

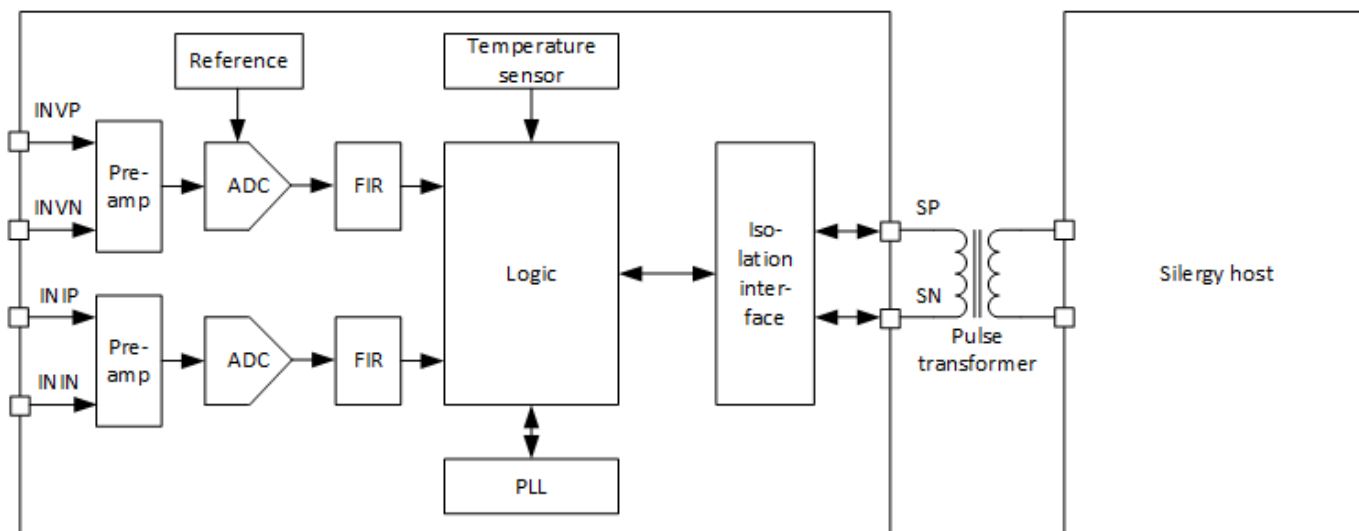
### General Description

The MAX71071 are dual-channel isolated analog-to-digital converters (ADCs) for use with a compatible host. The device provides current and voltage measurements to the host while the host provides control, command, and power to the MAX71071. A pulse transformer provides the isolated data, clock, and power path between the device and host, eliminating the need for additional isolation components in the measurement subsystem. These metrology ADCs operate over the industrial temperature range and come in a 10-pin  $\mu$ SOP package.

### Benefits and Features

- Accurately Measure Voltage and Current
  - Dual 24-Bit ADC
  - 0.1% Accuracy Over 2000:1 Dynamic Range
  - Exceeds IEC 62053/ANSI C12.20 Standards
  - On-Chip Temperature Sensor Enables Localized Digital Temperature Compensation
- Galvanic Isolation Through Pulse Transformer provides Power, Bidirectional Data, and Timing Reference
  - 1.4mA Typical Consumption
  - On-Chip PLL and Power Monitoring

### Block Diagram



Absolute Maximum Ratings

(All voltages with respect to V<sub>SSA</sub>.)

Supplies and Ground Pins

|                       |                |
|-----------------------|----------------|
| V <sub>CC</sub> ..... | -0.5V to +3.6V |
| V <sub>SS</sub> ..... | -0.1V to +0.1V |

Analog Input Pins

|                        |                                                   |
|------------------------|---------------------------------------------------|
| INP, INN, SP, SN ..... | -10mA to +10mA, -0.5V to (V <sub>CC</sub> + 0.5V) |
|------------------------|---------------------------------------------------|

Digital Pins

|                                                   |                                |
|---------------------------------------------------|--------------------------------|
| TEST.....                                         | -10mA to +10mA, -0.5V to +3.6V |
| Operating Junction Temperature (peak, 100ms)..... | +140°C                         |
| Operating Junction Temperature (continuous) ..... | +125°C                         |
| Storage Temperature.....                          | -45°C to +165°C                |
| Solder Temperature (10s duration) .....           | +250°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.

Package Thermal Characteristics (Note 1)

μSOP

Junction-to-Ambient Thermal Resistance (θ<sub>JA</sub>)

|                         |            |
|-------------------------|------------|
| Multilayer Board .....  | 113.10°C/W |
| Single-Layer Board..... | 180°C/W    |

Junction-to-Case Thermal Resistance (θ<sub>JC</sub>).....42°C/W

**Note 1:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board.

Recommended External Components

| NAME           | FROM            | TO              | FUNCTION                                                  | VALUE | UNITS |
|----------------|-----------------|-----------------|-----------------------------------------------------------|-------|-------|
| C1             | V <sub>CC</sub> | V <sub>SS</sub> | Bypass capacitor for supply                               | 1.0   | μF    |
| R1, R2, R3, R4 | Sensor          | ND              | To establish proper bias for INVN/INVP and ININ/INIP pins | 1.0   | kΩ    |

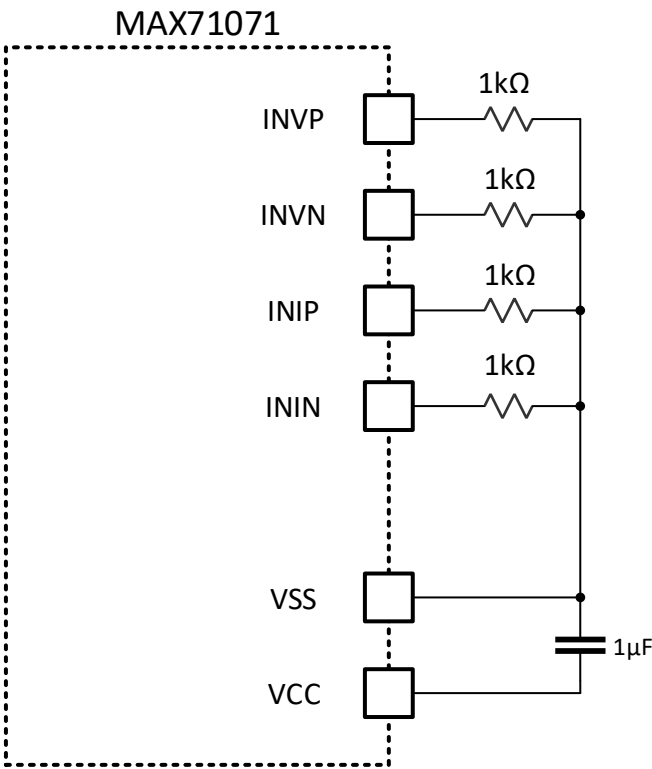


Figure 1. Recommended External Components Circuit

## Recommended Operating Conditions

| PARAMETER                      | CONDITIONS | MIN | TYP | MAX | UNITS |
|--------------------------------|------------|-----|-----|-----|-------|
| V <sub>CC</sub> Supply Voltage |            | 2.5 |     | 3.6 | V     |
| Operating Temperature Range    |            | -40 |     | +85 | °C    |

## Performance Specifications

(Limits are production tested at T<sub>A</sub> = +25°C. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization.)

| PARAMETER                                                                                                                                                      | CONDITIONS                                                                                                                      | MIN                                        | TYP   | MAX    | UNITS                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|-------|--------|----------------------|
| SUPPLY CURRENT                                                                                                                                                 |                                                                                                                                 |                                            |       |        |                      |
| V <sub>CC</sub> Current, Normal Operation                                                                                                                      | V <sub>CC</sub> = 3.3V, voltage ADC preamp bypassed                                                                             | 1.2                                        | 1.6   |        | mA                   |
| V <sub>REF</sub>                                                                                                                                               |                                                                                                                                 |                                            |       |        |                      |
| V <sub>REF</sub> (22), V <sub>REF</sub> Output Voltage                                                                                                         | T <sub>A</sub> = +22°C                                                                                                          | 1.1925                                     | 1.195 | 1.1975 | V                    |
| V <sub>REF</sub> Power Supply Sensitivity<br>ΔV <sub>REF</sub> /ΔV <sub>CC</sub>                                                                               |                                                                                                                                 | -2.4                                       |       | +2.4   | mV/V                 |
| V <sub>NOM</sub> Definition                                                                                                                                    | V <sub>NOM</sub> (T) = V <sub>REF</sub> (22) + (T - 22) x TC <sub>1</sub><br>+ (T - 22) <sup>2</sup> x TC <sub>2</sub> (Note 2) |                                            |       |        | V                    |
| TC <sub>1</sub> and TC <sub>2</sub> Equations                                                                                                                  |                                                                                                                                 | TC <sub>1</sub> = 316 – TRIMT*5.94         |       |        | μV/C                 |
|                                                                                                                                                                |                                                                                                                                 | TC <sub>2</sub> = -0.582 + TRIMT*(0.00132) |       |        | μV/(C <sup>2</sup> ) |
| V <sub>REF</sub> (T) Deviation from<br>V <sub>NOM</sub> (T)<br>[(V <sub>REF</sub> (T) - V <sub>NOM</sub> (T))/V <sub>NOM</sub> (T)]<br>x [10 <sup>6</sup> /62] | (Note 3)                                                                                                                        | -93                                        | 0     | +93    | ppm/°C               |
| V <sub>CC</sub> VOLTAGE MONITOR                                                                                                                                |                                                                                                                                 |                                            |       |        |                      |
| BNOM: Nominal Value, T <sub>A</sub> =<br>+22°C                                                                                                                 | V <sub>CC</sub> = 3.0V                                                                                                          | 120                                        |       |        | LSB                  |
| V <sub>CC</sub> Voltage                                                                                                                                        | V <sub>CC</sub> = 3.0 + (BSENSE - 120) x 0.0244 (Note 4)                                                                        |                                            |       |        | V                    |
| Measurement Error                                                                                                                                              |                                                                                                                                 | -150                                       |       | +150   | mV                   |
| TEMPERATURE MONITOR                                                                                                                                            |                                                                                                                                 |                                            |       |        |                      |
| T <sub>NOM</sub> : Nominal Value, T <sub>A</sub> =<br>+22°C                                                                                                    |                                                                                                                                 | 945                                        |       |        | LSB                  |
| Temperature Error                                                                                                                                              | T <sub>A</sub> = -40°C, -10°C, +55°C, +85°C (Note 3)                                                                            | 0                                          |       |        | °C                   |
| TETIME: Duration of<br>Temperature Measurement                                                                                                                 | V <sub>CC</sub> = 3.0V                                                                                                          | 14                                         | 30    |        | ms                   |
| POWER PULSE                                                                                                                                                    |                                                                                                                                 |                                            |       |        |                      |
| Power Pulse Frequency                                                                                                                                          |                                                                                                                                 | 1.638                                      |       |        | MHz                  |
| PULSE I/O                                                                                                                                                      |                                                                                                                                 |                                            |       |        |                      |
| SP and SN Outputs<br>V <sub>OH</sub> (ONE Pulse)                                                                                                               | I <sub>OH</sub> = 1mA                                                                                                           | V <sub>CC</sub> -<br>0.28                  |       |        | V                    |
| SN and SN Outputs<br>V <sub>OL</sub> (ONE Pulse)                                                                                                               | I <sub>OL</sub> = 1mA                                                                                                           |                                            |       | 0.287  | V                    |

## Performance Specifications (continued)

(Limits are production tested at  $T_A = +25^\circ\text{C}$ . Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization.)

| PARAMETER                                                   | CONDITIONS                                                 | MIN        | TYP | MAX      | UNITS            |
|-------------------------------------------------------------|------------------------------------------------------------|------------|-----|----------|------------------|
| PREAMP GAIN                                                 |                                                            |            |     |          |                  |
| Gain = 14x                                                  |                                                            | 14 - 2%    | 14  | 14 + 2%  | V/V              |
| Gain = 9x                                                   |                                                            | 9 - 2%     | 9   | 9 + 2%   | V/V              |
| Gain = 4x                                                   |                                                            | 4 - 2%     | 4   | 4 + 2%   | V/V              |
| Phase Shift                                                 |                                                            | 1          |     |          | m°               |
| Phase Shift Variation vs. Supply                            | (Note 3)                                                   | -10        |     | +10      | m°/V             |
| Phase Shift Variation vs. Temperature                       | (Note 3)                                                   | -0.1       |     | +0.1     | m°/°C            |
| Input Current                                               | Preamp gain = 4x, 9x, 14x                                  | 7.5        | 13  | 24       | μA               |
| PREAMP OFFSET                                               |                                                            |            |     |          |                  |
| Gain = 14x                                                  | (Note 7)                                                   | -1.7       |     | +1.7     | mV               |
| Gain = 9x                                                   | (Note 7)                                                   | -1.9       |     | +1.9     | mV               |
| Gain = 4x                                                   | (Note 7)                                                   | -2.25      |     | +2.25    | mV               |
| ADC CONVERTER                                               |                                                            |            |     |          |                  |
| Usable Input Range (I <sub>NP</sub> - I <sub>NN</sub> )     |                                                            | -250/gain  |     | 250/gain | mV <sub>PK</sub> |
| THD (FIRST 10 HARMONICS)                                    |                                                            |            |     |          |                  |
| Preamp Gain = 1x                                            | V <sub>IN</sub> = 65Hz, 64kpts FFT, Blackman-Harris window | 85         |     |          | dB               |
| 250mV <sub>PK</sub> /Preamp Gain, Preamp Gain = 4x, 9x, 14x | V <sub>IN</sub> = 65Hz, 64kpts FFT, Blackman-Harris window | 85         |     |          | dB               |
| 20mV <sub>PK</sub> /Preamp Gain, Preamp Gain = 4x, 9x, 14x  | V <sub>IN</sub> = 65Hz, 64kpts FFT, Blackman-Harris window | 85         |     |          | dB               |
| Input Impedance                                             | Preamp bypassed (Note 6)                                   | 20         |     | 40       | kΩ               |
|                                                             | Preamp = 4x                                                | 6.5        | 12  | 18       |                  |
|                                                             | Preamp = 9x                                                | 3.5        | 6.3 | 9.1      |                  |
|                                                             | Preamp = 14x                                               | 2.3        | 4.3 | 6.3      |                  |
| LSB SIZE                                                    |                                                            |            |     |          |                  |
| Preamp Gain = 14x                                           | FIR length = 100                                           | 22.9       |     |          | nV/LSB           |
| Preamp Gain = 9x                                            | FIR length = 100                                           | 35.5       |     |          | nV/LSB           |
| Preamp Gain = 4x                                            | FIR length = 100                                           | 79.9       |     |          | nV/LSB           |
|                                                             |                                                            |            |     |          |                  |
| Digital Full Scale<br>L = FIR Length                        | FIR length = 100                                           | ±1,000,000 |     |          | LSB              |
| ADC Gain Error vs. % Power Supply Variation                 | V <sub>IN</sub> = 250mV <sub>PK</sub> , 55Hz               |            |     | 120      | ppm/%            |
| Current Channel Gain Variation                              | V <sub>IN</sub> = 250mV <sub>PK</sub> , 55Hz (Note 3)      |            |     | 90       | ppm/%            |
| Input Offset, Preamp Bypassed                               |                                                            |            |     | -4       | mV               |

**Note 2:** This relationship describes the nominal behavior of  $V_{REF}$  at different temperatures.

**Note 3:** Guaranteed by design, not production tested.

**Note 4:** This is a definition, and it is not a measured quantity.

**Note 5:** N/A

**Note 6:** For Preamp gain = 4x, 9x, and 14x, an internal amplifier with both input and feedback resistors is used in front of the ADC. External source impedance can degrade the gain significantly by adding resistance to the input resistor. For bypassed preamp (gain = 1), the ADC is directly connected to the input, and only the interaction of the internal impedance with the source impedance will decrease the signal amplitude, with no change in gain.

**Note 7:** This is the offset of the preamp as well as of the ADC, meaning this is the total offset seen at the ADC input.

## Pin Configuration

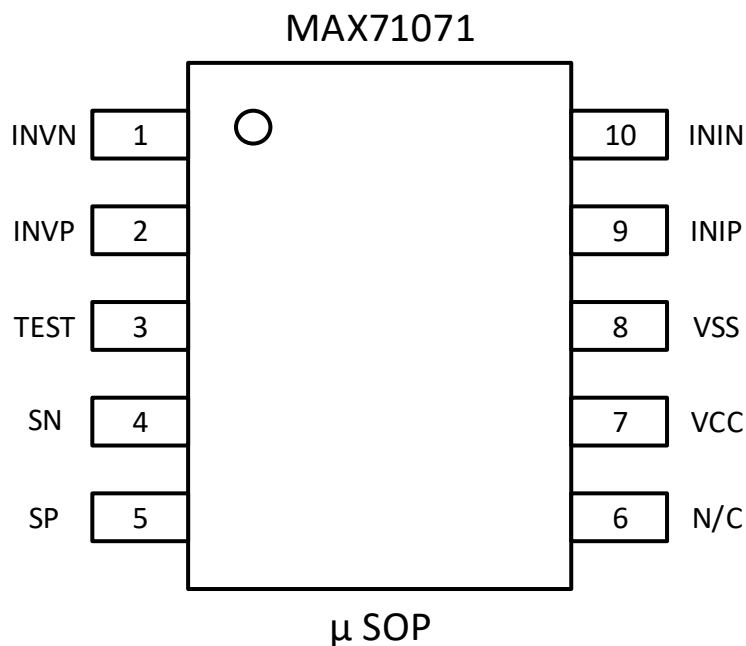


Figure 2. Pin Diagram

## Pin Description

| PIN | NAME            | FUNCTION                                                |
|-----|-----------------|---------------------------------------------------------|
| 1   | INVN            | Voltage Channel Negative Input                          |
| 2   | INVP            | Voltage Channel Positive Input                          |
| 3   | TEST            | Test Mode Enable. Must be grounded in normal operation. |
| 4   | SN              | Transformer Negative                                    |
| 5   | SP              | Transformer Positive                                    |
| 6   | N.C.            | Not Connected                                           |
| 7   | V <sub>CC</sub> | Power Bypass. Connect 1μF capacitor to ground.          |
| 8   | V <sub>SS</sub> | Ground.                                                 |
| 9   | INIP            | Current Channel Positive Input                          |
| 10  | ININ            | Current Channel Negative Input                          |

## Detailed Description

The MAX71071 are dual-channel isolated metrology analog-to-digital converters (ADCs) that are compatible with MAX71xxx MAX78615 hosts. The device digitizes a current signal from a shunt type current sensor and/or a voltage signal from a resistor-divider. The two input channels of the MAX71071 are identical except that the voltage channel contains an option to bypass the preamp.

The device continuously sends ADC data to the host. The host can request the device to return certain ancillary data such as the temperature monitor output. The MAX71071 communicate with the host through a pulse transformer to provide isolation from the high-voltage power domain.

The MAX71071 include a rectifier, two staring preamp/ADC channels, bandgap, temperature monitor, PLL, and BIAS block.

### Rectifier

The active rectifier in the device rectifies the power pulses received from the host through the pulse transformer to create the  $V_{CC}$  voltage. The block also has the drivers that drive the data bits out of the MAX71071 and through the transformer.

### ISO Interface

The isolated interface block receives the incoming data from the host and transmits data back to the host through the pulse transformer.

### Preamp

The preamp is a low-noise differential amplifier. The INP and INN pins are the differential inputs to the preamp. It has three gain settings (4x, 9x, and 14x) The gain is controlled by the host, using two preamp gain control bits:

| Bit 1 | Bit 0 | Gain |
|-------|-------|------|
| 0     | 0     | 4    |
| 0     | 1     | 9    |
| 1     | 0     | 14   |
| 1     | 1     | N/A  |

The inputs are  $V_{SS}$  referenced, and the output of the preamp connects directly to the ADC.

### Bandgap

The device includes an on-chip precision bandgap voltage reference that incorporates autozero techniques as well as production trims to minimize errors caused by component mismatch and drift. The result is a voltage output with a predictable temperature coefficient that is compensated in firmware by the host.

### Temperature Monitor

The temperature monitor block performs a temperature and a supply measurement whenever the MAX71071 receives an instruction from the host requesting for STEMP or BSENSE. This request causes the MAX71071 to return STEMP or BSENSE from the previous measurement and to initiate a new measurement for both. The temperature can be determined from the STEMP reading as follows:

$$T = 22.85 + STEMP \cdot 0.344 + (STEMP^2) \cdot 1.95 \cdot 10^{-5}$$

### Temperature Compensation

The host can implement temperature compensation for each connected MAX71071 based on the temperature reported by each MAX71071 and its fuse settings. Linear (TC1) and quadratic (TC2) coefficients can be obtained as follows:

$$TC_1 = 316 - TRIMT \cdot 5.94 \mu V/C$$

$$TC_2 = -0.582 + TRIMT \cdot (0.00132) \mu V/(C^2)$$

See section *Application Information* on how to read TRIMT.

### PLL

The PLL locks to the incoming power pulses to create reference clocks for the ADC and communications interface to the host. The PLL is typically stable after power pulses have been applied for 5ms.

### Pulse I/O

The pulse I/O block in the MAX71071 receives the incoming data from the MAX71xxx host and transmits the data back to the host. The integrated output is applied to the input of a comparator, and the comparator output is captured by a flip-flop at the end of the integration time.

### ADC

Two proven Teridian delta-sigma ADCs digitize the voltage and current-sense voltages.

## Application Information

### Trim Fuse Information

To establish the temperature coefficient for the purpose of temperature compensation, the host IC reads the *TRIMT* value, using read code 0b001 and *TMUX*[2:0] setting = 0b00x. *TRIMT* is an 8-bit unsigned integer.

Device temperature, supply voltage, and other parameters can be read using the settings in the table below.

| <i>RD_CODE2</i> | <i>RD_CODE1</i> | <i>RD_CODE0</i> | <i>TMUX2</i> | <i>TMUX1</i> | <i>TMUX0</i> | Function                           |
|-----------------|-----------------|-----------------|--------------|--------------|--------------|------------------------------------|
| 0               | 0               | 0               | X            | X            | X            | ZERO command                       |
| 0               | 0               | 1               | 0            | 0            | X            | Read TRIMBGA, TRIMT                |
| 0               | 0               | 1               | 0            | 1            | X            | Read BG_STEP, IBIAS, TEMP_MON      |
| 0               | 0               | 1               | 1            | 0            | X            | Read TRIMBGB, TRIMBGD              |
| 0               | 0               | 1               | 1            | 1            | X            | Read Device ID, TRIMBGC            |
| 0               | 1               | 0               | 0            | 0            | X            | Read STEMP                         |
| 0               | 1               | 0               | 0            | 1            | X            | Read VSENSE                        |
| 0               | 1               | 0               | 1            | 0            | X            | Read VERSION                       |
| 0               | 1               | 0               | 1            | 1            | X            | MAX71071 sends 0xD9BA test pattern |
| 0               | 1               | 1               | 0            | 1            | 1            | RESET command                      |
| 1               | 1               | 0               | X            | X            | X            | Illegal code                       |

## Functional Diagram

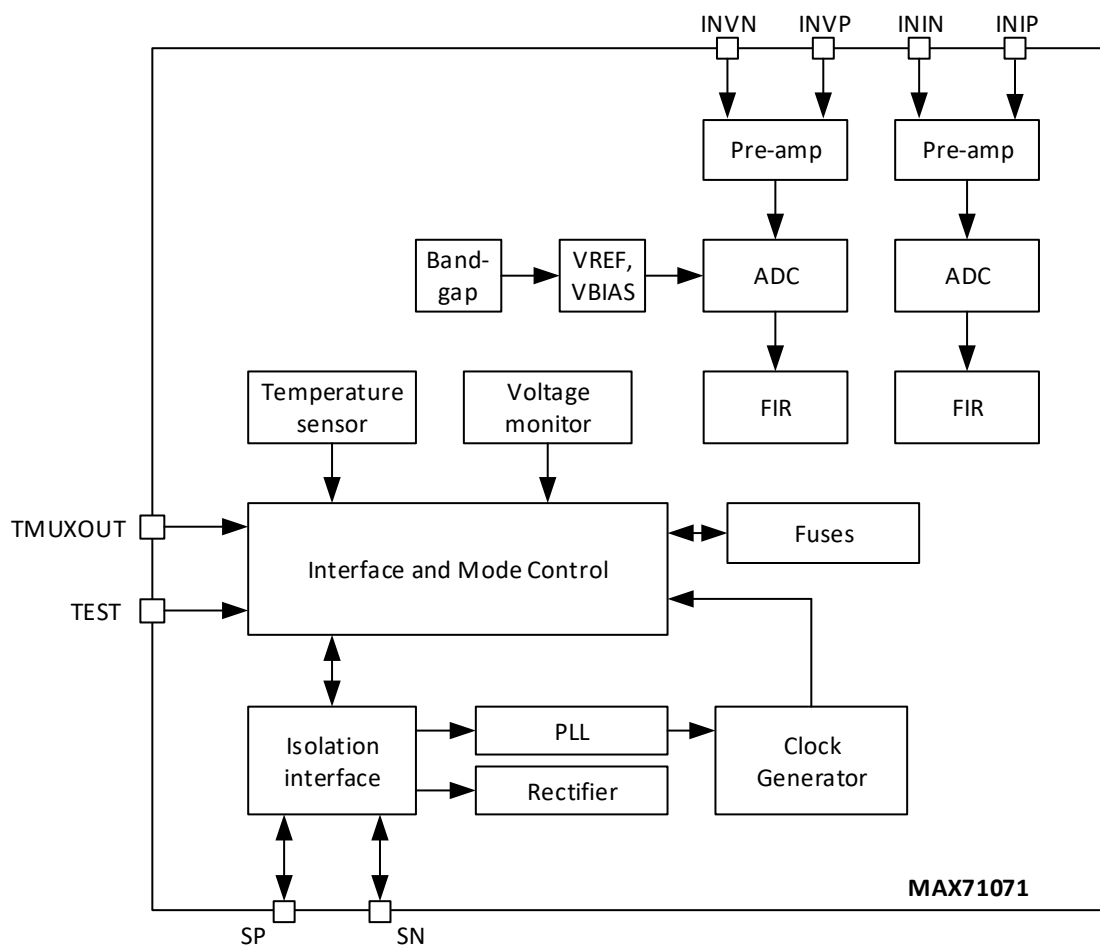


Figure3. Functional Block Diagram

## Ordering Information

| PART       | TEMP RANGE     | PIN-PACKAGE  |
|------------|----------------|--------------|
| MAX71071+  | -40°C to +85°C | 10 $\mu$ SOP |
| MAX71071+T | -40°C to +85°C | 10 $\mu$ SOP |

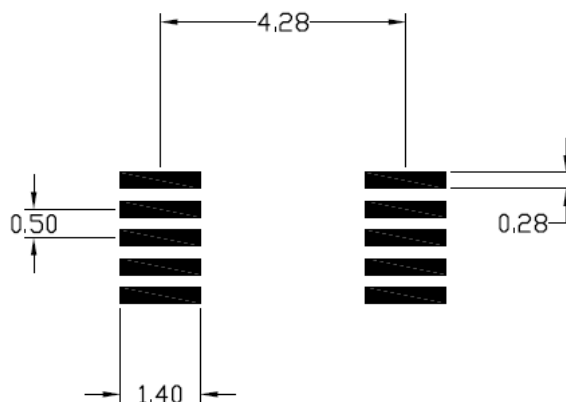
+Denotes a lead(Pb)-free/RoHS-compliant package.

T = Tape and reel.

\*Future product—contact factory for availability.

## Package Information

Package outline information is appended to this document. Land patterns (footprints) are shown below.



### NOTES:

1. ALL DIMENSIONS IN MM.
2. LAND PATTERN COMPLIES TO: IPC7351A.
3. TOLERANCE:  $\pm 0.02$  MM.

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION                                                                                                              | PAGES CHANGED |
|-----------------|---------------|--------------------------------------------------------------------------------------------------------------------------|---------------|
| 0               | 3/2014        | Initial release                                                                                                          | —             |
| 1               | 1/2015        | Updated the <i>Benefits and Features</i> section                                                                         | 1             |
| 2               | 4/2016        | Rebranding only                                                                                                          | All           |
| 3               | 6/2019        | Added data for pre-amp offset                                                                                            | 4             |
|                 |               | Added compensated tolerance for VREF over temperature                                                                    | 4             |
|                 |               | Added notes 6 and 7                                                                                                      | 5             |
|                 |               | Added typical time for PLL to stabilize                                                                                  | 6             |
|                 |               | Added formula for temperature reading and compensation                                                                   | 6             |
|                 |               | Added legal disclaimer                                                                                                   | 10            |
|                 |               | Removed references to MAX71071H                                                                                          | all           |
| 4               | 4/2020        | Corrected Figure 1 (removed reference to MAX71071H)                                                                      | 2             |
|                 |               | Added TC <sub>1</sub> and TC <sub>2</sub> equations in electrical specifications, corrected voltage levels for Pulse I/O | 3             |
|                 |               | Added table with trim fuse information                                                                                   | 7             |
|                 |               | Added land pattern (PCB footprint)                                                                                       | 9             |
|                 |               | Corrected package drawing                                                                                                | 12            |

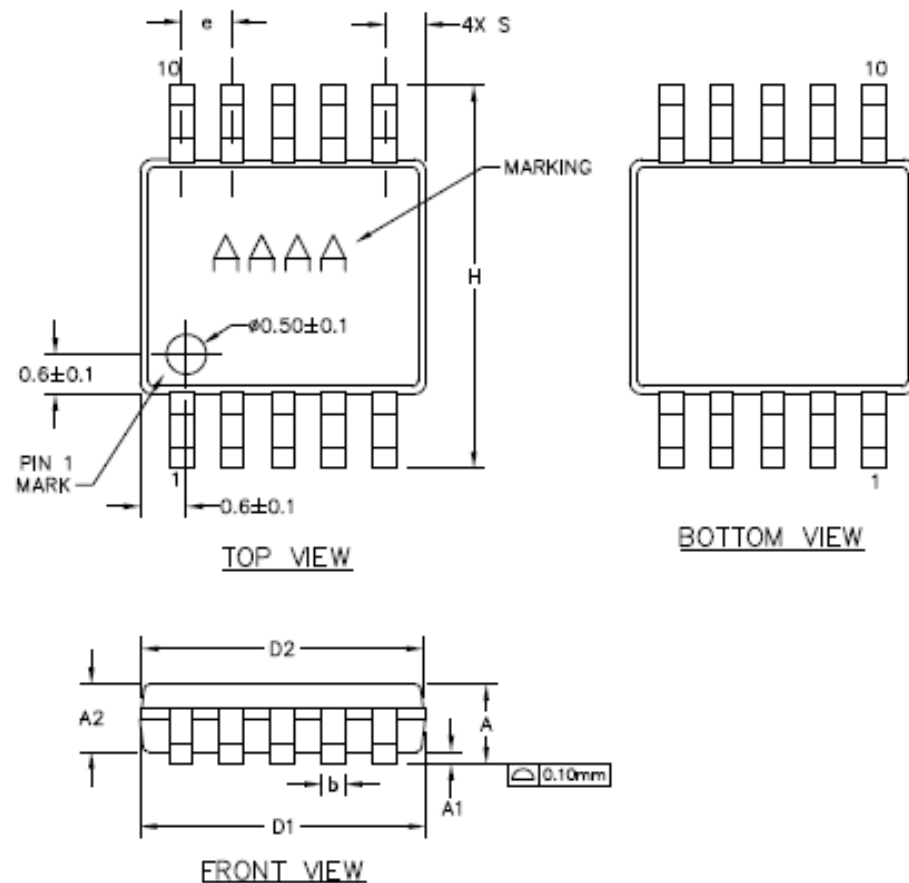
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## NOTES:

1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED  $0.15\text{mm}$  ( $.006''$ ).
3. CONTROLLING DIMENSION: MILLIMETERS.
4. COMPLIES TO JEDEC MO-187, LATEST REVISION, VARIATION BA.
5. MARKING SHOWN IS FOR PKG. ORIENTATION ONLY.
6. ALL DIMENSIONS APPLY TO BOTH LEADED ( $\rightarrow$ ) AND PkFREE ( $\leftarrow$ ) PKG. CODES.

—DRAWING NOT TO SCALE—

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

Pkg Codes: U10-2; U10CN-1; U10+5;  
U10M-5; U10-2C; U10-6C

