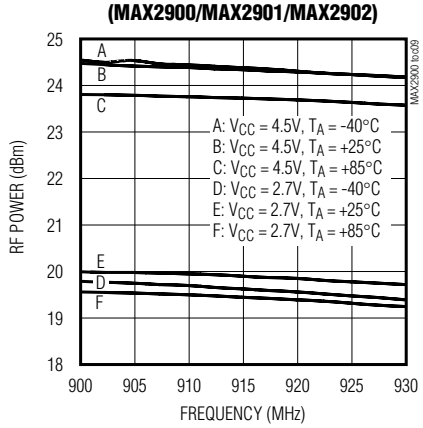

**LOWPASS FILTER 3-dB RESPONSE vs. $R_{RLPF}$**




**BPSK MODULATION OUTPUT vs. TIME**



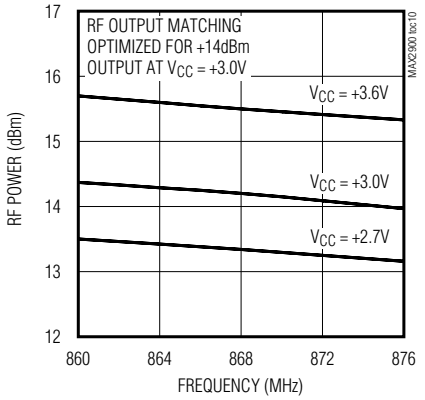

**RF POWER vs. FREQUENCY (MAX2900/MAX2901/MAX2902)**



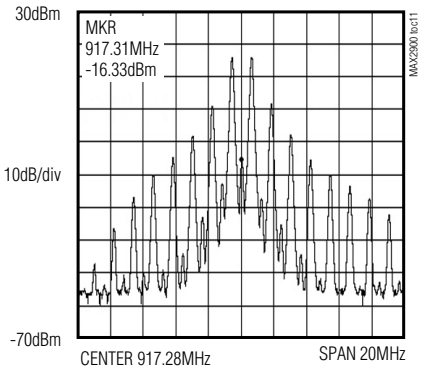
## Typical Operating Characteristics (continued)

(MAX290_ EV kits. $V_{CC}$ = +4.5V, $f_{RF}$ = 917.28MHz (MAX2900/MAX2901/MAX2902) or $f_{RF}$ = 868MHz (MAX2903/MAX2904), $R_{RLPF}$ = 68kΩ, $R_{PWRSET}$ = 22kΩ, VASK = VREG, $f_{REF}$ = 14.56MHz (MAX2900/MAX2901/MAX2902) or $f_{REF}$ = 13.78MHz (MAX2903/MAX2904), chip rate on MODIN = 1.22 Mbps, RF output matching network optimized for +23dBm, $V_{CC}$ = 4.5V, $T_A$ = +25°C, unless otherwise noted.)

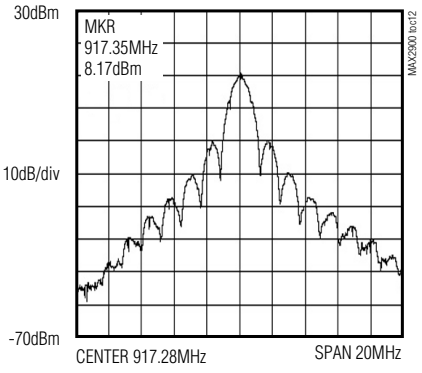
**RF POWER vs. FREQUENCY (MAX2903/MAX2904)**



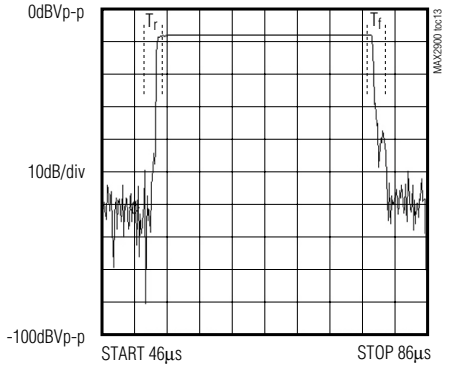

**OUTPUT SPECTRUM WITH 600kHz SQUARE WAVE INPUT AT MODIN**



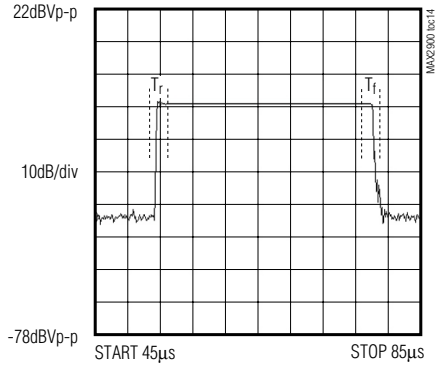

**OUTPUT SPECTRUM WITH PN SEQUENCE AT 1.22MHz AT MODIN**



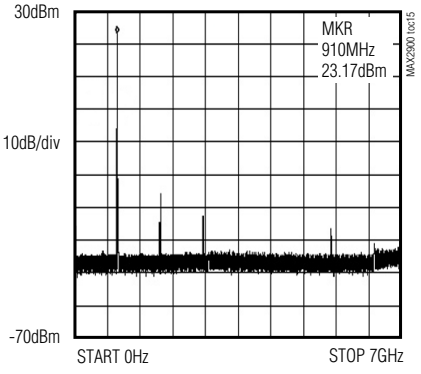

**RF OUT RISE AND FALL TIME TRANSIENT WITH SQUARE OOK**



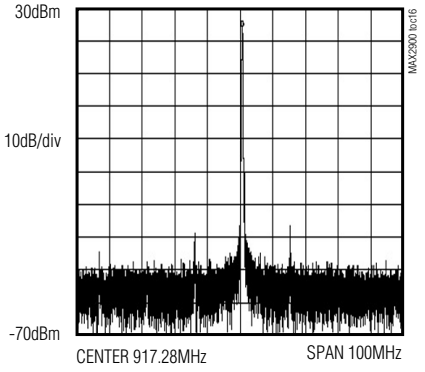

**RF OUT RISE AND FALL TIME TRANSIENT WITH SQUARE ASK**



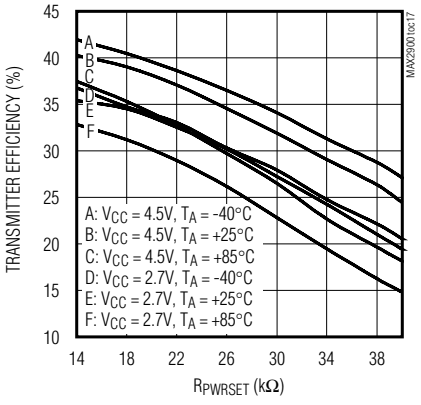

**SPURIOUS LEVEL FROM DC TO 7TH HARMONIC**




**SPURIOUS LEVEL BETWEEN ±50MHz FROM CARRIER FREQUENCY**




**TRANSMITTER EFFICIENCY vs. $R_{PWRSET}$**



# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands

## Pin Description

| PIN | | | NAME | PIN TYPE | FUNCTION |
|---|---|---|---|---|---|
| MAX2900 | MAX2901 MAX2903 | MAX2902 MAX2904 | | | |
| 1 | 1 | 1 | VTUNE | Analog Input | VCO tuning voltage input |
| 2 | 2 | 2 | GND | Supply Pin | Ground |
| 3 | 3 | 3 | VREG | Analog Input/Output | Regulated voltage output to supply the VCO. Bypass with a 0.01µF capacitor to GND as close to the part as possible. |
| 4 | 4 | 4 | VCC1 | Supply Pin | Power supply pin for VCO circuits. Bypass with a 1000pF and a 10µF capacitor to GND as close to the part as possible. |
| 5 | 5 | 5 | RLPF | Analog Input Resistor to Ground | Resistor to ground on this pin sets the modulation filter bandwidth. |
| 6 | 6 | 6 | EN | Digital Input | Chip-enable digital input pin. Set EN low maintain the chip in power-down mode. |
| 7 | 7 | 7 | REFEN | Digital Input | Enable for crystal oscillator and frequency reference buffer. |
| 8 | 8 | 8 | MODIN | Digital Input | BPSK modulation input |
| 9 | 9 | 9 | OOKIN | Digital Input | On-off keying modulation. On state = high. |
| 10 | 10 | 10 | VCC2 | Supply | Power supply pin for internal RF buffer circuits. Bypass with a 100pF and a 0.01µF capacitor to GND as close to the part as possible. |
| 11 | 11 | 11 | VASK | Analog Voltage Input | ASK voltage input pin |
| 12 | 12 | — | LD | Digital Output | Lock detector output digital pin. Level is high when PLL is inside lock range. |
| — | — | 12 | D.C. | Do NOT Connect | — |
| 13 | 13 | 13 | PWRSET | Analog Input Resistor to Ground | Current input set to adjust output power. |
| 14 | 14 | 14 | VCC3 | Supply | Power supply pin for RF power amplifier circuits. Bypass with a 100pF capacitor to GND as close to the part as possible. |

## Pin Description (continued)

| PIN | | | NAME | PIN TYPE | FUNCTION |
|---|---|---|---|---|---|
| MAX2900 | MAX2901 MAX2903 | MAX2902 MAX2904 | | | |
| 15 | 15 | 15 | GND | Supply Pin | Ground |
| 16, 17 | 16, 17 | 16, 17 | RF-, RF+ | RF Output | RF differential output, open-collector type |
| 18 | — | — | N.C. | Not Connected | — |
| — | 18 | — | GND | Supply Pin | Ground |
| — | — | 18 | D.C. | Do Not Connect | — |
| 19 | — | 19 | N.C. | Not Connected | — |
| — | 19 | — | DIVOUT | ECL Output | Divider output |
| — | 20, 21 | 20, 21 | VCO-, VCO+ | Open Collector RF | VCO output (differential) |
| 20 | — | — | D1 | Digital Input | Channel selection bit 1 |
| 21 | — | — | D0 | Digital Input | Channel selection bit 0 |
| 22 | 22 | 22 | OSC | Analog Input | Crystal oscillator connection. See *Typical Operating Circuit*. |
| 23 | 23 | 23 | REFIN | Analog Voltage Input | Reference input pin analog (can be used as input or as crystal oscillator driver). See *Typical Operating Circuit*. |
| 24 | 24 | — | VCC4 | Supply Pin | Power-supply pin for the synthesizer circuits. Bypass with a 1000pF capacitor to GND as close to the part as possible. |
| — | — | 24 | VCC4 | Supply Pin | Power-supply pin for the digital circuits. Bypass with a 100pF capacitor to GND as close to the part as possible. |
| 25 | 25 | 25 | REFOUT | Analog Output | Buffered clock analog output pin |
| 26 | — | — | D2 | Digital Input | Channel selection bit 2 |
| — | 26 | — | DIV63 | Digital Input | Division ratio selections (division ratio = 62 when DIV63 = high; division ratio = 63 when DIV63 = low). |
| — | — | 26 | N.C. | Not Connected | — |
| 27 | 27 | — | VCC5 | Supply Pin | Power-supply pin for charge pump circuits. Bypass with a 100pF capacitor to GND as close to the part as possible. |
| — | — | 27 | VCC5 | Supply Pin | Power-supply pin. Bypass with a 100pF capacitor to GND as close to the part as possible. |
| 28 | 28 | — | CPOUT | Analog Output | Charge pump output pin |
| — | — | 28 | D.C. | Do Not Connect | — |
| GROUND | GROUND | GROUND | GROUND | Electrical Ground | Back side of package is connected to ground. |

# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands

## Detailed Description

### Principles of Operation

When EN goes high, the reference and the VCO start while the PA stays in the off mode. For MAX2900/MAX2901/MAX2903, the PLL also starts when EN goes high. After the lock-detect pin LD goes high, the PA is set to stand-by mode. For the MAX2902/MAX2904, the VCO loop has to be closed by using an external synthesizer. After this, pulling OOKIN high turns on the PA. The internal modulation filter smoothes the power ramp-up of the PA.

The modulation filter BW is typically 0.8MHz, used for a 1.22Mbps chip rate, and can be adjusted by varying RLPF. A high value can be used for RLPF to get a slow PA ramping up when BPSK is not used.

The reference blocks can be turned on separately (and earlier) by pulling REFEN high, to allow the crystal frequency to settle.

The device supports various modulation modes:

- BPSK, filtered by the internal modulation filter, is obtained through the MODIN pin. This is the preferred mode of operation for MAX2900.
- OOK is obtained digitally with the OOKIN pin.
- ASK is obtained through the ASK pin.
- FM is imposed on the VCO or the reference.
- FM is the preferred mode of operation for the MAX2903/MAX2904 due to the narrowband operation common in Europe.

The maximum output power is set by the output matching network and the external biasing resistor on the PWRSET pin.

For the MAX2901–MAX2904, differential LO outputs are provided to drive a companion receiver and/or an external synthesizer.

### Power-Up Modes

The circuit has four modes of operations, defined as follows:

1) Shutdown mode: Pin EN and REFEN are low, all functions are off, and the current consumption is leakage only.
2) Synth mode: Pin EN and REFEN are high, pin OOKIN is low. The reference circuits, VCO, and synthesizer are turned on. The power amplifier is in stand-by mode. Total current is less than 50mA. Note that as long as the LD pin is not going high, indicating that the PLL is unlocked, OOKIN high is ignored.
3) Transmit mode: Pin EN and REFEN are high. If output pin LD is high, the device is ready to transmit. When OOKIN is high, the power amplifier is turned on. The current consumption varies between 50mA and 120mA, depending on the output power requested by the combination of the OOK duty cycle, the PWRSET value, and output matching circuit.
4) Reference Only mode: This mode enables the use of the crystal reference from the IC to drive the external logic ICs. To obtain this mode, set the REFEN pin high and EN low. In this mode, only the reference circuit turns on, the crystal oscillator starts, and the clock is present at the REFOUT pin. The current consumption remains much lower than that in the SYNTH mode because the VCO, synthesizer, and PA standby circuits are off. When EN goes high, the IC goes into the SYNTH mode.

### Synthesizer Programming

The three pins D0–D2 (MAX2900) and DIV63 (MAX2901/MAX2903) are used as digital entries to program the synthesizer division ratios. Tables 4 and 5 show the division ratios obtained for the various pin logic levels.

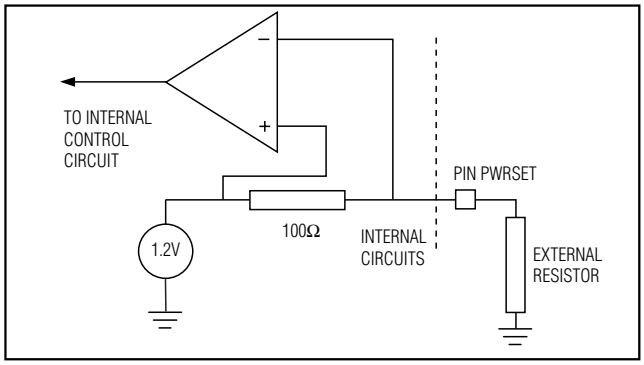



*Figure 1. PIN PWRSET Equivalent Circuit*

### Analog Input Control Pins

The two pins PWRSET and VASK are analog inputs used to control the power of the transmitter. The equivalent input schematics are defined in Figures 1, 2, and 3. The PWRSET pin sets the biasing of the amplification chain. Because the last stage of the amplifier operates in saturation, the output power mostly depends on the load and supply voltage. The purpose of the PWRSET resistor is to achieve optimum biasing (and therefore efficiency) for various maximum output power configurations. For a given application with a known operating voltage and peak power, a fixed value of resistor is determined. The output power range of -7dBm to +23dBm at 4.5V is obtained by choosing a combination of output load line and the resistor on PWRSET; 22kΩ is

used on the EV kit board for +23dBm output power at 4.5V, and 22kΩ is also recommended for +20dBm output power at +3.0V. For +17dBm at 3.0V, 36kΩ is recommended. The current consumption, efficiency, and distortion in the amplification chain are affected by the choice of the resistor RPWRSET, offering a lot of design flexibility.

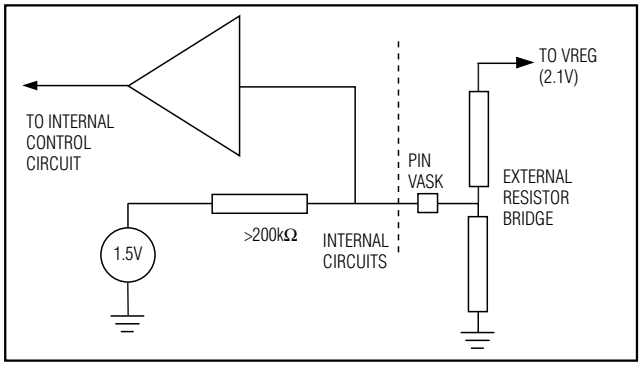



*Figure 2. PIN VASK Equivalent Circuit*

The VASK pin is an input to the internal gain control circuitry. The gain control is greater than 30dB over the full range of input voltages from 0 to VREG = 2.1V. This input is used for ASK modulation. At 1V, a typical 15dB attenuation is obtained from the peak power. When this input is not used, connect VASK to VREG.

The RLPF input controls the modulation filter center frequency.

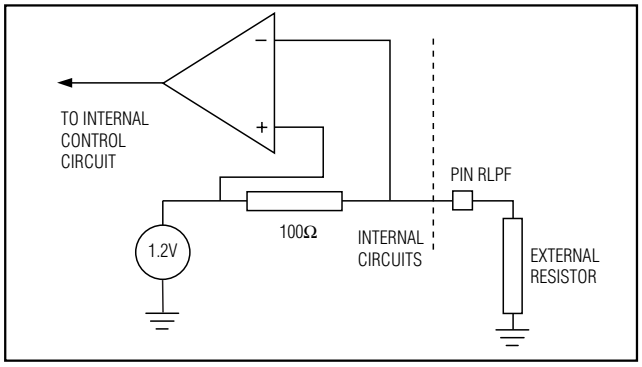



*Figure 3. PIN RLPF Equivalent Circuit*

The RLPF pin sets the bandwidth of the modulation filter. The default filter bandwidth, obtained with a 68kΩ resistor, is for 1.2Mchips/s. The bandwidth is increased to accommodate 5Mchips/s by decreasing the resistor value to about 26kΩ. The minimum value for the resistor is 12kΩ, which generates the maximum filter bandwidth. A higher value can be used in FM mode to set up a slow ramp-up time for the PA.

### Data Filter Characteristics

The data filter approximates a 3rd-order Butterworth filter. The 3dB cut-off frequency is adjusted through the resistor on pin RLPF, which controls the first two poles of the filter (the last high-frequency pole is fixed and set around 10MHz). The filter is adjustable in a range from approximately 700kHz to 7MHz.

With the nominal setting (3dB cut off at 0.8MHz), the filter attenuation is 10dB at 3.6MHz. If used with a BPSK at 1.22MHz, this provides about 30dB of modulation rolloff at 3.6MHz. Hence, a significant channelization effect is obtained.

In the wideband setting (3dB cut off at 5MHz), the attenuation at 30MHz is still 30dB, helping to pass the FCC spurious emissions at 960MHz.

# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands

## Table 1. MAX2900 Power-Up Modes

| LOGIC LEVEL | | | INTERNAL BLOCK STATUS | | | |
|---|---|---|---|---|---|---|
| REFEN | EN | OOKIN | REFERENCE | VCO MOD FILTER | SYNTHESIZER | PA |
| 0 | 0 | X | Off | Off | Off | Off |
| 1 | 0 | X | On | Off | Off | Off |
| 1 | 1 | 0 | On | On | On | Off |
| 1 | 1 | 1 | On | On | On | On only after LD goes high |

## Table 2. MAX2901/MAX2903 Power-Up Modes

| REFEN | EN | OOKIN | REFERENCE | VCO MOD FILTER | SYNTHESIZER | PA |
|---|---|---|---|---|---|---|
| 0 | 0 | X | Off | Off | Off | Off |
| 1 | 0 | X | On | Off | Off | Off |
| 1 | 1 | 0 | On | On | On | Off |
| 1 | 1 | 1 | On | On | On | On only after LD goes high |

## Table 3. MAX2902/MAX2904 Power-Up Modes

| REFEN | EN | OOKIN | REFERENCE | VCO MOD FILTER | PA |
|---|---|---|---|---|---|
| 0 | 0 | X | Off | Off | Off |
| 1 | 0 | 0 | On | Off | Off |
| 0 | 1 | 0 | Off | On | Off |
| 1 | 1 | 0 | On | On | Off |
| 0 | 1 | 1 | Off | On | On |
| 1 | 1 | 1 | On | On | On |

## Table 4. MAX2900 Synthesizer Programming

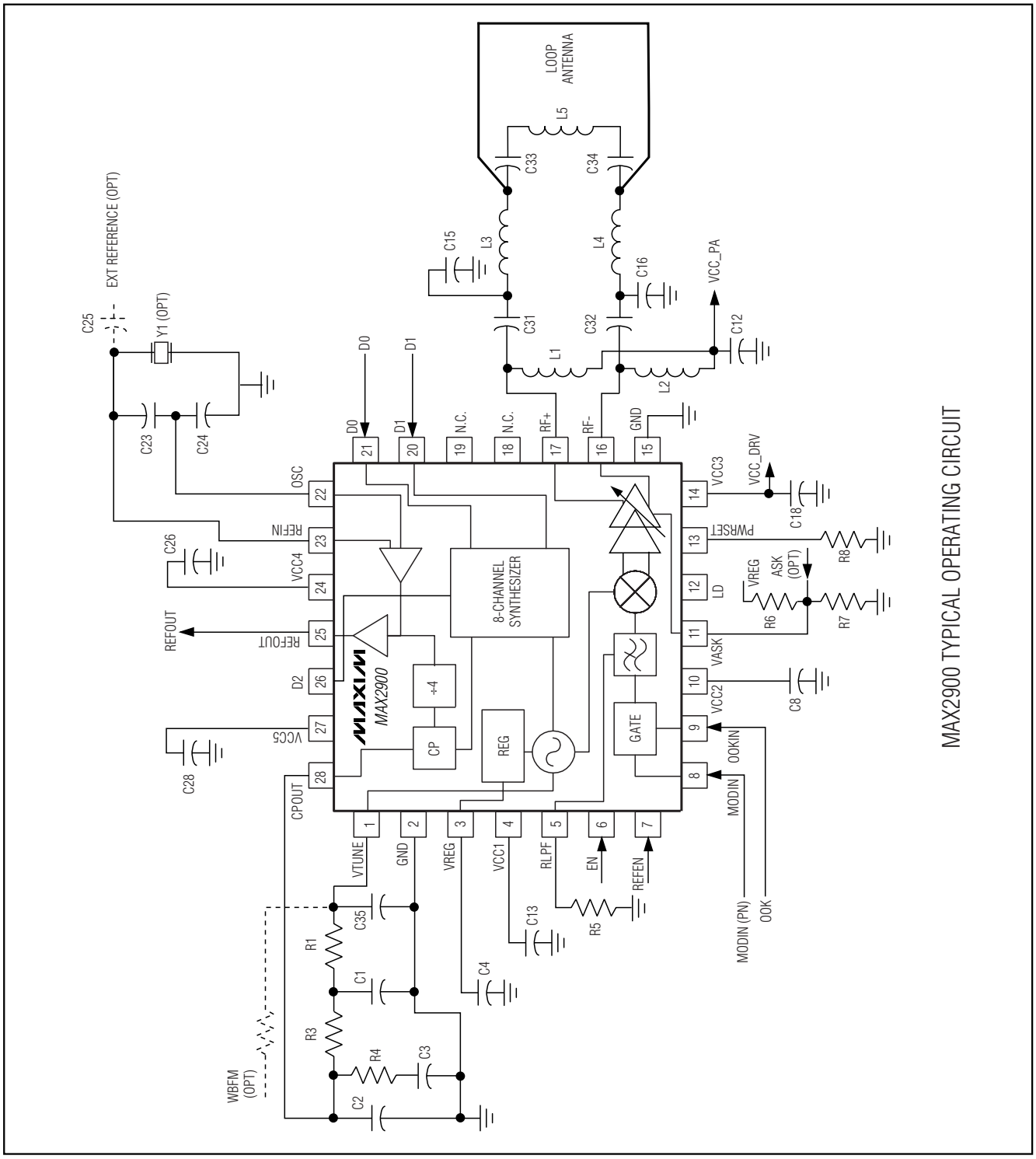
| D0 | D1 | D2 | DIVISION RATIO |
|---|---|---|---|
| 0 | 1 | 1 | 249 |
| 0 | 1 | 0 | 250 |
| 0 | 0 | 1 | 251 |
| 0 | 0 | 0 | 252 |
| 1 | 1 | 1 | 253 |
| 1 | 1 | 0 | 254 |
| 1 | 0 | 1 | 255 |
| 1 | 0 | 0 | 256 |

## Table 5. MAX2901/MAX2903 Synthesizer Programming

| DIV 63 | DIVISION RATIO |
|---|---|
| 0 | 62 |
| 1 | 63 |

# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands

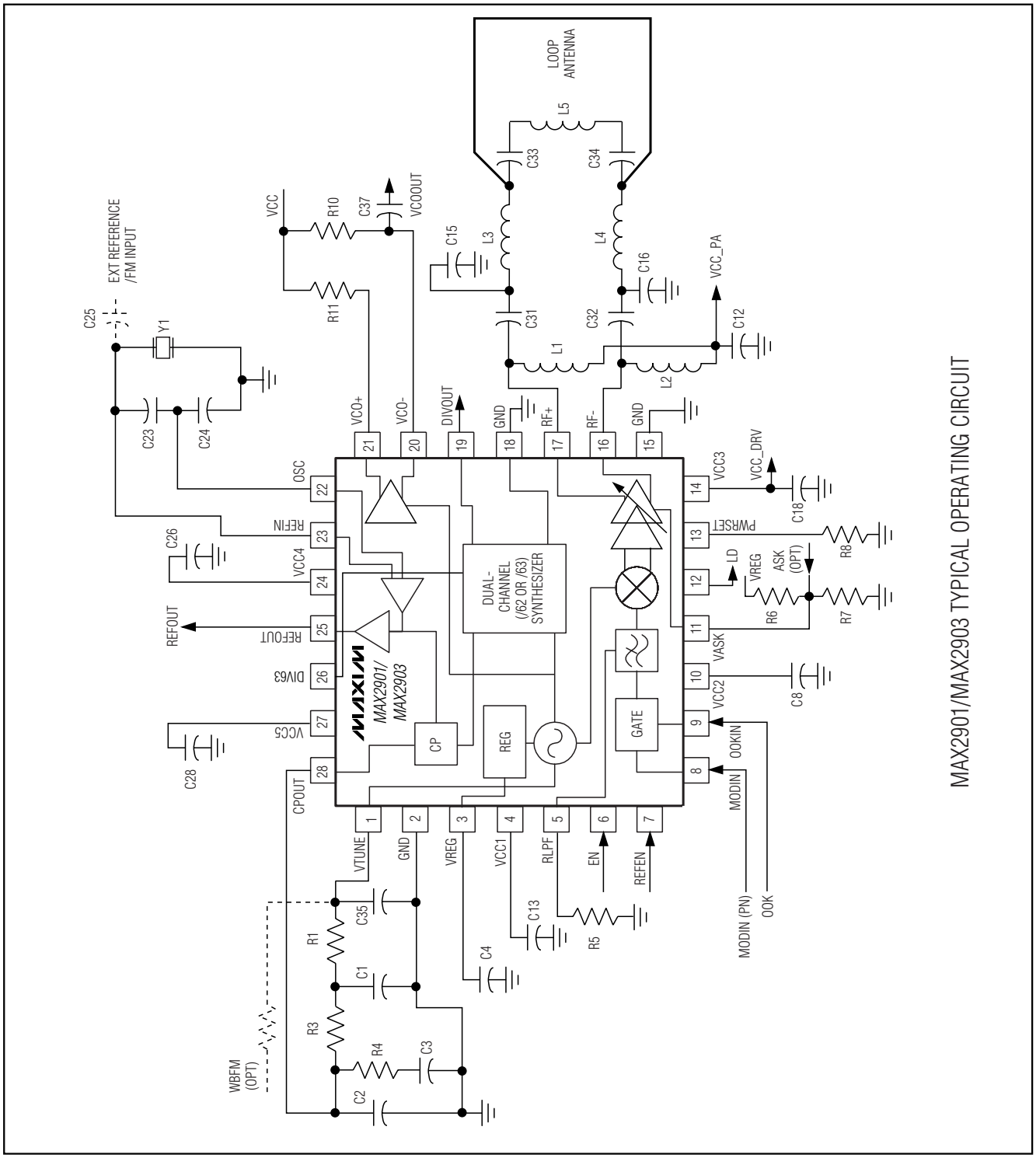
## Typical Operating Circuits



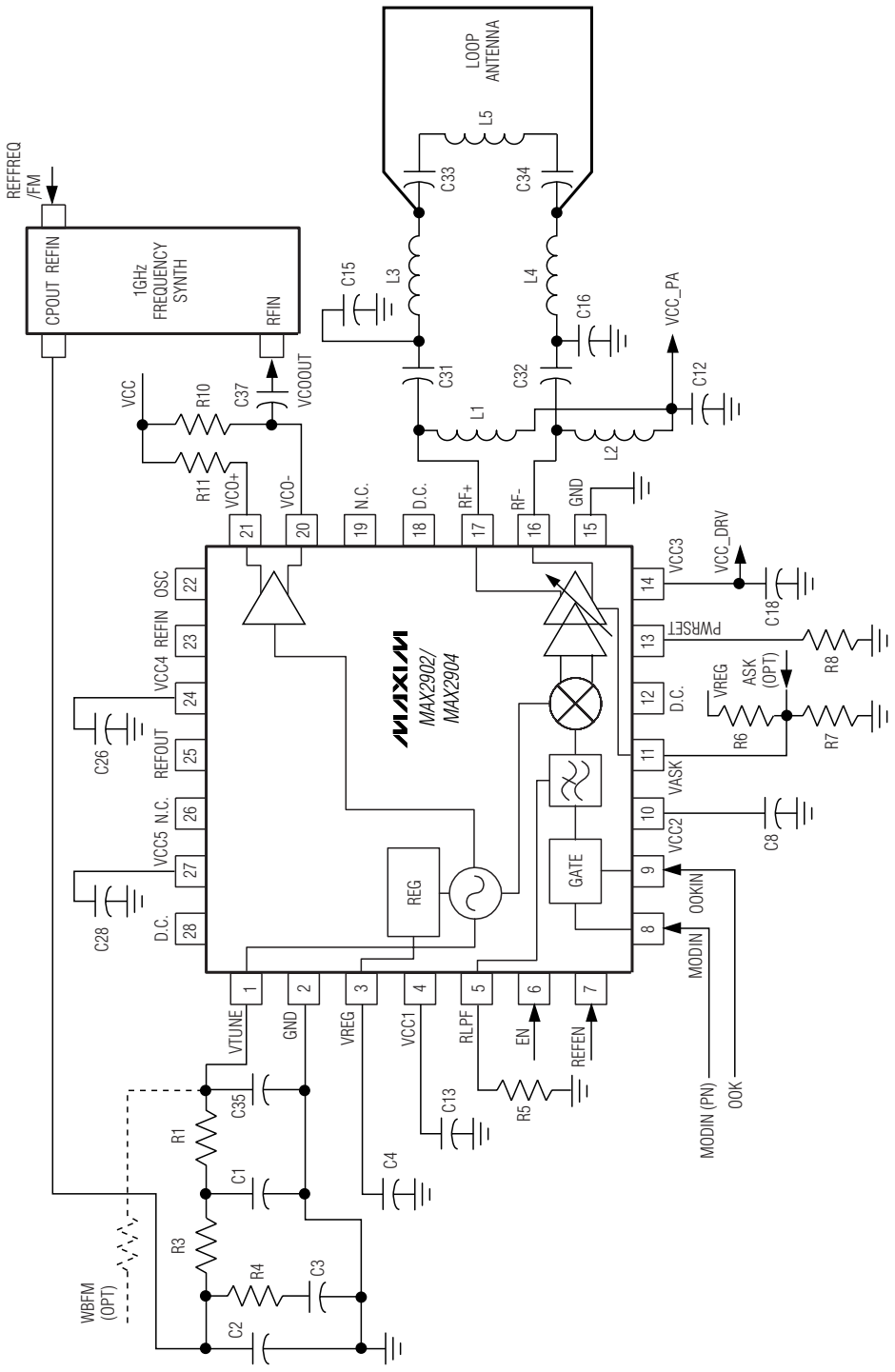

MAX2900 TYPICAL OPERATING CIRCUIT

# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands

## Typical Operating Circuits (continued)



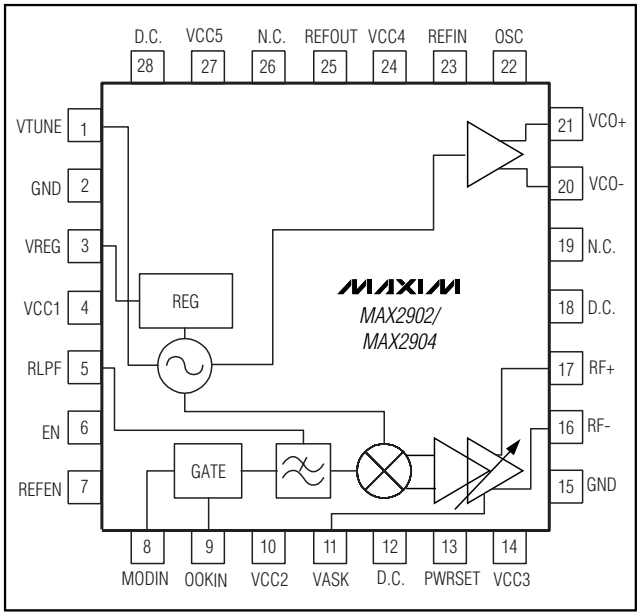
## Typical Operating Circuits (continued)




MAX2902/MAX2904 TYPICAL OPERATING CIRCUIT

# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands

## Functional Diagrams/ Pin Configurations (continued)



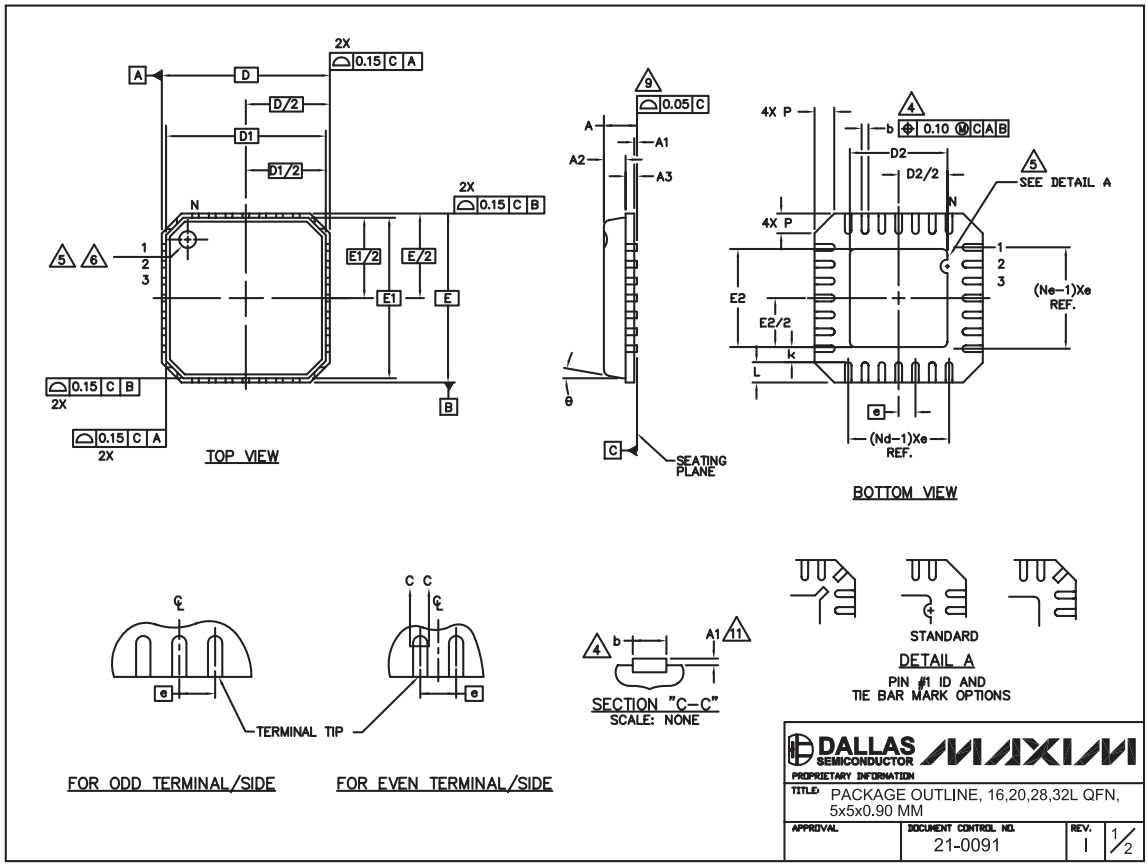

## Chip Information

TRANSISTOR COUNT: 898

## 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**.)

32L QFN.EPS



# 200mW Single-Chip Transmitter ICs for 868MHz/915MHz ISM Bands

## Package Information (continued)

(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**.)

| COMMON DIMENSIONS | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PKG | 16L 5x5 | | | 20L 5x5 | | | 28L 5x5 | | | 32L 5x5 | | |
| SYMBOL | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| A | 0.80 | 0.90 | 1.00 | 0.80 | 0.90 | 1.00 | 0.80 | 0.90 | 1.00 | 0.80 | 0.90 | 1.00 |
| A1 | 0.00 | 0.01 | 0.05 | 0.00 | 0.01 | 0.05 | 0.00 | 0.01 | 0.05 | 0.00 | 0.01 | 0.05 |
| A2 | 0.00 | 0.65 | 1.00 | 0.00 | 0.65 | 1.00 | 0.00 | 0.65 | 1.00 | 0.00 | 0.65 | 1.00 |
| A3 | 0.20 REF | | | 0.20 REF | | | 0.20 REF | | | 0.20 REF | | |
| b | 0.28 | 0.33 | 0.40 | 0.23 | 0.28 | 0.35 | 0.18 | 0.23 | 0.30 | 0.18 | 0.23 | 0.30 |
| D | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 |
| D1 | 4.75 BSC | | | 4.75 BSC | | | 4.75 BSC | | | 4.75 BSC | | |
| E | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 |
| E1 | 4.75 BSC | | | 4.75 BSC | | | 4.75 BSC | | | 4.75 BSC | | |
| e | 0.80 BSC | | | 0.65 BSC | | | 0.50 BSC | | | 0.50 BSC | | |
| k | 0.25 | – | – | 0.25 | – | – | 0.25 | – | – | 0.25 | – | – |
| L | 0.35 | 0.55 | 0.75 | 0.35 | 0.55 | 0.75 | 0.35 | 0.55 | 0.75 | 0.30 | 0.40 | 0.50 |
| N | 16 | | | 20 | | | 28 | | | 32 | | |
| ND | 4 | | | 5 | | | 7 | | | 8 | | |
| NE | 4 | | | 5 | | | 7 | | | 8 | | |
| P | 0.00 | 0.42 | 0.60 | 0.00 | 0.42 | 0.60 | 0.00 | 0.42 | 0.60 | 0.00 | 0.42 | 0.60 |
| θ | 0° | | 12° | 0° | | 12° | 0° | | 12° | 0° | | 12° |

| EXPOSED PAD VARIATIONS | | | | | | |
|---|---|---|---|---|---|---|
| PKG. CODES | D2 | | | E2 | | |
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| G1655-3 | 2.95 | 3.10 | 3.25 | 2.95 | 3.10 | 3.25 |
| G2055-1 | 2.55 | 2.70 | 2.85 | 2.55 | 2.70 | 2.85 |
| G2055-2 | 2.95 | 3.10 | 3.25 | 2.95 | 3.10 | 3.25 |
| G2855-1 | 2.55 | 2.70 | 2.85 | 2.55 | 2.70 | 2.85 |
| G2855-2 | 2.95 | 3.10 | 3.25 | 2.95 | 3.10 | 3.25 |
| G3255-1 | 2.95 | 3.10 | 3.25 | 2.95 | 3.10 | 3.25 |

NOTES:

1. DIE THICKNESS ALLOWABLE IS 0.305mm MAXIMUM (.012 INCHES MAXIMUM)
2. DIMENSIONING & TOLERANCES CONFORM TO ASME Y14.5M. – 1994.
3. N IS THE NUMBER OF TERMINALS.
   Nd IS THE NUMBER OF TERMINALS IN X–DIRECTION & Ne IS THE NUMBER OF TERMINALS IN Y–DIRECTION.
4. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25mm FROM TERMINAL TIP.
5. THE PIN #1 IDENTIFIER MUST BE EXISTED ON THE TOP SURFACE OF THE PACKAGE BY USING INDENTATION MARK OR INK/LASER MARKED. DETAILS OF PIN #1 IDENTIFIER IS OPTIONAL, BUT MUST BE LOCATED WITHIN ZONE INDICATED.
6. EXACT SHAPE AND SIZE OF THIS FEATURE IS OPTIONAL.
7. ALL DIMENSIONS ARE IN MILLIMETERS.
8. PACKAGE WARPAGE MAX 0.05mm.
9. APPLIED FOR EXPOSED PAD AND TERMINALS.
   EXCLUDE EMBEDDED PART OF EXPOSED PAD FROM MEASURING.
10. MEETS JEDEC MO220; EXCEPT DIMENSION "b".
11. APPLIED FOR EXPOSED PAD AND TERMINALS. EXCLUDE EMBEDDING PART OF EXPOSED PAD FROM MEASURING.
12. THIS PACKAGE OUTLINE APPLIES TO ANVIL SINGULATION (STEPPED SIDES).

DALLAS SEMICONDUCTOR MAXIM
PROPRIETARY INFORMATION

| TITLE: PACKAGE OUTLINE, 16,20,28,32L QFN, 5x5x0.90 MM | | | |
|---|---|---|---|
| APPROVAL | DOCUMENT CONTROL NO. 21-0091 | REV. I | 2/2 |