

DATA SHEET

SA647 **Low-voltage digital IF receiver**

Product specification

1998 Aug 10

Low-voltage digital IF receiver

SA647

DESCRIPTION

The SA647 is a low-voltage high performance monolithic digital system with high-speed RSSI incorporating a mixer, oscillator with buffered output, two limiting intermediate frequency amplifiers, fast logarithmic received signal strength indicator (RSSI), voltage regulator, RSSI op amp and power down pin. The SA647 is available in TSSOP (thin shrink small outline package).

The SA647 was designed for portable digital communication applications and will function down to 2.7V. The limiter amplifier has differential outputs with 2MHz small signal bandwidth. The RSSI output has access to the feedback pin. This enables the designer to level adjust the outputs or add filtering.

FEATURES

- $V_{CC} = 2.7$ to $5.5V$
- Low power receiver ($5.3mA @ 3V$)
- Power down mode ($I_{CC} = 110\mu A$)
- Fast RSSI rise and fall times
- Extended RSSI range with temperature compensation
- RSSI op amp
- 2MHz limiter small signal bandwidth
- Filter matching ($1.5k\Omega$)
- Differential limiter output
- Oscillator buffer
- TSSOP-20 package

APPLICATIONS

- NADC (North American Digital Cellular)
- Digital receiver systems
- Cellular radio

PIN CONFIGURATION

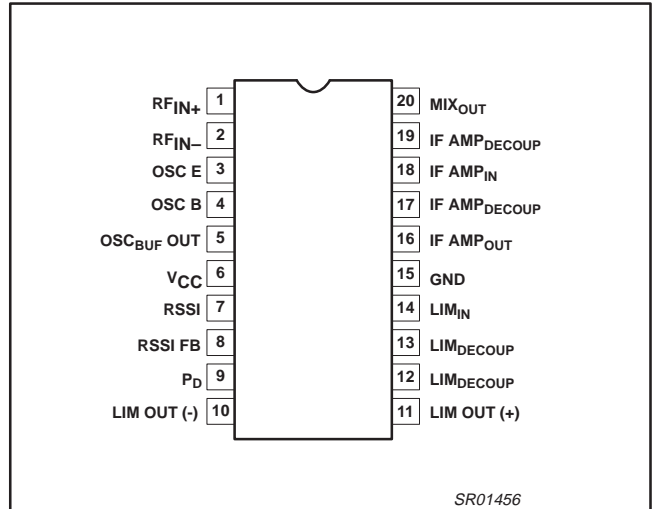


Figure 1. Pin Configuration

ORDERING INFORMATION

| DESCRIPTION | TEMPERATURE RANGE | ORDER CODE | DWG # |
|--|-------------------|------------|----------|
| 20-Pin Plastic Thin Shrink Small Outline Package (Surface-mount) | -40 to +85°C | SA647DH | SOT360-1 |

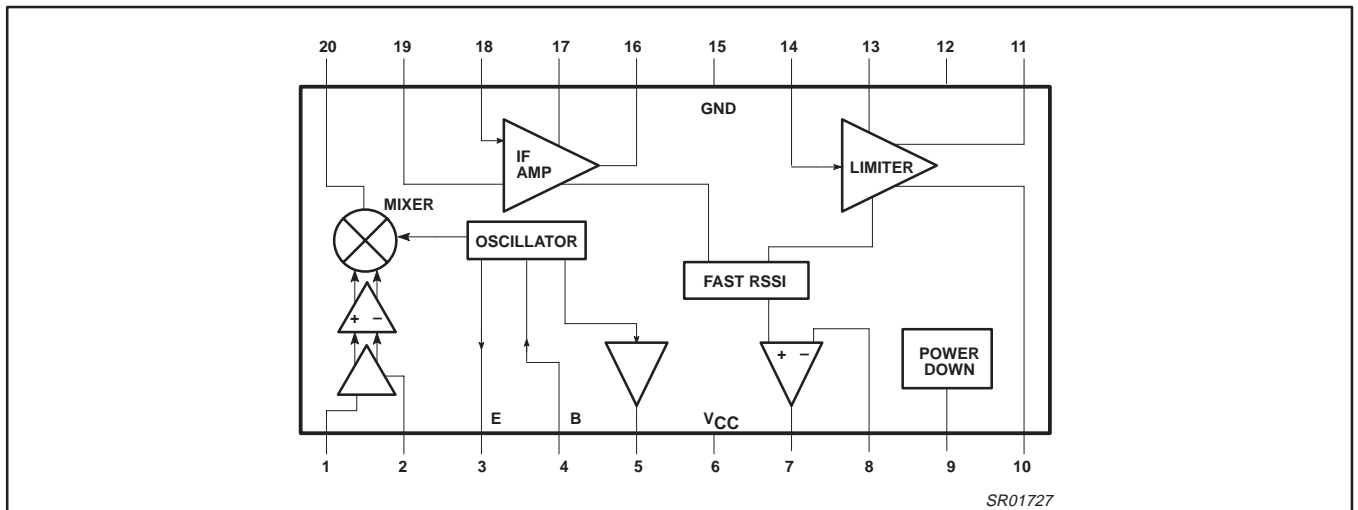


Figure 2. Block Diagram

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PIN DESCRIPTION

| PIN NO. | SYMBOL | FUNCTION |
|---------|--------------------------|--------------------------|
| 1 | RF _{IN} | RF input |
| 2 | RF BYPASS | RF bypass |
| 3 | OSC _E | Oscillator emitter |
| 4 | OSC _B | Oscillator base (input) |
| 5 | OSC _{BUF} OUT | Oscillator buffer output |
| 6 | V _{CC} | Supply voltage |
| 7 | RSSI | RSSI output |
| 8 | RSSI FB | RSSI Feedback |
| 9 | P _D | Power Down |
| 10 | LIM _{OUT(-)} | Limiter output (neg) |
| 11 | LIM _{OUT(+)} | Limiter output (pos) |
| 12 | LIM _{DECOUP} | Limiter decoupling |
| 13 | LIM _{DECOUP} | Limiter decoupling |
| 14 | LIM _{IN} | Limiter input |
| 15 | GND | Ground |
| 16 | IF AMP _{OUT} | IF amplifier output |
| 17 | IF AMP _{DECOUP} | IF amplifier decoupling |
| 18 | IF AMP _{IN} | IF amplifier input |
| 19 | IF AMP _{DECOUP} | IF amplifier decoupling |
| 20 | MIX _{OUT} | Mixer output |

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ABSOLUTE MAXIMUM RATINGS

| SYMBOL | PARAMETER | RATING | UNITS |
|-----------|-------------------------------------|----------------------------|-------|
| V_{CC} | Supply voltage | -0.3 to +6.0 | V |
| V_{IN} | Voltage applied to any other pin | -0.3 to ($V_{CC} + 0.3$) | V |
| T_{STG} | Storage temperature range | -65 to +150 | °C |
| T_A | Operating ambient temperature range | -40 to +85 | °C |

NOTE: Thermal impedance (θ_{JA}) = 135°C/W

DC ELECTRICAL CHARACTERISTICS

 $V_{CC} = +3.0V$, $T_A = 25^\circ C$; unless otherwise stated.

| SYMBOL | PARAMETER | TEST CONDITIONS | LIMITS | | | UNITS |
|--------------|----------------------------|-------------------------|--------|----------|-------------|-----------|
| | | | MIN | TYP | MAX | |
| V_{CC} | Power supply voltage range | | 2.7 | | 5.5 | V |
| I_{CC} | DC current drain | | 4 | 5.3 | 7 | mA |
| | Standby | Pin 9 = LOW | | 0.11 | | mA |
| | Input current | Pin 9 = LOW | -10 | | 10 | μA |
| | | Pin 9 = HIGH | -10 | | 10 | |
| | Input level | Pin 9 = LOW | 0 | | $0.3V_{CC}$ | V |
| Pin 9 = HIGH | | $0.7 V_{CC}$ | | V_{CC} | | |
| τ_{on} | Power-up time | RSSI valid (10% to 90%) | | 10 | | μsec |
| τ_{off} | Power-down time | RSSI valid (90% to 10%) | | 5 | | μsec |

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AC ELECTRICAL CHARACTERISTICS $V_{CC} = +3.0V$, Mixer input freq = 110.52MHz, LO input freq = 109.92MHz, $T_A = 25^{\circ}C$; unless otherwise stated.

| SYMBOL | PARAMETER | TEST CONDITIONS | LIMITS | | | UNITS |
|--------------------------|---|--|--------|-----------|-----|-------------------|
| | | | MIN | TYP | MAX | |
| Mixer/Osc section | | | | | | |
| f_{IN} | Input signal frequency | | | | 200 | MHz |
| f_{OSC} | Crystal oscillator frequency | | | | 200 | MHz |
| NF | Noise figure at 110.52MHz | Matched input and output 50 Ω | | 4.5 | | dB |
| IIP3 | Third-order input intercept point | Matched input and output to 50 Ω | | -29.5 | | dBm |
| G_{CP} | Conversion power gain | Matched input and output to 50 Ω | 17 | 20 | 23 | dB |
| R_{IN} | Mixer input resistance | at 110.52 MHz | | 670 | | Ω |
| C_{IN} | Mixer input capacitance | at 110.52 MHz | | 3.0 | | pF |
| R_{OUT} | Mixer output resistance | at 600 kHz | | 1.5 | | k Ω |
| I_{SOL} | Mixer RF to LO isolation | | | 32 | | dB |
| | Buffered LO output level, DC coupled | 10k 3.9pF load | 110 | 230 | 320 | mV _{P-P} |
| | External input level | f = 110.52 MHz at Pin 4 | 250 | | | mV _{P-P} |
| IF section | | | | | | |
| | IF amp power gain | Matched input and output 50 Ω | 30 | 36 | | dB |
| | Limiter power gain | | 51 | 60 | | dB |
| IF_{BW} | IF amp bandwidth | | | 2 | | MHz |
| | RSSI output | Input power level = -113dBm, Pin 1 | | 0.30 | | V |
| | | Input power level = -68dBm, Pin 1 | | 1.00 | | V |
| | | Input power level = -29dBm, Pin 1 | | 1.55 | | V |
| | RSSI range | | | 85 | | dB |
| | RSSI accuracy | | | ± 1.5 | | dB |
| | RSSI ripple | | | 30 | | mV _{P-P} |
| | RSSI speed – (Rise Time) Input @ Pin 1 | No filter | | 5 | | μs |
| | RSSI speed – (Fall time) Input @ Pin 1 | No filter | | 25 | | μs |
| | IF input impedance | | | 1.5 | | k Ω |
| | IF output impedance | | | 1.5 | | k Ω |
| | Limiter input impedance | | | 1.5 | | k Ω |
| | Limiter output impedance | (Pin 10, Pin 11) | | 230 | | Ω |
| | Limiter output (each pin) | Output load is 1.5K in parallel with 30 pF to GND each pin | 240 | 350 | 420 | mV _{P-P} |
| | Limiter output DC level | | | 1.27 | | V |
| | Differential output matching | | | ± 5 | | mV |
| | Limiter output offset | | | 0.09 | | V |

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CIRCUIT DESCRIPTION

Mixer

The mixer has a single-ended input. The input impedance is 670Ω in parallel with a 3.0pF cap at 110.52MHz RF. The mixer output can drive a 1500Ω ceramic filter without any matching required.

Oscillator and Buffer

The on-board oscillator supplies the signal for the mixer down-conversion. The internally biased transistor can be configured as a Colpitts or Butler overtone crystal oscillator. The transistor's bias current can be increased if desired by adding a shunt resistor from Pin 3 to ground. The oscillator's buffered output (Pin 5) can be used as a feedback signal to lock the oscillator to an appropriate reference.

IF Amplifier and IF Limiter

The IF strip provides more than 96dB of power gain for the down converted signal. Its bandwidth is 2MHz . The input and output impedance of the IF amplifier and the input impedance of the IF limiter are set to 1500Ω . A second filter is connected between the IF amplifier and the limiter for improved channel selectivity and reduced instability. The overall gain can be reduced if desired by adding an external attenuator after the IF amplifier. The differential limiter outputs (Pins 10 and 11) are available for demodulator circuits.

RSSI

The received signal strength indicator provides a linear voltage indication of the received signal strength in dB for a typical range of 85dB . The response time to a change in input signal is less than a few microseconds and the delay is kept to a minimum because of the use of a minimum phase shift circuit. Because of the speed of the RSSI circuit, the RSSI rise and fall time will be dominated by the bandwidth of the external bandpass filter that is placed between the mixer and the IF. Since the RSSI function requires the signal to propagate through the whole IF strip, and the rise and fall time of the filters are inversely proportional to their bandwidth, there is a trade-off between channel selectivity and RSSI response. Therefore, it is recommended that all channel selection filters be placed before the IF strip, just after the mixer. This will make the delay of the RSSI independent of the mixer input signal amplitude. Also, a 6dB insertion loss between the IF and limiter sections (Pins 16 and 14) will give optimum flatness of RSSI versus mixer input signal.

The RSSI curve is temperature compensated and in addition is designed for improved consistency from unit to unit.

DC Power Supply

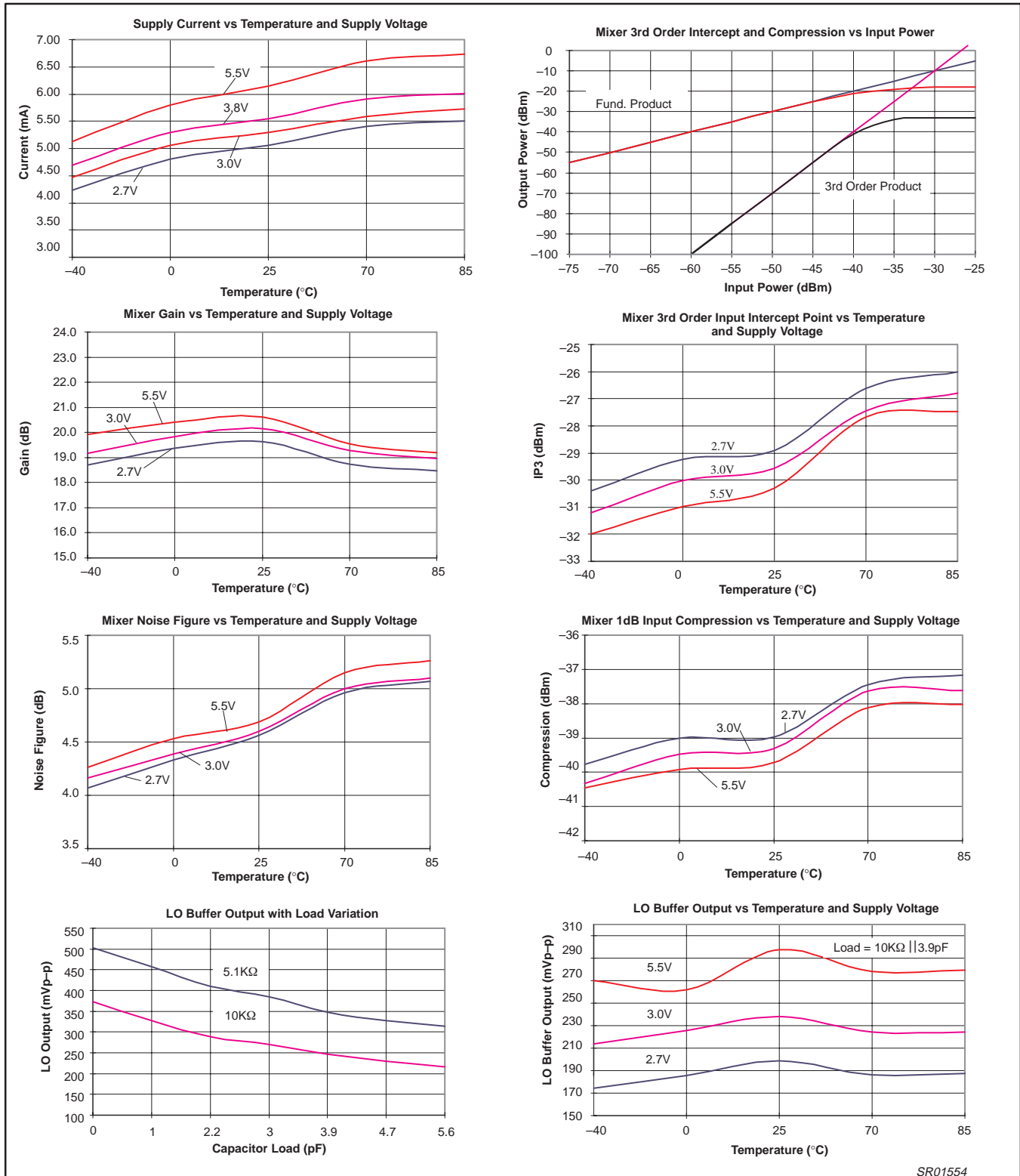
The IC is designed for operation between 2.7 and 5.5V . A power supply dependent biasing scheme is used in the mixers to benefit from the large headroom available at higher V_{CCS} .

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PERFORMANCE CHARACTERISTICS

$V_{CC} = +3.0V$, Mixer input freq = 110.52MHz, LO input freq = 109.92MHz, $T_A = 25^{\circ}C$; unless otherwise stated.

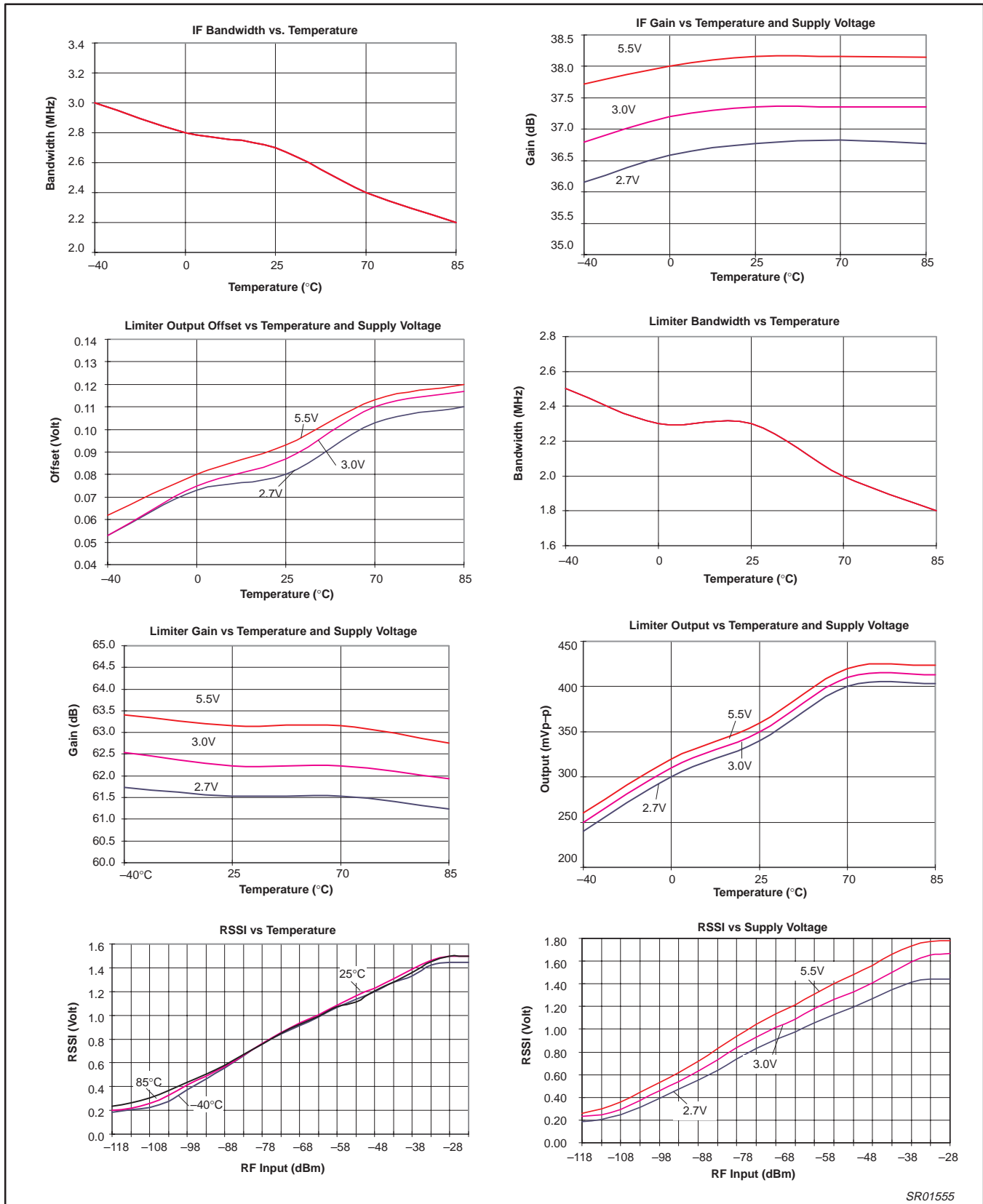


SR01554

Figure 3.

Low-voltage digital IF receiver

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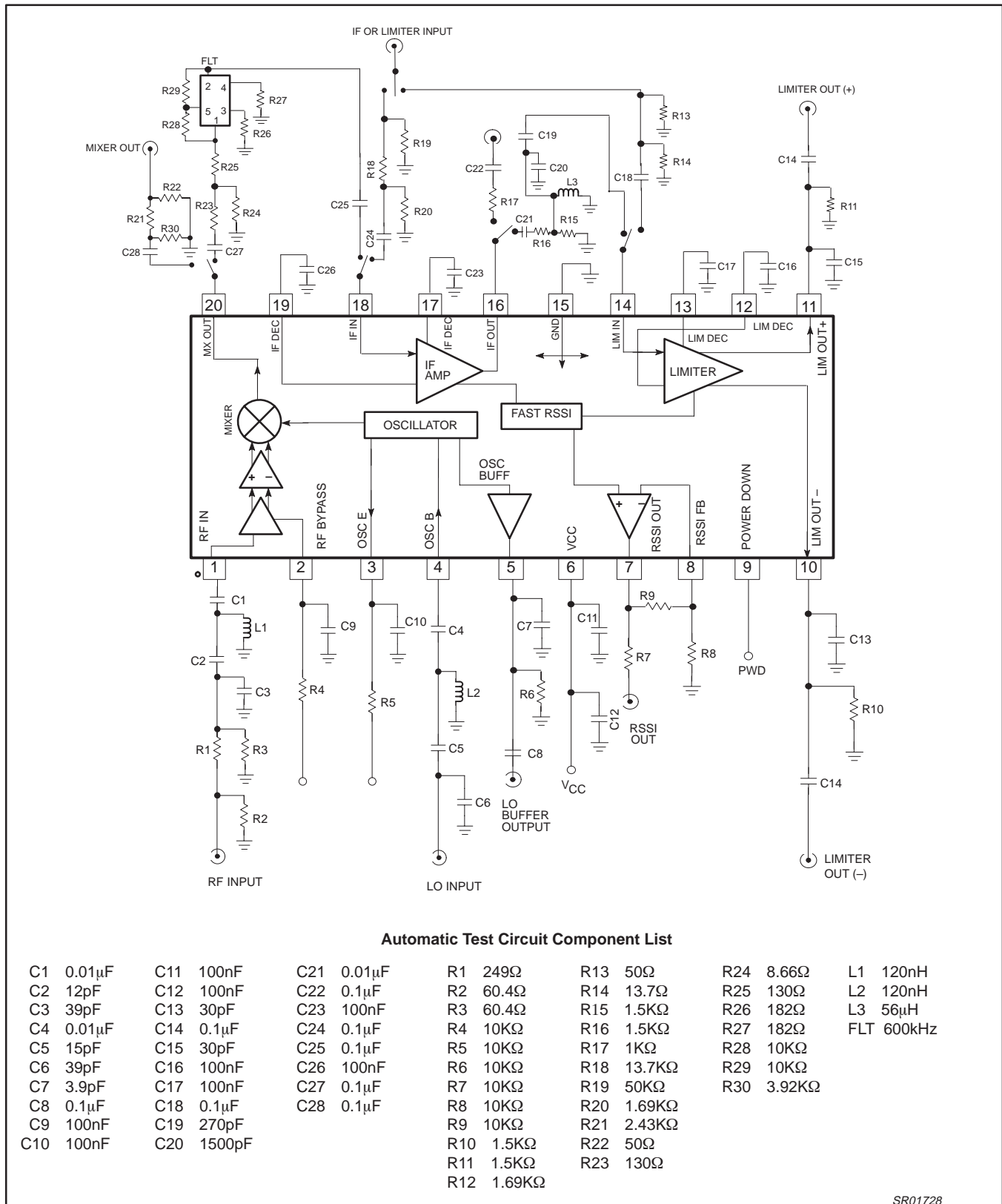
SR01555

Figure 4.

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GENERAL TEST CIRCUIT DESCRIPTION



SR01728

Figure 5.

Low-voltage digital IF receiver

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| PIN No. | PIN MNEMONIC | DC V | EQUIVALENT CIRCUIT | PIN No. | PIN MNEMONIC | DC V | EQUIVALENT CIRCUIT |
|---------|--------------|-------|--------------------|---------|-----------------|------------|--------------------|
| 1 | RF IN | +2.35 | | 6 | V _{CC} | +3.00 | |
| 2 | RF BYPASS | +1.56 | | | 7 | RSSI OUT | +0.20 |
| 3 | OSC E | +2.21 | | 8 | RSSI FEEDBACK | +0.20 | |
| 4 | OSC B | +2.78 | | | 9 | POWER DOWN | +2.00 |
| 5 | OSC BUFFER | +2.21 | | | | | |

SR01729

Figure 6.

Low-voltage digital IF receiver

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| PIN No. | PIN MNEMONIC | DC V | EQUIVALENT CIRCUIT | PIN No. | PIN MNEMONIC | DC V | EQUIVALENT CIRCUIT |
|----------|------------------|-------|--------------------|---------|---------------|-------|--------------------|
| 10 11 | LIMITER OUT | +1.25 | | 16 | IF AMP OUT | +1.28 | |
| 12 | LIMITER DECOUP | +1.28 | | 17 | IF AMP DECOUP | +1.28 | |
| 13 | LIMITER COUPLING | +1.28 | | 18 | IF AMP IN | +1.28 | |
| 14 | LIMITER IN | +1.28 | | 19 | IF AMP DECOUP | +1.28 | |
| 15 | GND | 0 | | 20 | MIXER OUT | +2.03 | |

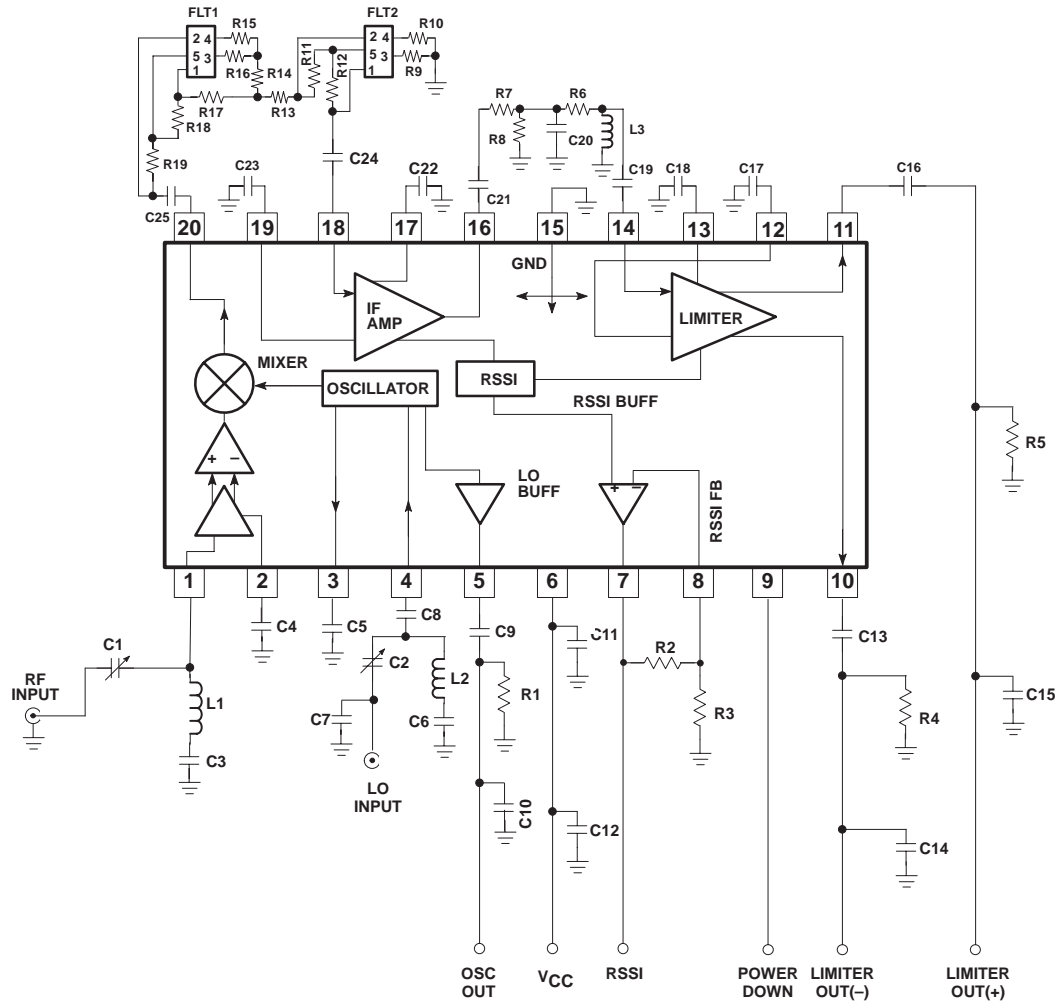
SR00509

Figure 7.

Low-voltage digital IF receiver

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GENERAL APPLICATIONS CIRCUIT



Component List

| | | | | | | | | | | | |
|-----|--------|-----|--------|-----|-------|-----|------------|-----|-------|--------|--------|
| C1 | 5–30pF | C11 | 0.1μF | C21 | 10nF | R1 | 10KΩ | R13 | 240Ω | L1 | 180nH |
| C2 | 5–30pF | C12 | 6.8pF | C22 | 0.1μF | R2 | 0Ω (short) | R14 | 4.5KΩ | L2 | 180nH |
| C3 | 0.1μF | C13 | 0.1μF | C23 | 0.1μF | R3 | OPEN | R15 | 180Ω | L3 | 56μH |
| C4 | 0.1μF | C14 | 30pF | C24 | 10nF | R4 | 5.1k | R16 | 180Ω | FLT1,2 | 600kHz |
| C5 | 0.1μF | C15 | 30pF | C25 | 10nF | R5 | 5.1k | R17 | 240Ω | | |
| C6 | 0.1μF | C16 | 0.1μF | | | R6 | 0Ω (short) | R18 | 10KΩ | | |
| C7 | 47pF | C17 | 0.1μF | | | R7 | 1.5KΩ | R19 | 10KΩ | | |
| C8 | 1nF | C18 | 0.1μF | | | R8 | 1.5KΩ | | | | |
| C9 | 10pF | C19 | 10nF | | | R9 | 180Ω | | | | |
| C10 | 3.9pF | C20 | 1500pF | | | R10 | 180Ω | | | | |
| | | | | | | R11 | 10KΩ | | | | |
| | | | | | | R12 | 0KΩ | | | | |

NOTE: R2 and R3 set the RSSI buffer gain. For unity gain short R2 (Pin 7 to Pin 8) and leave R9 open.

SR01730

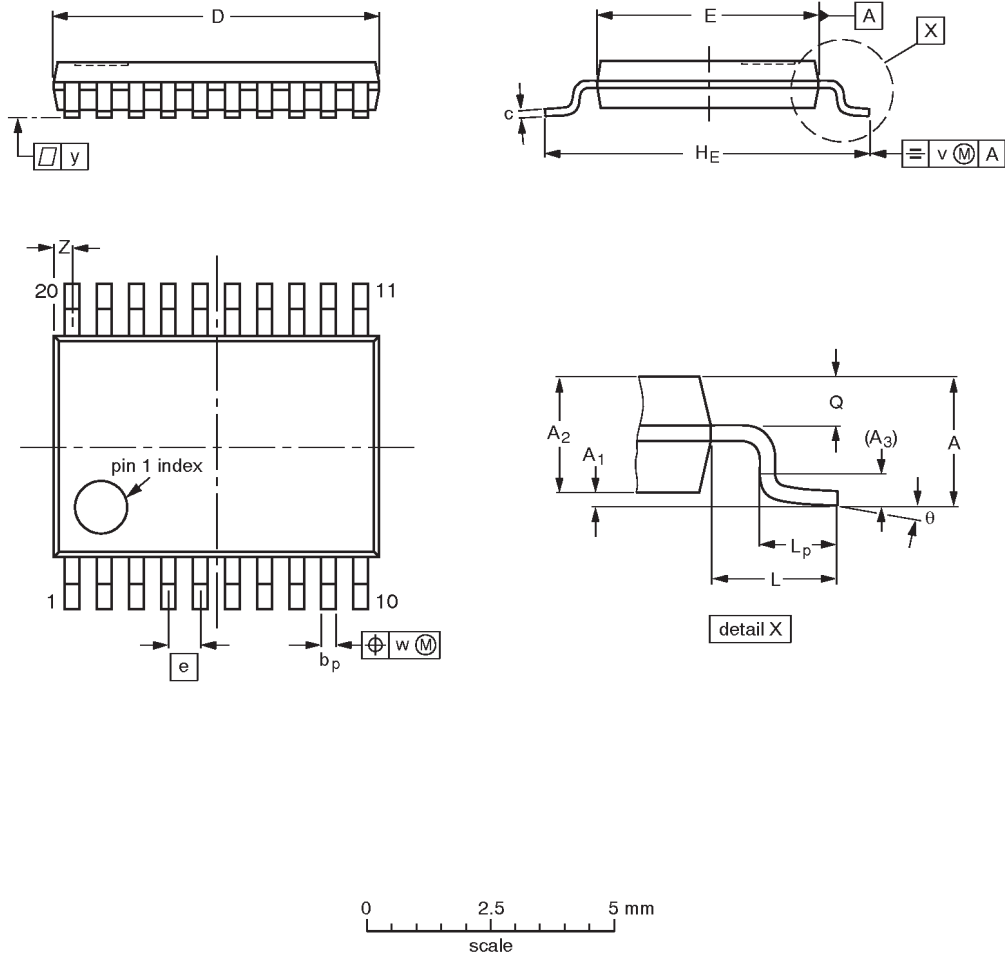
Figure 8.

Low-voltage digital IF receiver

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TSSOP20: plastic thin shrink small outline package; 20 leads; body width 4.4 mm

SOT360-1



DIMENSIONS (mm are the original dimensions)

| UNIT | A max. | A ₁ | A ₂ | A ₃ | b _p | c | D ⁽¹⁾ | E ⁽²⁾ | e | H _E | L | L _p | Q | v | w | y | Z ⁽¹⁾ | θ |
|------|--------|----------------|----------------|----------------|----------------|------------|------------------|------------------|------|----------------|-----|----------------|------------|-----|------|-----|------------------|----------|
| mm | 1.10 | 0.15 0.05 | 0.95 0.80 | 0.25 | 0.30 0.19 | 0.2 0.1 | 6.6 6.4 | 4.5 4.3 | 0.65 | 6.6 6.2 | 1.0 | 0.75 0.50 | 0.4 0.3 | 0.2 | 0.13 | 0.1 | 0.5 0.2 | 8° 0° |

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|----------|------|--|---------------------|-----------------------|
| | IEC | JEDEC | EIAJ | | | |
| SOT360-1 | | MO-153AC | | | | -93-06-16 95-02-04 |

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Data sheet status

| Data sheet status | Product status | Definition [1] |
|---------------------------|----------------|--|
| Objective specification | Development | This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice. |
| Preliminary specification | Qualification | This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product. |
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[1] Please consult the most recently issued datasheet before initiating or completing a design.

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Philips Semiconductors
811 East Arques Avenue
P.O. Box 3409
Sunnyvale, California 94088-3409
Telephone 800-234-7381

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Date of release: 08-98

Document order number:

9397 750 04241

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