19-2351; Rev 0; 4/02

EVALUATION KIT AVAILABLE

# MAXIM

# Upstream CATV Amplifier



## General Description

The MAX3505 programmable power amplifier is designed for use in CATV upstream applications. The MAX3505 drives 64dBmV (QPSK) into a 75Ω load when driven with a 34dBmV nominal input signal. Both input and output ports are differential, requiring that an external balun be used at the output port. The variable gain feature provides greater than 56dB of dynamic range, which is controlled by an SPI™ 3-wire interface. Gain control is available in 0.5dB steps. The device operates over a frequency range of 5MHz to 65MHz. The MAX3505 is internally matched for use with a 1:1 balun.

This device operates from a single 5VDC supply and draws 285mA during transmit (100% duty cycle, 64dBmV out). The bias current is automatically adjusted based on the output level to increase efficiency. Additionally, the device can be disabled between bursts to minimize noise and save power while still maintaining a match at the output port. In addition, a shutdown mode is available to disable all circuitry and reduce current consumption to 5µA (typ).

The MAX3505 is available in a 20-pin QFN package. The device operates in the extended industrial temperature range (-40°C to +85°C).

## Applications

DOCSIS™/EuroDOCSIS™ and DVB Cable Modems

OpenCable™ Set-Top Box

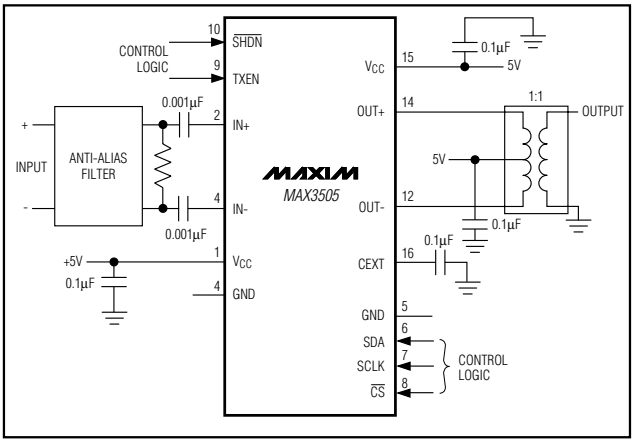
Telephony Over Cable

CATV Status Monitor

*SPI is a trademark of Motorola, Inc.*

*DOCSIS/EuroDOCSIS/OpenCable are trademarks of CableLabs.*

## Typical Operating Circuit




## Features

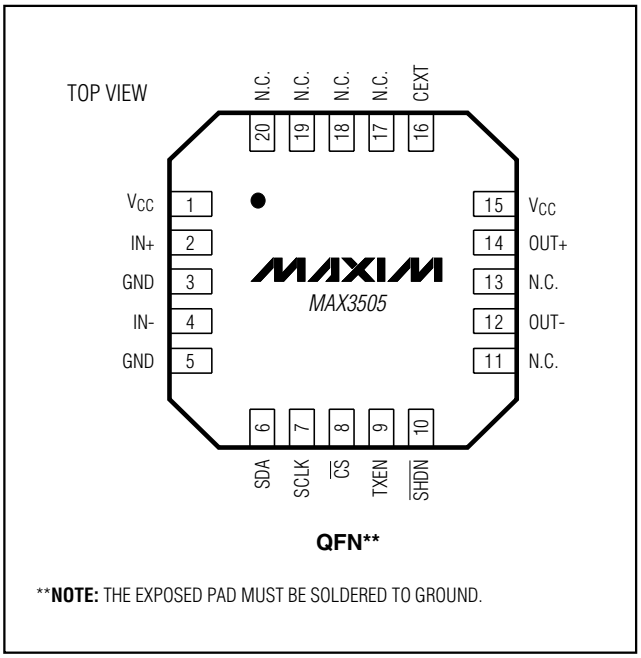
- ♦ **Single 5V Supply Operation**
- ♦ **Accurate Gain Control, ±1dB over 56dB Range**
- ♦ **Gain Programmable in 0.5dB Steps**
- ♦ **-55dBc Harmonic Distortion at 65MHz**
- ♦ **Low Burst On/Off Transient**

## Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE |
|---|---|---|
| MAX3505EGP | -40°C to +85°C | 20 QFN-EP* (5mm × 5mm) |

**EP = exposed pad*

## Pin Configuration




**QFN****

****NOTE:** THE EXPOSED PAD MUST BE SOLDERED TO GROUND.



***For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.***

## ABSOLUTE MAXIMUM RATINGS

$V_{CC}$, OUT+, OUT-.....-0.5V to +6.5V
Input Voltage Levels (all inputs).....-0.3V to ($V_{CC}$ + 0.3V)
Continuous Input Voltage (IN+, IN-).....$2V_{P-P}$
Continuous Current (OUT+, OUT-).....175mA
Continuous Power Dissipation ($T_A$ = +85°C)
20-Pin QFN (derate 27mW/°C above +85°C) .....1800mW

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.*

## DC ELECTRICAL CHARACTERISTICS

(MAX3505EV kit; $V_{CC}$ = 4.75V to 5.25V, $V_{GND}$ = 0V, TXEN = $\overline{SHDN}$ = high, $T_A$ = -40°C to +85°C. Typical parameters are at $V_{CC}$ = 5.0V, $T_A$ = +25°C, unless otherwise specified.) (Note1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | | 4.75 | | 5.25 | V |
| Supply-Current Transmit Mode | $I_{CC}$ | D7 = 1, gain code = 123 ($A_V$ = 31dB) | | 285 | 335 | mA |
| | | D7 = 0, gain code = 92 ($A_V$ = 0dB) | | 55 | | |
| Supply-Current Transmit Disable Mode | $I_{CC}$ | TXEN = low | | 4.8 | 7 | mA |
| Supply-Current Low-Power Standby | $I_{CC}$ | $\overline{SHDN}$ = low | | 5 | | µA |
| **LOGIC INPUTS** | | | | | | |
| Input High Voltage | $V_{INH}$ | | 2.0 | | | V |
| Input Low Voltage | $V_{INL}$ | | | | 0.8 | V |
| Input High Current | $I_{BIASH}$ | $V_{INH}$ = 3.3V | | | 100 | µA |
| Input Low Current | $I_{BIASL}$ | $V_{INL}$ = 0V | -100 | | | µA |

## AC ELECTRICAL CHARACTERISTICS

(MAX3505 EV kit; $V_{CC}$ = 4.75V to 5.25V, $V_{GND}$ = 0V, $P_{IN}$ = 34dBmV, TXEN = $\overline{SHDN}$ = high, $T_A$ = -40°C to +85°C. Typical parameters are at $T_A$ =+25°C, unless otherwise specified.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Voltage Gain, $f_{IN}$ = 5MHz | $A_V$ | D7 = 1, gain code = 123, $T_A$ = 0°C to +85°C | 29.5 | 31 | 32.5 | dB |
| | | D7 = 1, gain code = 119, $T_A$ = 0°C to +85°C | 27.5 | 29 | 30.5 | |
| | | D7 = 1, gain code = 99, $T_A$ = 0°C to +85°C | 17.5 | 19 | 20.5 | |
| | | D7 = 1, gain code = 82, $T_A$ = 0°C to +85°C | 9 | 10.5 | 12 | |
| | | D7 = 0, gain code = 112, $T_A$ = 0°C to +85°C | 8 | 9.5 | 11 | |
| | | D7 = 0, gain code = 92, $T_A$ = 0°C to +85°C | -2 | -0.5 | +1 | |
| | | D7 = 0, gain code = 72, $T_A$ = 0°C to +85°C | -12 | -10.5 | -9 | |
| | | D7 = 0, gain code = 43, $T_A$ = 0°C to +85°C | -26.5 | -25.0 | -23.5 | |

## AC ELECTRICAL CHARACTERISTICS (continued)

(MAX3505 EV kit; $V_{CC}$ = 4.75V to 5.25V, $V_{GND}$ = 0V, $P_{IN}$ = 34dBmV, TXEN = $\overline{SHDN}$ = high, $T_A$ = -40°C to +85°C. Typical parameters are at $V_{CC}$ = 5.0V, $T_A$ = +25°C, unless otherwise specified.) (Note1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Voltage Gain, $f_{IN}$ = 65MHz | $A_V$ | D7 = 1, gain code = 125, $T_A$ = -40°C to +85°C (Note 2) | 29.0 | | | dB |
| Gain Rolloff | | $V_{OUT}$ = 64dBmV, $f_{IN}$ = 5MHz to 42MHz (Note 2) | | -0.5 | -0.85 | dB |
| | | $V_{OUT}$ = 64dBmV, $f_{IN}$ = 5MHz to 65MHz (Note 2) | | -0.85 | -1.35 | |
| Gain Step Size | | $f_{IN}$ = 5MHz to 65MHz, $A_V$ = -26dB to +27dB | | 0.5 | | dB |
| | | $f_{IN}$ = 5MHz to 65MHz, $A_V$ = -26dB to +27dB; any 2-bit transition of D0, D1 | 0.7 | 1.0 | 1.3 | |
| | | $f_{IN}$ = 5MHz to 65MHz, D7 = 0, gain code = 112; to D7 = 1, gain code = 82 | 0.65 | 1.0 | 1.35 | |
| Transmit-Disable Mode Noise | | TXEN = low, BW = 160kHz, $f_{IN}$ = 5MHz to 65MHz (Note 2) | | | -65 | dBmV |
| Isolation in Transmit-Disable Mode | | TXEN = low, $f_{IN}$ = 5MHz to 65MHz (Note 2) | 60 | | | dB |
| Transmit Mode Noise | | BW = 160kHz, $f_{IN}$ = 5MHz to 65MHz, $A_V$ = -26dB to +30dB (Note 2) | | | -55 | dBc |
| Transmit Enable Transient Duration | | TXEN input rise/fall time < 0.1µs (Note 2) | | | 2 | µs |
| Transmit Disable Transient Duration | | TXEN input rise/fall time < 0.1µs (Note 2) | | | 2 | µs |
| Transmit Disable/ Transmit Enable Transient Step Size | | D7 = 1, gain code = 119 ($A_V$ = 29dB) | | 30 | 80 | $mV_{P-P}$ |
| | | D7 = 1, gain code = 83 ($A_V$ = 11dB) | | | 20 | |
| | | D7 = 0, gain code = 92 ($A_V$ = -0.5dB) | | 3 | | |
| Input Impedance | $Z_{IN}$ | $f_{IN}$ = 5MHz to 65MHz, differential (Note 2) | | 2 | | kΩ |
| Output Return Loss | | $f_{IN}$ = 5MHz to 65MHz, in 75Ω system, D7 = 1, gain code = 119 ($A_V$ = 27dB) | | 10 | | dB |
| Output Return Loss in Transmit-Disable Mode | | $f_{IN}$ = 5MHz to 65MHz, in 75Ω system, TXEN = low | | 10 | | dB |

## AC ELECTRICAL CHARACTERISTICS (continued)

(MAX3505 EV kit; $V_{CC}$ = 4.75V to 5.25V, $V_{GND}$ = 0V, $P_{IN}$ = 34dBmV, TXEN = $\overline{SHDN}$ = high, $T_A$ = -40°C to +85°C. Typical parameters are at $T_A$ =+25°C, unless otherwise specified.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Two-Tone Third-Order Distortion | IM3 | Input tones at 42MHz and 42.2MHz, both 31dBmV, $V_{OUT}$ = 60dBmV/tone (Note 2) | | -53 | -47 | dBc |
| | | Input tones at 65MHz and 65.2MHz, both 31dBmV, $V_{OUT}$ = 60dBmV/tone | | -47 | | |
| 2nd Harmonic Distortion | HD2 | $f_{IN}$ = 33MHz, $V_{OUT}$ = 64dBmV | | -55 | -50 | dBc |
| | | $f_{IN}$ = 65MHz, $V_{OUT}$ = 64dBmV (Note 2) | | -55 | -50 | |
| 3rd Harmonic Distortion | HD3 | $f_{IN}$ = 22MHz, $V_{OUT}$ = 64dBmV | | -55 | -50 | dBc |
| | | $f_{IN}$ = 65MHz, $V_{OUT}$ = 64dBmV | | -55 | -48.5 | |

## TIMING CHARACTERISTICS

($V_{CC}$ = 4.75V to 5.25V, $V_{GND}$ = 0V, TXEN = $\overline{SHDN}$ = high, $T_A$ = +25°C, D7 = 1, unless otherwise specified.)

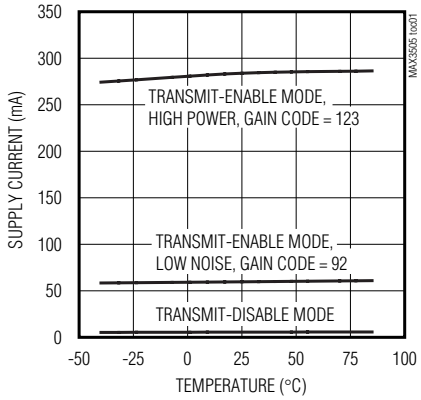
| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| SEN to SCLK Rise Set Time | $t_{SENS}$ | | 20 | | | ns |
| SEN to SCLK Rise Hold Time | $t_{SENH}$ | | 10 | | | ns |
| SDA to SCLK Setup Time | $t_{SDAS}$ | | 10 | | | ns |
| SDA to SCLK Hold Time | $t_{SDAH}$ | | 20 | | | ns |
| SDA Pulse-Width High | $T_{DATAH}$ | | 50 | | | ns |
| SDA Pulse-Width Low | $T_{DATAL}$ | | 50 | | | ns |
| SCLK Pulse-Width High | $t_{SCLKH}$ | | 50 | | | ns |
| SCLK Pulse-Width Low | $t_{SCLKL}$ | | 50 | | | ns |

**Note 1:** All parameters are guaranteed by design and characterization to ±3 sigma for $T_A$ < +25°C, unless otherwise specified.
**Note 2:** Guaranteed by design and characterization to ±6 sigma.

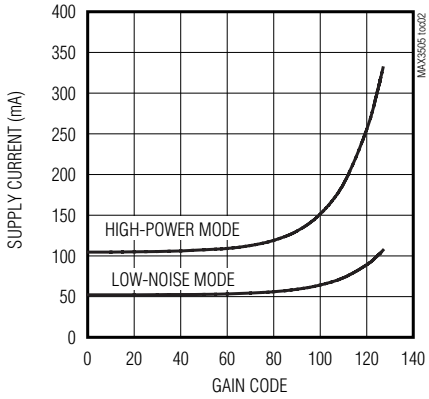
## Typical Operating Characteristics

(Typical applications circuit; $V_{CC}$ = 5V, $V_{IN}$ = 34dBmV, TXEN = $\overline{SHDN}$ = high, $f_{IN}$ = 20MHz, $Z_{LOAD}$ = 75Ω, $T_A$ = +25°C, unless otherwise noted.)

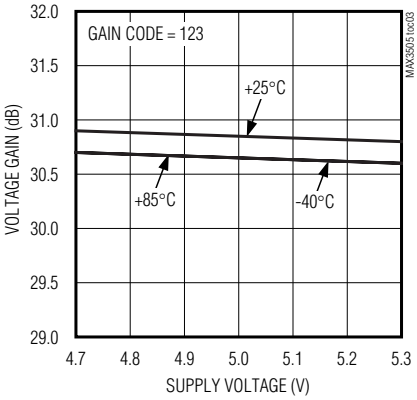
**SUPPLY CURRENT vs. TEMPERATURE**



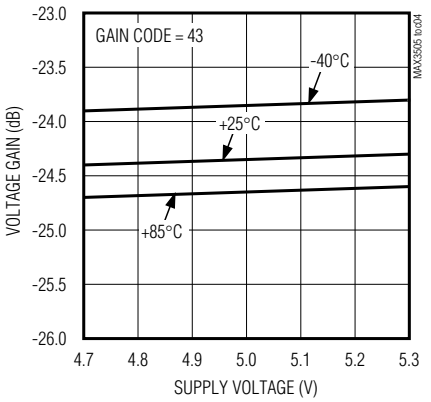

**SUPPLY CURRENT vs. GAIN CODE**



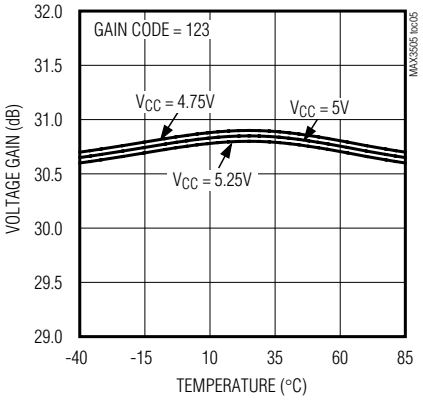

**VOLTAGE GAIN vs. SUPPLY VOLTAGE HIGH-POWER MODE**



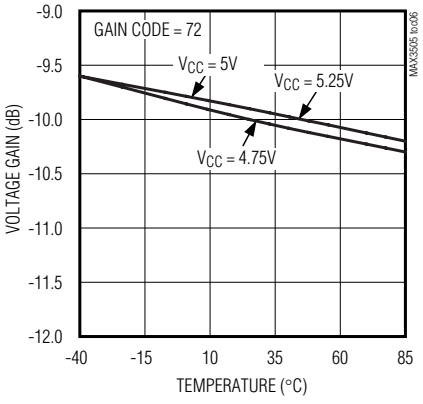

**VOLTAGE GAIN vs. SUPPLY VOLTAGE LOW-POWER MODE**



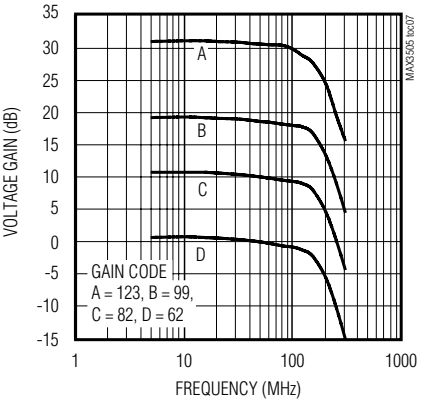

**VOLTAGE GAIN vs. TEMPERATURE HIGH-POWER MODE**



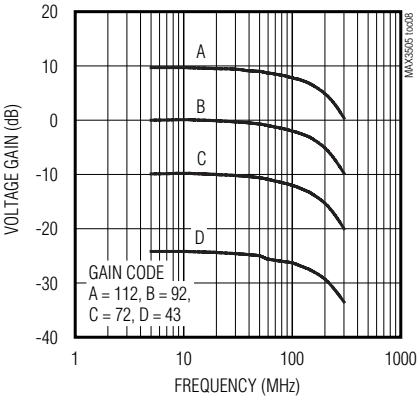

**VOLTAGE GAIN vs. TEMPERATURE LOW-NOISE MODE**



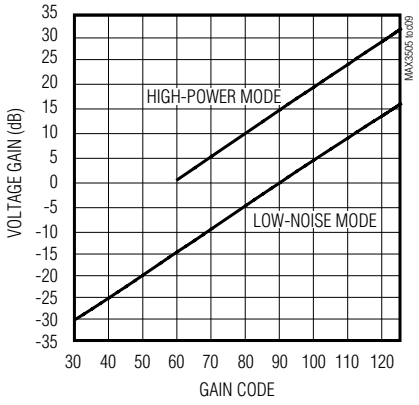

**VOLTAGE GAIN vs. FREQUENCY HIGH-POWER MODE**




**VOLTAGE GAIN vs. FREQUENCY LOW-NOISE MODE**




**VOLTAGE GAIN vs. GAIN CODE**

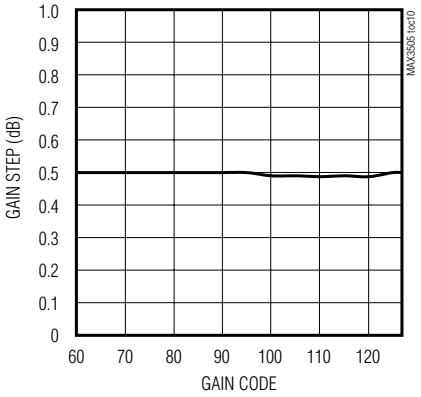


# Upstream CATV Amplifier

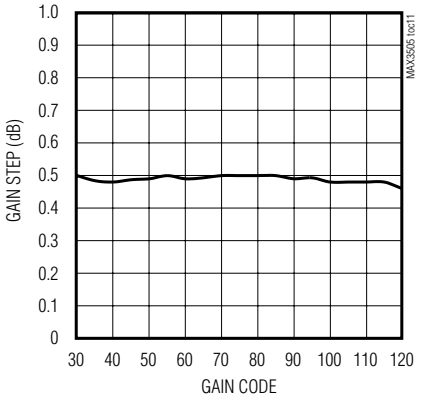
## Typical Operating Characteristics (continued)

(Typical applications circuit; $V_{CC}$ = 5V, $V_{IN}$ = 34dBmV, TXEN = $\overline{SHDN}$ = high, $f_{IN}$ = 20MHz, $Z_{LOAD}$ = 75Ω, $T_A$ = +25°C, unless otherwise noted.)

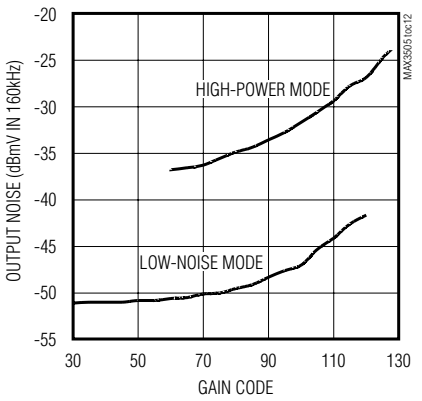
**GAIN STEP vs. GAIN CODE HIGH-POWER MODE**



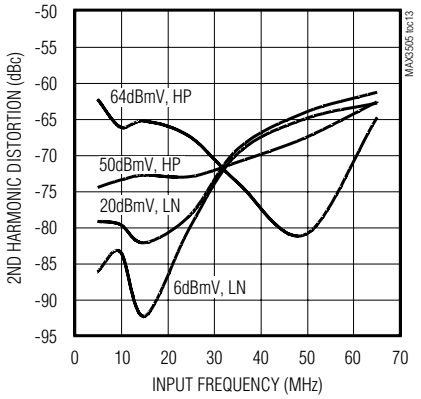

**GAIN STEP vs. GAIN CODE LOW-NOISE MODE**



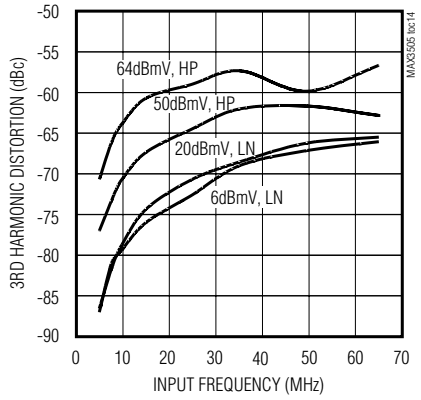

**TRANSMIT NOISE vs. GAIN CODE**



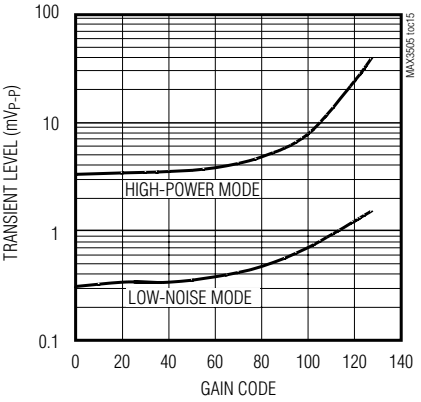

**2ND HARMONIC DISTORTION vs. INPUT FREQUENCY**



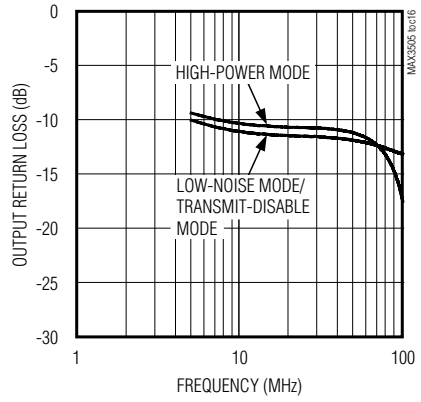

**3RD HARMONIC DISTORTION vs. INPUT FREQUENCY**



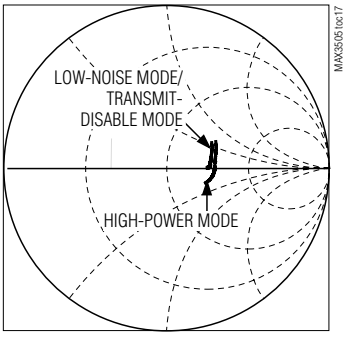

**POWER-UP/DOWN TRANSIENTS vs. GAIN CODE**



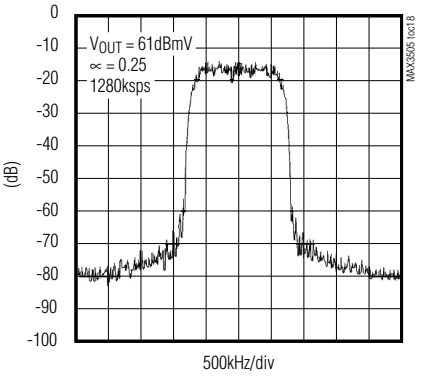

**OUTPUT RETURN LOSS vs. FREQUENCY (75Ω SYSTEM)**




**OUTPUT IMPEDANCE (75Ω SYSTEM)**

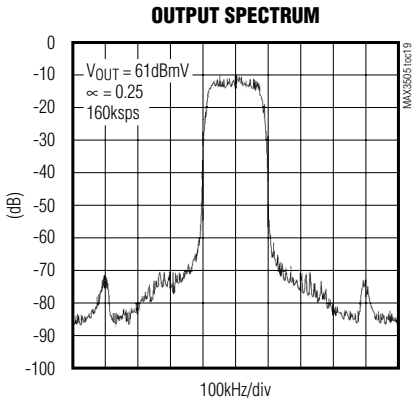


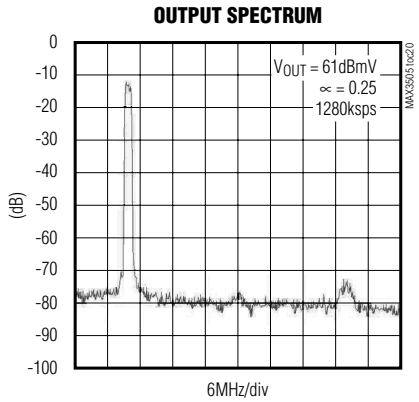

**OUTPUT SPECTRUM**



## Typical Operating Characteristics (continued)

(Typical applications circuit; $V_{CC}$ = 5V, $V_{IN}$ = 34dBmV, TXEN = $\overline{SHDN}$ = high, $f_{IN}$ = 20MHz, $Z_{LOAD}$ = 75Ω, $T_A$ = +25°C, unless otherwise noted.)



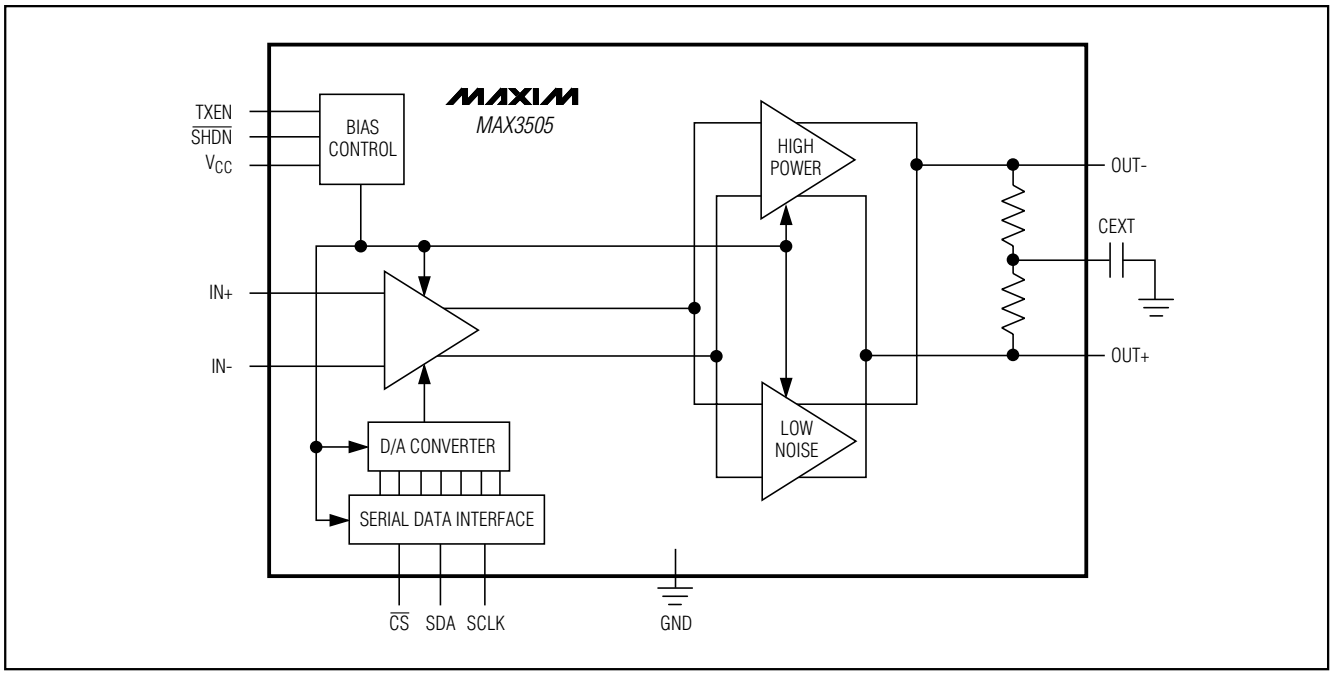




## Pin Description

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | $V_{CC}$ | Programmable-Gain Amplifier (PGA) +5V Supply. Bypass to GND with a 0.1µF decoupling capacitor as close to the part as possible. |
| 2 | IN+ | Positive PGA Input. Along with IN-, this port forms a high-impedance differential input to the PGA. Driving this port differentially increases the rejection of second-order distortion at low output levels. |
| 3 | GND | PGA RF Ground. As with all ground connections, maintain the shortest possible (low-inductance) length to the ground plane. |
| 4 | IN- | Negative PGA Input. When not used, this port must be AC-coupled to ground. See IN+. |
| 5 | GND | Ground |
| 6 | SDA | Serial-Interface Data. TTL-compatible input. See the *Serial Interface* section. |
| 7 | SCLK | Serial-Interface Clock. TTL-compatible input. See the *Serial Interface* section. |
| 8 | $\overline{CS}$ | Serial-Interface Enable. TTL-compatible input. See the *Serial Interface* section. |
| 9 | TXEN | Transmit Enable. Drive TXEN high to place the device in transmit-enable mode. |
| 10 | $\overline{SHDN}$ | Shutdown. When $\overline{SHDN}$ is set low, all functions (including the serial interface) are disabled. |
| 11,13,17–20 | N.C. | No Connection |
| 12 | OUT- | Negative Output. Along with OUT+, this port forms a 75Ω impedance output. This port is matched to a 75Ω load using a 1:1 transformer. |
| 14 | OUT+ | Positive Output. See OUT-. |
| 15 | $V_{CC}$ | Output Amplifier Bias, +5V Supply. Bypass to GND with a 0.1µF decoupling capacitor as close to the part as possible. |
| 16 | CEXT | RF Output Bypass. Bypass to GND with a 0.1µF capacitor. |
| Exposed Pad | GND | Ground |

# Upstream CATV Amplifier

## Functional Diagram




## Detailed Description

### Programmable-Gain Amplifier

The PGA consists of the variable-gain amplifier (VGA) and the digital-to-analog converter (DAC), which provide better than 56dB of output-level control in 0.5dB steps. The PGA is implemented as a programmable Gilbert-cell attenuator. The gain of the PGA is determined by a 7-bit word (D6–D0) programmed through the serial data interface (Tables 1 and 2).

Specified performance is achieved when the input is driven differentially. The device can be driven single ended. To drive the device in this manner, one of the input pins must be capacitively coupled to ground. Use a capacitor value large enough to allow for a low-impedance path to ground at the lowest frequency of operation. For operation down to 5MHz, a 0.001µF capacitor is suggested.

### Output Amplifiers

The output amplifiers are class A differential amplifiers, capable of driving +64dBmV (QPSK) differentially. This architecture provides superior even-order distortion performance but requires that a transformer be used to convert to a single-ended output. In transmit-disable mode, the output amplifiers are powered down. A resistor is placed across the output, so that the output impedance remains matched when the amplifier is in transmit-disable mode. Disabling the output devices also results in low output noise.

To match the output impedance to a 75Ω load, the transformer must have a turns ratio of 1:1. The differential amplifier is biased directly from the +5V supply using the center tap of the output transformer. This provides a significant benefit when switching between transmit mode and transmit-disable mode. Stored energy due to bias currents within the transformer cancels and prevents switching transients from reaching the load.

### Serial Interface

The serial interface has an active-low enable ($\overline{CS}$) to bracket the data, with data clocked in MSB first on the rising edge of SCLK. Data is stored in the storage latch on the rising edge of $\overline{CS}$. The serial interface controls the state of the PGA and the output amplifiers. Tables 1 and 2 show the register format. Serial-interface timing is shown in Figure 1.

## Applications Information

### High-Power and Low-Noise Modes

The MAX3505 has two transmit modes, high power (HP) and low noise (LN). Each of these modes is actuated by the high-order bit, D7, of the 8-bit programming word. When D7 is a logic 1, HP mode is enabled. When D7 is a logic 0, LN mode is enabled.

Each of these modes is characterized by the activation of a distinct output stage. In HP mode, the output stage exhibits 16dB higher gain than LN mode. The lower gain of the LN output stage allows for significantly lower output noise and lower transmit-enable/transmit-disable transients.

The full range of gain codes (D6–D0) can be used in either mode. For DOCSIS applications, HP mode is recommended for output levels at or above 34.5dBmV (D7 = 1, gain code = 82), LN mode when the output level is below +33.5dBmV (D7 = 0, gain code = 112).

### Shutdown Mode

In normal operation, the shutdown pin ($\overline{SHDN}$) is held high. When $\overline{SHDN}$ is taken low, all circuits within the IC are disabled. Only leakage currents flow in this state. Data stored within the serial-data interface latches is lost upon entering this mode. Current consumption is reduced to 5µA (typ) in shutdown mode.

### Transformer

A transformer is required at the output of the MAX3505 to convert from differential to single-ended drive. This transformer must have adequate bandwidth to cover the intended application. Note that most RF transformers specify bandwidth with a 50Ω source on the primary and a matching resistance on the secondary winding. Operating in a 75Ω system tends to shift the low-frequency edge of the transformer bandwidth specification up by a factor of 1.5, due to primary inductance. Keep this in mind when specifying a transformer.

Bias to the output stage is provided through the center tap on the transformer primary. This greatly diminishes the on/off transients present at the output when switching between transmit and transmit-disable modes. Commercially available transformers typically have adequate balance between half-windings to achieve substantial transient cancellation.

Finally, keep in mind that transformer core inductance varies proportionally with temperature. If the application requires low temperature extremes (less than 0°C), adequate primary inductance must be present to sustain low-frequency output capability as temperatures drop. In general, this is not a problem, as modern RF transformers have adequate bandwidth.

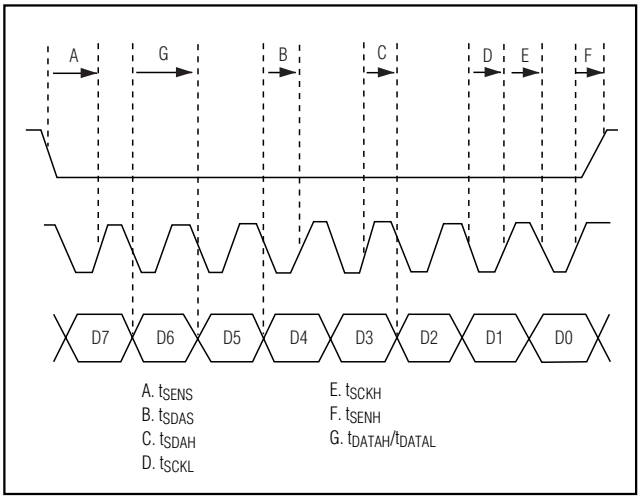



*Figure1. Serial-Interface Timing Diagram*

**Table 1. Serial-Interface Control Word**

| BIT | MNEMONIC | DESCRIPTION |
|---|---|---|
| MSB 7 | D7 | High-power/low-noise mode select |
| 6 | D6 | Gain code, bit 6 |
| 5 | D5 | Gain code, bit 5 |
| 4 | D4 | Gain code, bit 4 |
| 3 | D3 | Gain code, bit 3 |
| 2 | D2 | Gain code, bit 2 |
| 1 | D1 | Gain code, bit 1 |
| LSB 0 | D0 | Gain code, bit 0 |

### Input Circuit

To achieve rated performance, drive the inputs of the MAX3505 differentially with an appropriate input level. The differential input impedance is approximately 2kΩ. Most applications require a differential lowpass filter preceding the device. The filter design dictates a terminating impedance of a specified value. Place this load impedance across the AC-coupled input pins (see the *Typical Operating Circuit*).

The MAX3505 has sufficient gain to produce an output level of 64dBmV (QPSK) when driven with a +34dBmV input signal. When a lower input level is present, the maximum output level is reduced proportionally and output linearity increases. If an input level greater than +34dBmV is used, the 3rd-order distortion performance degrades slightly.

**Table 2. Chip-State Control Bits**

| $\overline{SHDN}$ | TXEN | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | GAIN CODE (DECIMAL) | STATES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | X | X | X | X | X | X | X | X | X | | Shutdown Mode |
| 1 | 0 | X | X | X | X | X | X | X | X | | Transmit-Disable Mode |
| 1 | 1 | 1 | X | X | X | X | X | X | X | | Transmit-Enable Mode, High Power |
| 1 | 1 | 0 | X | X | X | X | X | X | X | | Transmit-Enable Mode, Low Noise |
| 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 43 | $A_V$ = -25.0dB* |
| 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 92 | $A_V$ = -0.5dB* |
| 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 112 | $A_V$ = 9.5dB* |
| 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 82 | $A_V$ = 10.5dB* |
| 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 99 | $A_V$ = 19.0dB* |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 123 | $A_V$ = 31.0dB* |

**Typical gain at +25°C, $V_{CC}$ = 5.0V.*

If single-ended sources drive the MAX3505, one of the input terminals must be capacitively coupled to ground (IN+ or IN-). The value of this capacitor must be large enough to look like a short circuit at the lowest frequency of interest. For operation at 5MHz with a 75Ω source impedance, a value of 0.001µF suffices.

## Layout Issues

A well-designed printed circuit (PC) board is an essential part of an RF circuit. For best performance, pay attention to power-supply layout issues, as well the output circuit layout.

### Output Circuit Layout

The differential implementation of the MAX3505's output has the benefit of significantly reducing even-order distortion, the most significant of which is 2nd-harmonic distortion. The degree of distortion cancellation depends on the amplitude and phase balance of the overall circuit. It is important to keep the trace lengths from the output pins equal.

### Power-Supply Layout

For minimal coupling between different sections of the IC, the ideal power-supply layout is a star configuration. This configuration has a large-value decoupling capacitor at the central power-supply node. The power-supply traces branch out from this node, each going to a separate power-supply node in the circuit. At the end of each of these traces is a decoupling capacitor that provides very low impedance at the frequency of interest. This arrangement provides local power-supply decoupling at each power-supply pin.

The power-supply traces must be made as thick as practical. Ground inductance degrades distortion performance. Therefore, ground plane connections should be made with multiple vias.

### Exposed-Paddle Thermal Considerations

The MAX3505's 20-pin QFN package provides a low thermal-resistance path to the die. It is important that the PC board on which the MAX3505 is mounted be designed to conduct heat from this contact. In addition, the EP should be provided with a low-inductance path to electrical ground. It is recommended that the EP be soldered to a ground plane on the PC board, either directly or through an array of plated via holes.

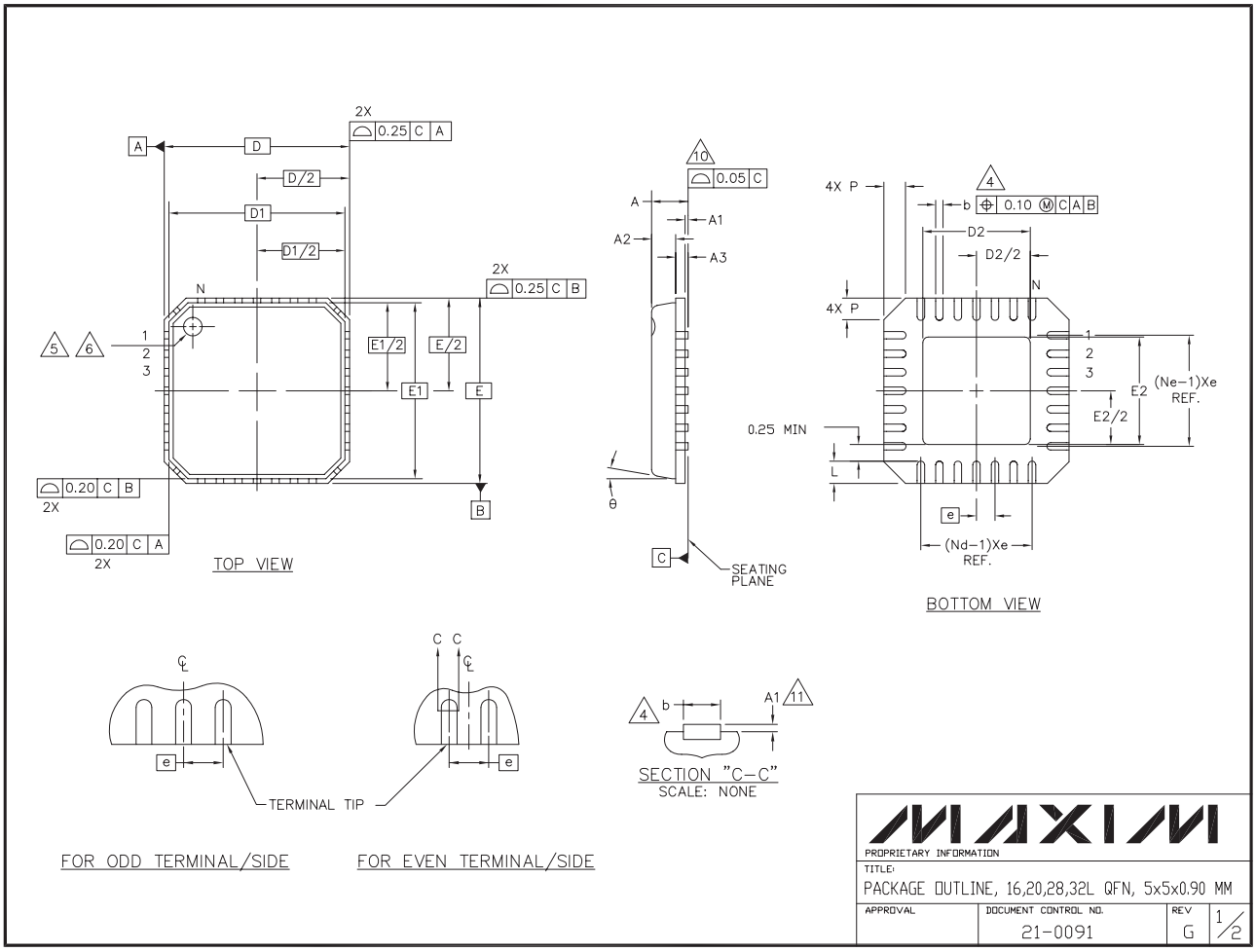
## Chip Information

TRANSISTOR COUNT: 1180

SUBSTRATE CONNECTED TO GND

## 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**.)



# Upstream CATV Amplifier

## 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**.)

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.
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.
11. THIS PACKAGE OUTLINE APPLIES TO ANVIL SINGULATION (STEPPED SIDES) AND TO SAW SINGULATION (STRAIGHT SIDES) QFN STYLES.

| SYMBOL | COMMON DIMENSIONS | | | NOTE |
|---|---|---|---|---|
| | MIN. | NOM. | MAX. | |
| A | 0.80 | 0.90 | 1.00 | |
| A1 | 0.00 | 0.01 | 0.05 | |
| A2 | 0.00 | 0.65 | 1.00 | |
| A3 | | 0.20 REF. | | |
| D | | 5.00 BSC | | |
| D1 | | 4.75 BSC | | |
| E | | 5.00 BSC | | |
| E1 | | 4.75 BSC | | |
| θ | 0° | – | 12° | |
| P | 0 | | 0.60 | |
| D2 | 1.25 | – | 3.25 | |
| E2 | 1.25 | – | 3.25 | |

| SYMBOL | PITCH VARIATION B | | | NOTE |
|---|---|---|---|---|
| | MIN. | NOM. | MAX. | |
| e | | 0.80 BSC | | |
| N | | 16 | | 3 |
| Nd | | 4 | | 3 |
| Ne | | 4 | | 3 |
| L | 0.35 | 0.55 | 0.75 | |
| b | 0.28 | 0.33 | 0.40 | 4 |

| SYMBOL | PITCH VARIATION B | | | NOTE |
|---|---|---|---|---|
| | MIN. | NOM. | MAX. | |
| e | | 0.65 BSC | | |
| N | | 20 | | 3 |
| Nd | | 5 | | 3 |
| Ne | | 5 | | 3 |
| L | 0.35 | 0.55 | 0.75 | |
| b | 0.23 | 0.28 | 0.35 | 4 |

| SYMBOL | PITCH VARIATION C | | | NOTE |
|---|---|---|---|---|
| | MIN. | NOM. | MAX. | |
| e | | 0.50 BSC | | |
| N | | 28 | | 3 |
| Nd | | 7 | | 3 |
| Ne | | 7 | | 3 |
| L | 0.35 | 0.55 | 0.75 | |
| b | 0.18 | 0.23 | 0.30 | 4 |

| SYMBOL | PITCH VARIATION D | | | NOTE |
|---|---|---|---|---|
| | MIN. | NOM. | MAX. | |
| e | | 0.50 BSC | | |
| N | | 32 | | 3 |
| Nd | | 8 | | 3 |
| Ne | | 8 | | 3 |
| L | 0.30 | 0.40 | 0.50 | |
| b | 0.18 | 0.23 | 0.30 | 4 |

MAXIM

PROPRIETARY INFORMATION

TITLE:

PACKAGE OUTLINE, 16,20,28,32L QFN, 5x5x0.90 MM

| APPROVAL | DOCUMENT CONTROL NO. | REV | |
|---|---|---|---|
| | 21-0091 | G | 2/2 |

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