

Features

- Fully integrated, PLL-stabilized VCO
- Flexible frequency range from 310 MHz to 450 MHz
- ASK achieved by on/off keying of internal power amplifier
- FM possible with external varactor
- Wide power supply range from 2.2 V to 5.5 V
- High over-all frequency accuracy
- Very low standby current
- Adjustable output power range from -12 dBm to +2 dBm
- Adjustable current consumption from 4.8 mA to 11.5 mA
- Differential output well-suited for loop antenna
- Conforms to EN 300 220 and similar standard

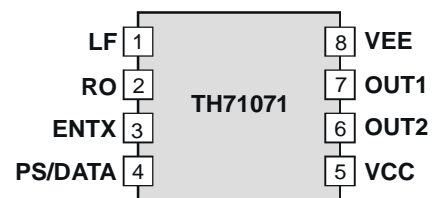
Ordering Information

| Part No. | Temperature Range | Package |
|-----------------|--------------------------|----------------|
| TH71071 | -40 C° to 85 °C | SOIC8 |

Application Examples

- Keyless car and central locking
- Low-power telemetry
- Alarm and security systems
- General digital data transmission
- General analog audio signal transmission
- Local oscillator signal generation

Pin Description



General Description

The TH71071 ASK transmitter IC is designed for applications in the European 433MHz industrial-scientific-medical (ISM) band, according to the EN 300 220 telecommunications standard. It can also be used for any other system with carrier frequencies ranging from 310 MHz to 450 MHz (e.g. for applications in the US 315MHz ISM band).

The transmitter's carrier frequency f_c is determined by the frequency of the reference crystal f_{ref} that is used. The integrated PLL synthesizer ensures that each RF value, ranging from 310 MHz to 450 MHz, can be achieved by using a crystal with reference frequency according to: $f_{ref} = f_c/N$, where $N = 32$ is the PLL feedback divider ratio.

Theory of Operation

General

As depicted in Fig.1, the TH71071 transmitter consists of a fully integrated voltage-controlled oscillator (VCO), a divide-by-32 divider (div32), a phase-frequency detector (PFD) and a charge pump. An external loop filter at pin LF determines the dynamic behaviour of the PLL and suppresses reference spurious signals.

The VCO's output signal feeds the power amplifier (PA). RF signal power P_o can be adjusted in six steps from $P_o = -12$ dBm to $+2$ dBm either by changing the value of resistor R_1 or by varying the voltage V_{PS} at pin PS/DATA. The open-collector differential output (OUT1, OUT2) can be used to either directly drive a loop antenna or to be converted to a single-ended impedance by means of a balanced-to-unbalanced (balun) transformer. For maximum available output power, the differential output should be matched to a load of approx. 1 k Ω .

Bandgap biasing ensures stable operation of the IC at a power supply range of 2.2 V to 5.5 V.

ASK Modulation

The TH71071 can be ASK-modulated by applying data directly at pin PS. This turns the PA on and off and therefore leads to an ASK signal at the output.

LO Source

Many applications require a stable RF source. For this purpose, the TH71071 can be used without modulation as an easy-to-use, PLL-stabilized, continuous wave (CW) generator.

Frequency Modulation (FM)

For FM operation an external varactor is required. It simply acts as a pulling capacitor connected in series to the crystal. Then the analog modulation signal, applied through a series resistor, directly modulates the XOSC.

Mode Control Logic

The mode control logic allows two different modes of operation as listed in the following table. The mode control pin ENTX is pulled-down internally. This guarantees that the whole circuit is shut down if this pin is left floating.

| ENTX | Mode | Description |
|------|-------------|--------------------------|
| 0 | TX disabled | whole circuit in standby |
| 1 | TX enable | TX active |

Table 1: Modes of operation

Block Diagram

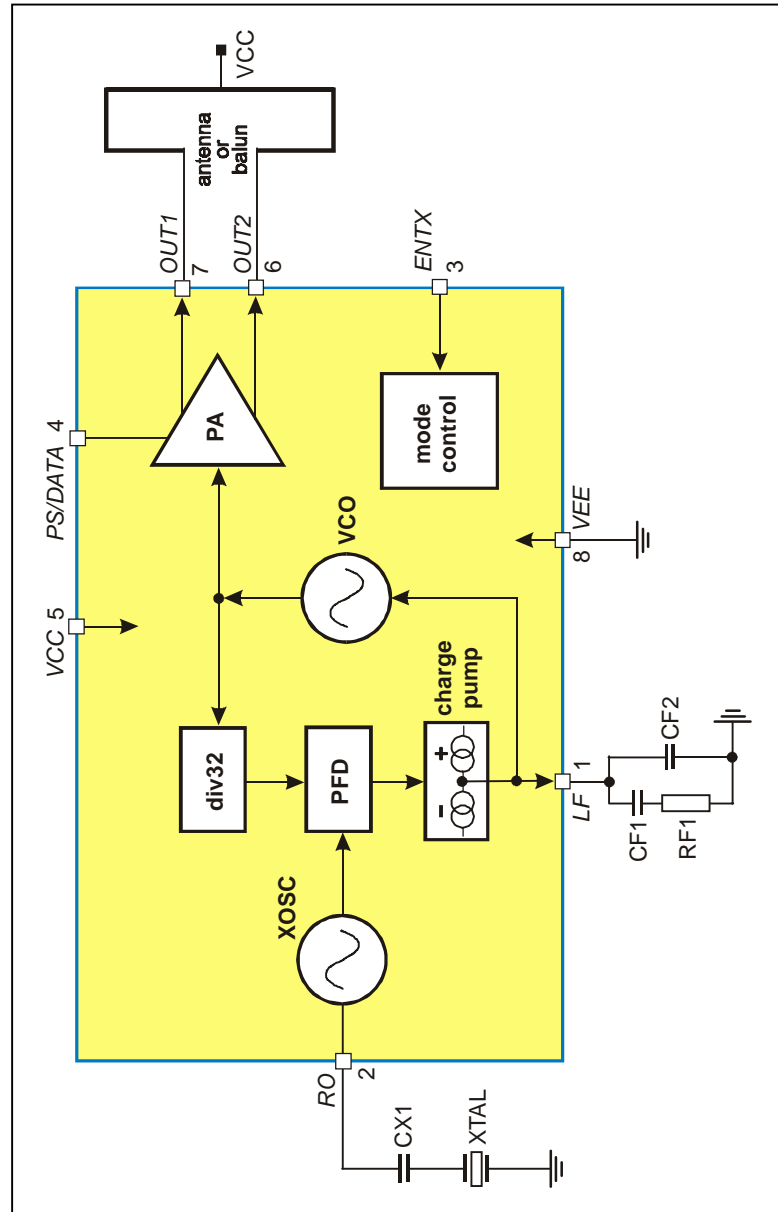
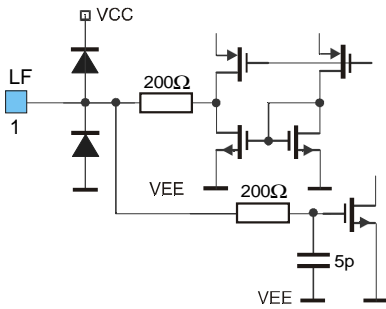
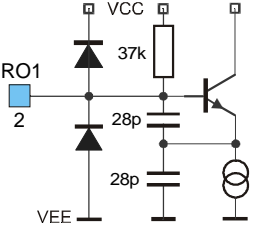
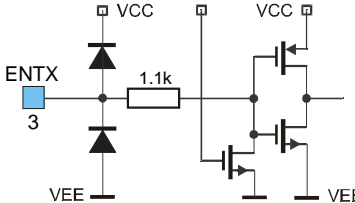
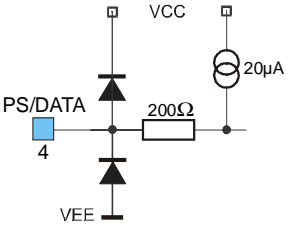
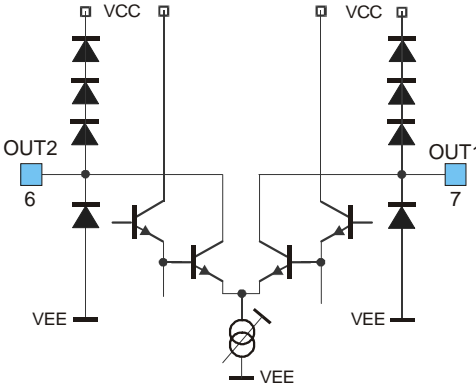


Fig. 1: TH71071 block diagram with external components

Pin Definition and Description

| Pin No. | Name | I/O Type | Functional Schematic | Description |
|---------|---------|------------|--|---|
| 1 | LF | analog I/O |  | connection to loop filter, charge pump output, VCO tuning input |
| 2 | RO | analog I/O |  | XOSC connection to XTAL, Colpitts type crystal oscillator |
| 3 | ENTX | input |  | mode control input, CMOS-compatible with internal pull-down |
| 4 | PS/DATA | analog I/O |  | power-select and ASK input, high-impedance comparator logic |
| 5 | VCC | supply | | positive power supply |
| 6 | OUT2 | output |  | differential power amplifier output, open collector |
| 7 | OUT1 | output | | differential power amplifier output, open collector |
| 8 | VEE | ground | | negative power supply |

Technical Data

Absolute Maximum Ratings

| Parameter | Symbol | Condition | Min | Max | Unit |
|-------------------------|-----------|--|------|--------------|------|
| Supply voltage | V_{cc} | | -0.3 | 7.0 | V |
| Input voltage | V_{in} | ENTX pin | -0.3 | $V_{CC}+0.3$ | V |
| Input current | I_{in} | ENTX pin | -1.0 | 1.0 | mA |
| Storage temperature | T_{STG} | | -40 | 150 | °C |
| Electrostatic discharge | V_{ESD} | human body model, MIL STD 833D method 3015.7 | -1.0 | +1.0 | kV |

Normal Operating Conditions

| Parameter | Symbol | Condition | Min | Max | Unit |
|-----------------------|-----------|--------------------------|------|-----|------|
| Supply voltage | V_{cc} | | 2.2 | 5.5 | V |
| Operating temperature | T_a | | -40 | 85 | °C |
| XOSC frequency | f_{ref} | set by the crystal | 9.69 | 14 | MHz |
| VCO frequency | f_c | $f_c = 32 \cdot f_{ref}$ | 310 | 450 | MHz |

DC Characteristics

all parameters under normal operating conditions, unless otherwise stated;
typical values at $T_a = 23\text{ °C}$ and $V_{cc} = 3\text{ V}$

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|--------------------|------------|------------------------------|--------------------|------|--------------------|---------------|
| Standby current | I_{SBY} | ENTX=0 | | 0.05 | 0.1 | μA |
| Operating current | I_{cc} | ENTX=1, $V_{PS}=1.1\text{V}$ | 7 | 9 | 10 | mA |
| Input HIGH voltage | V_{HIGH} | ENTX pin | $0.7 \cdot V_{cc}$ | | $V_{cc}+0.3$ | V |
| Input LOW voltage | V_{LOW} | ENTX pin | -0.3 | | $0.3 \cdot V_{cc}$ | V |
| Input current | I_{in} | ENTX=0 | -1 | | 1 | μA |
| Pull down current | I_{pd} | ENTX=1 | 2 | 8 | 15 | μA |

AC Characteristics

all parameters under normal operating conditions, unless otherwise stated;
typical values at $T_a = 23\text{ }^\circ\text{C}$ and $V_{cc} = 3\text{ V}$;
ENTX = 1, $V_{PS} = 1.1\text{ V}$, $f_c = 433.6\text{ MHz}$, test circuit shown in Fig. 2

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|-------------------------|-----------------|---------------------------------------|-----|-----------|-----|---------------|
| Output power | P_o | | | -1 | | dBm |
| FM deviation | Δf_{FM} | adjustable with varactor and V_{FM} | | ± 6 | | kHz |
| Modulation frequency FM | f_{mod} | | | 5 | | kHz |
| Data rate ASK | R_{ASK} | NRZ | | 40 | | kbit/s |
| Reference spurs | P_{ref} | @ $f_c \pm f_{ref}$ | | -44 | | dBm |
| Harmonic content | P_{harm} | @ $2f_c, 3f_c, 4f_c$ | | -40 | | dBm |
| Spurious output signal | P_{off} | $V_{PS} \leq 0.1\text{ V}$ | | -60 | | dBm |
| Phase noise | PN | @ $f_c \pm 500\text{ kHz}$ | | -87 | | dBc/Hz |
| VCO gain | K_{VCO} | | | 200 | | MHz/V |
| Charge pump current | I_{CP} | | | ± 260 | | μA |
| Start-up time | t_{on} | from "all OFF" to any other mode | | | 0.9 | ms |

Output Power Selection

typical values at $T_a = 23\text{ }^\circ\text{C}$ and $V_{cc} = 3\text{ V}$;
ENTX = 1, $f_c = 433.6\text{ MHz}$, test circuit shown in Fig. 2

| R1 / k Ω | 0 | 7.5 | 11 | 15 | 24 | 43 |
|------------------|------------|------------|------------|------------|------------|------------|
| R2 / k Ω | ∞ | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 |
| V_{PS} / V | ≥ 2 | 1.1 | 0.9 | 0.7 | 0.5 | 0.3 |
| I_{cc} / mA | 11.5 | 8.6 | 7.3 | 6.2 | 5.3 | 4.8 |
| P_o / dBm | 2 | -1 | -4 | -7 | -10 | -12 |
| P_{harm} / dBm | ≤ -40 | ≤ -40 | ≤ -40 | ≤ -45 | ≤ -45 | ≤ -50 |

If the transmitter is operated at any supply voltage V_{cc} ,
the values for R_1 and R_2 can be calculated as follows:

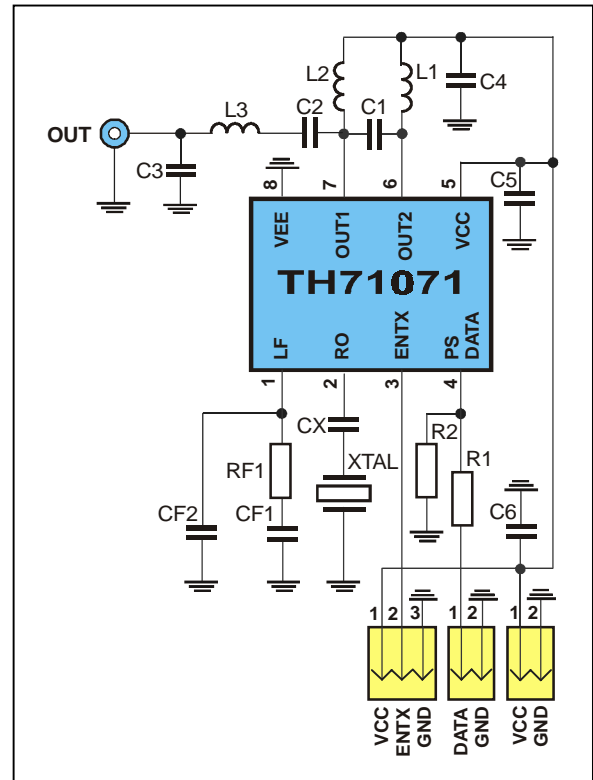
$$R_1 = R_2 \cdot \left(\frac{V_{cc}}{V_{PS}} - 1 \right)$$

Crystal Parameter

| Parameter | Symbol | Condition | Min | Max | Unit |
|----------------------|---------------|----------------------|------|-----|----------|
| Crystal frequency | $f_{crystal}$ | fundamental mode, AT | 9.69 | 14 | MHz |
| Load capacitance | C_{load} | | 10 | 15 | pF |
| Static capacitance | C_0 | | | 7 | pF |
| Resonance resistance | R_m | | | 60 | Ω |
| Spurious response | a_{spur} | | | -10 | dB |

Test Circuit

Fig. 2: Test circuit for ASK with 50Ω matching network



Test circuit component list to Fig. 2

| Part | Size | Value | Tolerance | Description |
|------|--------|----------------------------------|------------------------------------|---|
| CF1 | 0603 | 10 nF | ±10% | loop filter capacitor |
| CF2 | 0603 | 56 pF | ±10% | loop filter capacitor |
| CX | 0603 | 68 pF | ±10% | XOSC capacitor |
| C1 | 0603 | 2.7 pF | ±5% | impedance matching capacitor |
| C2 | 0805 | 100 pF | ±5% | impedance matching capacitor |
| C3 | 0805 | 3.9 pF | ±5% | impedance matching capacitor |
| C4 | 0603 | 330 pF | ±10% | blocking capacitor |
| C5 | 0603 | 330 pF | ±10% | blocking capacitor |
| C6 | 0805 | 33 nF | ±10% | blocking capacitor |
| L1 | 0603 | 22 nH | ±5% | impedance matching inductor |
| L2 | 0603 | 27 nH | ±5% | impedance matching inductor |
| L3 | 0603 | 33 nH | ±5% | impedance matching inductor |
| RF1 | 0603 | 1.5 kΩ | ±10% | loop filter resistor |
| R1 | 0603 | See output power selection table | ±10% | ASK power-select resistor, not requirement at CW mode |
| R2 | 0603 | See output power selection table | ±10% | ASK or CW mode power-select resistor |
| XTAL | HC49/S | 13.55 MHz fundamental wave | ±30ppm calibration ±30ppm temp. | crystal, C _{load} = 12 pF to 15 pF, C _{0, max} = 7 pF, R _{m, max} = 60 Ω |

Spectrum Plots

All plots depict TH71071's typical performance at $V_{CC} = 3.0\text{ V}$ and $T_a = 23\text{ }^\circ\text{C}$, derived with the test circuit shown in Fig. 2.

Fig. 3: RF output signal and spurious emissions, CW mode

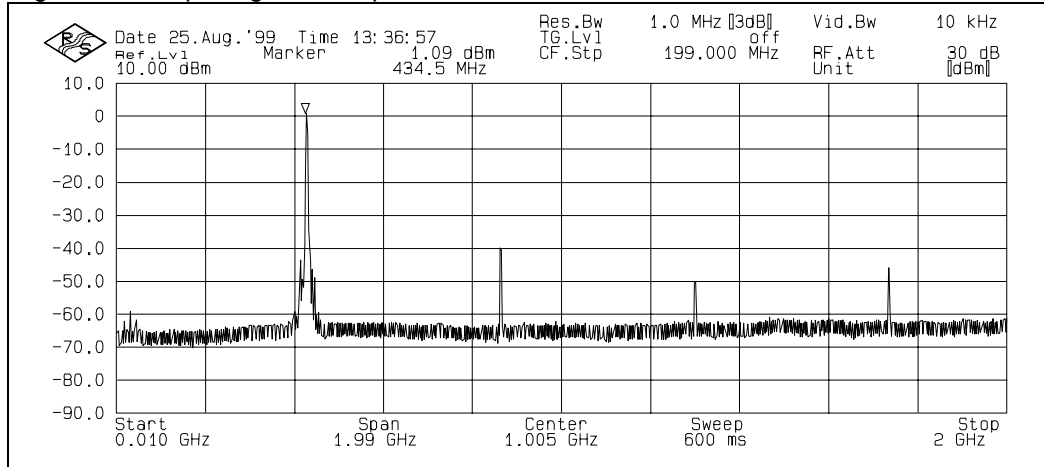


Fig. 4: Single-sideband phase noise at 500 kHz offset, CW mode

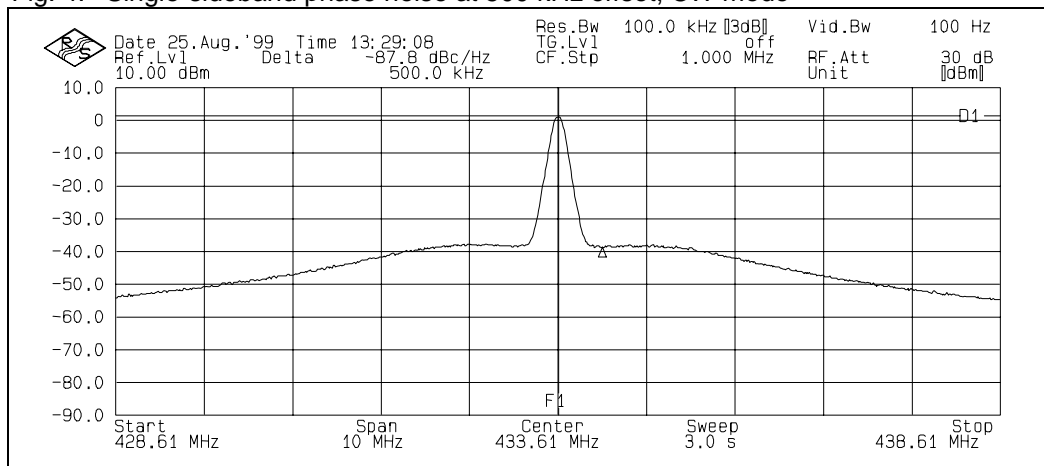
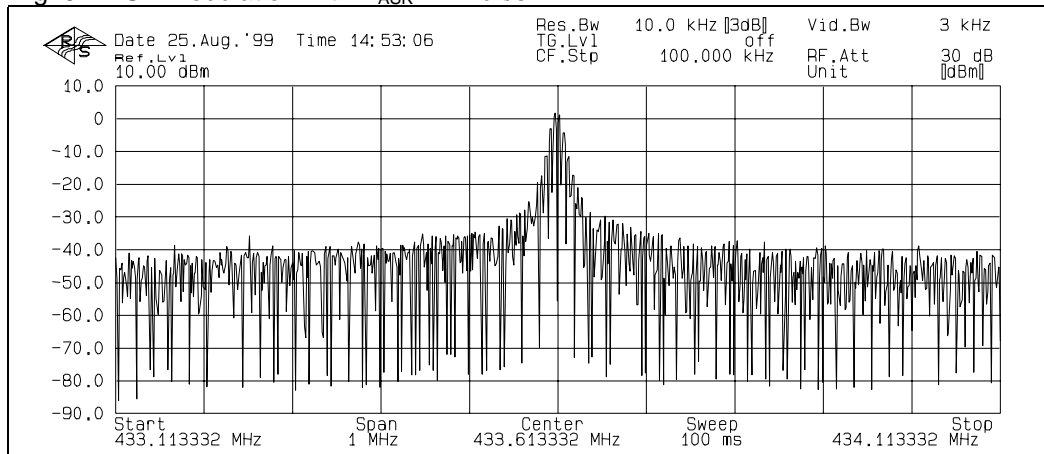


Fig. 5: ASK modulation with $R_{ASK} = 4\text{ kbit/s NRZ}$



Package Information

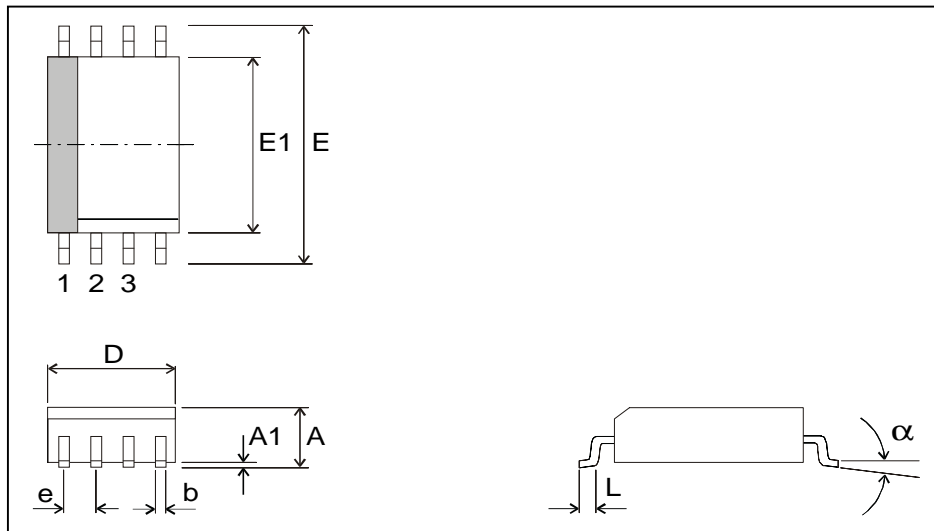


Fig. 6: SOIC8 (Small Outline Package)

| all Dimension in mm, coplanarity < 0.1mm | | | | | | | | | |
|---|-------|-------|--------|-------|--------|------|-------|-------|----|
| | D | E1 | E | A | A1 | e | b | L | α |
| min | 4.80 | 3.81 | 5.80 | 1.32 | 0.10 | 1.27 | 0.36 | 0.41 | 0° |
| max | 4.98 | 3.99 | 6.20 | 1.72 | 0.25 | | 0.46 | 1.27 | 8° |
| all Dimension in inch, coplanarity < 0.004" | | | | | | | | | |
| min | 0.189 | 0.150 | 0.2284 | 0.060 | 0.0040 | 0.05 | 0.014 | 0.016 | 0° |
| max | 0.196 | 0.157 | 0.2440 | 0.068 | 0.0098 | | 0.018 | 0.050 | 8° |

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