ABRIDGED DATA SHEET

EVALUATION KIT AVAILABLE

MAX35101 Time-to-Digital Converter with Analog Front-End

General Description

The MAX35101 is a time-to-digital converter with built-in amplifier and comparator targeted as a complete analog front-end (AFE) solution for the ultrasonic heat meter and flow meter markets.

With a time measurement accuracy of 20ps and automatic differential time-of-flight (TOF) measurement, this device makes for simplified computation of liquid flow. Early edge detection ensures measurements are made with consistent wave patterns to greatly improve accuracy and eliminate erroneous measurements.

Multihit capability with stop-enable windowing allows the device to be fine-tuned for the application. Internal analog switches, an autozero amplifier/comparator, real-time clock (RTC), and programmable receiver sensitivity provide the analog interface and control for a minimal electrical bill of material solution. The RTC provides an event timing mode that is configurable and runs cyclic algorithms to minimize microprocessor interactivity and increase battery life.

Built-in arithmetic logic unit provides TOF difference measurements. A programmable receiver hit accumulator can be utilized to minimize the host microprocessor access and thus minimize current consumption.

For temperature measurement, the MAX35101 supports up to four (4) 2-wire PT1000/500 platinum resistive temperature detectors (RTD).

A simple 4-wire SPI interface allows any microcontroller to effectively configure the device for its intended measurement.

On-board 8KB user flash allows the MAX35101 to be nonvolatile-configurable and provide nonvolatile energy use data to be logged. Configuration can be recalled anytime with a SPI command.

Applications

- Ultrasonic Heat Meters
- Ultrasonic Water Meters
- Ultrasonic Gas Meters

Features and Benefits

- Early Edge Detect Ultrasonic Time-of-Flight
  - Time-to-Digital Accuracy Down to 20ps
  - Measurement Range Up to 8ms
  - Multihit Capability
  - Early Edge Detect to Provide Advanced Accuracy
  - Programmable TOF Hit Accumulator
  - Two Channels: Single-Stop Channel
  - Stop-Enable Windowing with Edge Trigger Select
  - Built-In Pulse Launcher with Programmable Frequency
  - Autozero Receiver Comparator
  - Programmable Acoustic Recovery Sensitivity
  - Automatic Two-Pulse Algorithm for Differential TOF Measurement
- Temperature Measurement
  - Up to Four (4) 2-Wire Sensors
  - PT1000 and PT500 RTD Support
- Event Timing Mode
  - Allows Automatic Measurement Cycles
  - Minimizes Microcontroller Interactivity to Reduce Power Consumption
- Tamper Detection
  - Single Input Pin Detects Tamper and Generates Processor Interrupt
- Power Consumption
  - 2.3V to 3.6V Single-Supply Operation
- General
  - 8KB of Nonvolatile Flash Memory for Data Logging
  - Built-in Real Time Clock for Time of Day Monitoring
  - 4MHz Oscillator Can Be a Ceramic Device to Lower System Cost
  - Small, 5mm x 5mm, 32-Pin TQFP Package
  - 4-Wire SPI Interface
  - -40°C to +85°C Operation

***Ordering Information* appears at end of data sheet.**

For related parts and recommended products to use with this part, refer to www.maximintegrated.com/MAX35101.related.

19-6830; Rev 0; 2/14

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Absolute Maximum Ratings

(Voltages relative to ground.)
Voltage Range on V_{CC} Pins.....-0.5V to +4.0V
Voltage Range on All Other Pins
(not to exceed 4.0V).....-0.5V to (V_{CC} + 0.5V)
Continuous Power Dissipation (T_A = +70°C)
TQFP (derate 27.80mW/ºC above +70°C).....2222.20mW

Operating Temperature Range..... -40°C to +85°C
Junction Temperature.....+150°C
Storage Temperature Range..... -55°C to +125°C
Lead Temperature (soldering, 10s).....+300°C
Soldering Temperature (reflow).....+260°C
ESD Protection (All Pins, Human Body Model).....±2kV

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)

TQFP
Junction-to-Ambient Thermal Resistance (θ_{JA}).....36°C/W
Junction-to-Case Thermal Resistance (θ_{JC}).....4°C/W

Note 1: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

Recommended Operating Conditions

(T_A = -40°C to +85°C, unless otherwise noted.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}		2.3	3.0	3.6	V
Input Logic 1 ($\overline{RST}$, CSW, SCK, DIN, $\overline{CE}$)	V_{IH}		V_{CC} x 0.7		V_{CC} + 0.3	V
Input Logic 0 ($\overline{RST}$, CSW, SCK, DIN, $\overline{CE}$)	V_{IL}		-0.3		V_{CC} x 0.3	V
Input Logic 1 (32KX1)	$V_{IH32KX1}$		V_{CC} x 0.85		V_{CC} + 0.3	V
Input Logic 0 (32KX1)	$V_{IL32KX1}$		-0.3		V_{CC} x 0.15	V

Electrical Characteristics

(V_{CC} = 2.3V to 3.6V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{CC} = 3.0V and T_A = +25°C.) (Notes 2, 3)

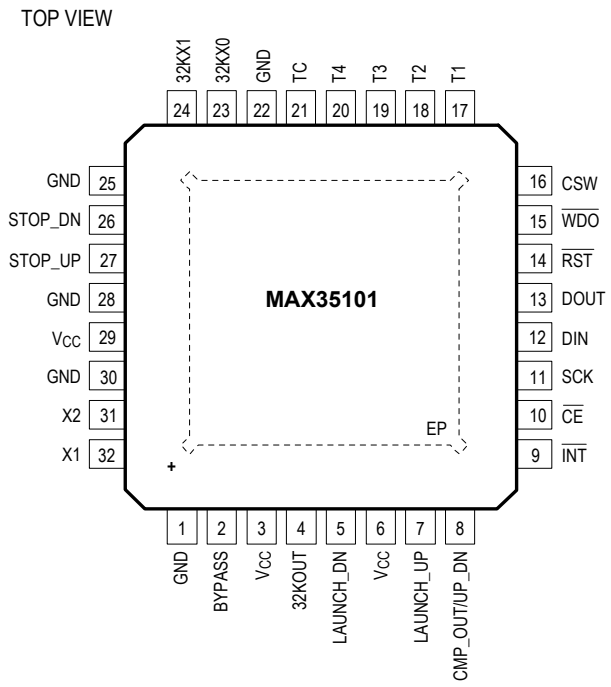
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Leakage (CSW, $\overline{RST}$, SCK, DIN, $\overline{CE}$)	I_L		-0.1		+0.1	µA
Output Leakage ($\overline{INT}$, $\overline{WDO}$, T1,T2,T3,T4)			-0.1		+0.1	µA
Output Voltage Low (32KOUT)	V_{OL32K}	2mA			0.2 x V_{CC}	V
Output Voltage High (32KOUT)	V_{OH32K}	-1mA	0.8 x V_{CC}			V
Output Voltage High (DOUT, CMP_OUT/UP_DN)	V_{OH}	-4mA	0.8 x V_{CC}			V
Output Voltage High (TC)	V_{OHTC}	V_{CC} = 3.3V, I_{OUT} = -4mA	2.9	3.1		V

Electrical Characteristics (continued)

(V_{CC} = 2.3V to 3.6V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{CC} = 3.0V and T_A = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage High (Launch_UP, Launch_DN)	$V_{OHLAUCH}$	V_{CC} = 3.3V, I_{OUT} = -50mA	2.8	3.0		V
Output Voltage Low ($\overline{WDO}$, $\overline{INT}$, DOUT, CMP_OUT/UP_DN)	V_{OL}	4mA			0.2 x V_{CC}	V
Pulldown Resistance (TC)	R_{TC}		650	1000	1500	Ω
Input Voltage Low (TC)	V_{ILTC}			0.36 x V_{CC}		V
Output Voltage Low (Launch_UP, Launch_DN)	$V_{OLLAUCH}$	V_{CC} = 3.3V, I_{OUT} = 50mA		0.2	0.4	V
Resistance (T1, T2, T3, T4)	R_{ON}			1		Ω
Input Capacitance ($\overline{CE}$, SCK, DIN, $\overline{RST}$, CSW)	C_{IN}	Not tested		7		pF
$\overline{RST}$ Low Time	t_{RST}				100	ns
CURRENT						
Standby Current	I_{DDQ}	No oscillators running, T_A = +25°C		0.1	1	µA
32kHz OSC Current	I_{32KHZ}	32kHz oscillator only (Note 4)		0.5	0.9	µA
4MHz OSC Current	I_{4MHZ}	4MHz oscillator only (Note 4)		40	85	µA
LDO Bias Current	I_{CCLDO}	I_{CCCPU} = 0 (Note 4)		15	35	µA
Time Measurement Unit Current	I_{CCTMU}	(Note 4)		4.5	8	mA
Calculator Current	I_{CCCPU}			2.5	5	mA
Device Current Drain	I_{CC3}	TOF_DIFF = 2 per second (3 hits), temperature = 1 per 30s		10		µA
	I_{CC6}	TOF_DIFF = 2 per second (6 hits), temperature = 1 per 30s		13		
FLASH Erase Current	I_{FLASH}			0.5	1	mA
ANALOG RECEIVER						
Analog Input Voltage (STOP_UP, STOP_DN)	V_{ANA}		10	700	2 x V_{CC} x (3/8)	mV_{P-P}
Input Offset Step Size	V_{STEP}			1		mV
STOP_UP/STOP_DN Bias Voltage	V_{BIAS}			V_{CC} x (3/8)		V
Receiver Sensitivity	V_{ANA}	Stop hit detect level (Note 5)	10			mV_{P-P}
TIME MEASUREMENT UNIT						
Measurement Range	t_{MEAS}	Time of flight	8		8000	µs
Time Measurement Accuracy	t_{ACC}	Differential time measurement		20		ps
Time Measurement Resolution	t_{RES}			3.8		ps

Pin Configuration



TQFP
(5mm x 5mm)

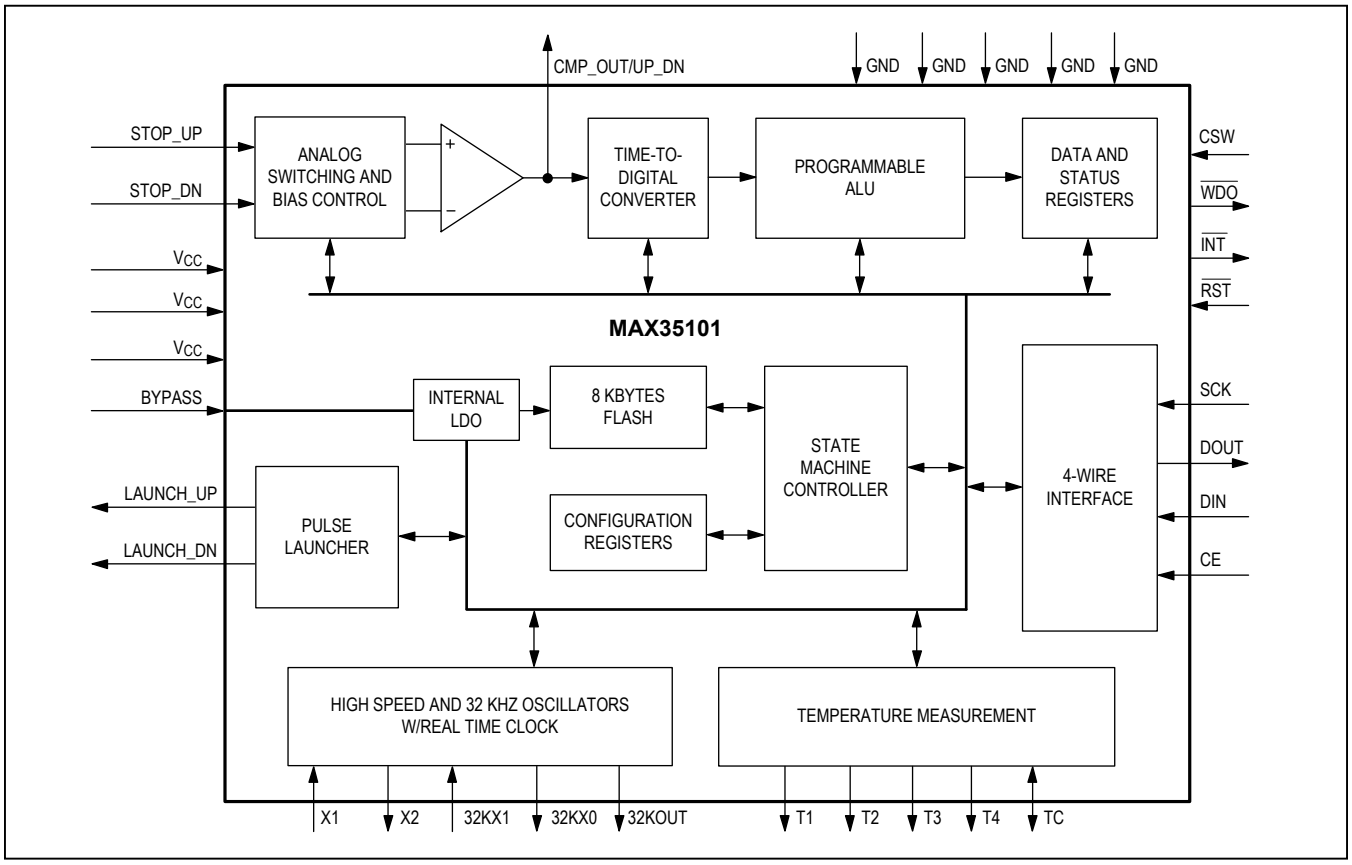
Pin Description

PIN	NAME	FUNCTION
1, 22, 25, 28, 30	GND	Device Ground
2	BYPASS	Connect this pin to ground with a capacitor (100nF) to provide stability for the on-board low-dropout regulator that is used to supply the flash circuitry. The effective series resistance of this capacitor needs to be in the 1Ω to 2Ω range.
3, 6, 29	V_{CC}	Main Supply. Typically sourced from a single lithium cell.
4	32KOUT	CMOS Output. Repeats the 32kHz crystal oscillator frequency.
5	LAUNCH_DN	CMOS Pulse Output Transmission in Downstream Direction of Water Flow
7	LAUNCH _UP	CMOS Pulse Output Transmission in Upstream Direction of Water Flow
8	CMP_OUT/UP_DN	CMOS Output. Indicates the direction (upstream or downstream) of which the pulse launcher is currently launching pulses OR the comparator output.
9	$\overline{INT}$	Active-Low Open-Drain Interrupt Output. The pin is driven low when the device requires service from the host microprocessor.
10	$\overline{CE}$	Active-Low CMOS Digital Input. Serial peripheral interface chip enable input.

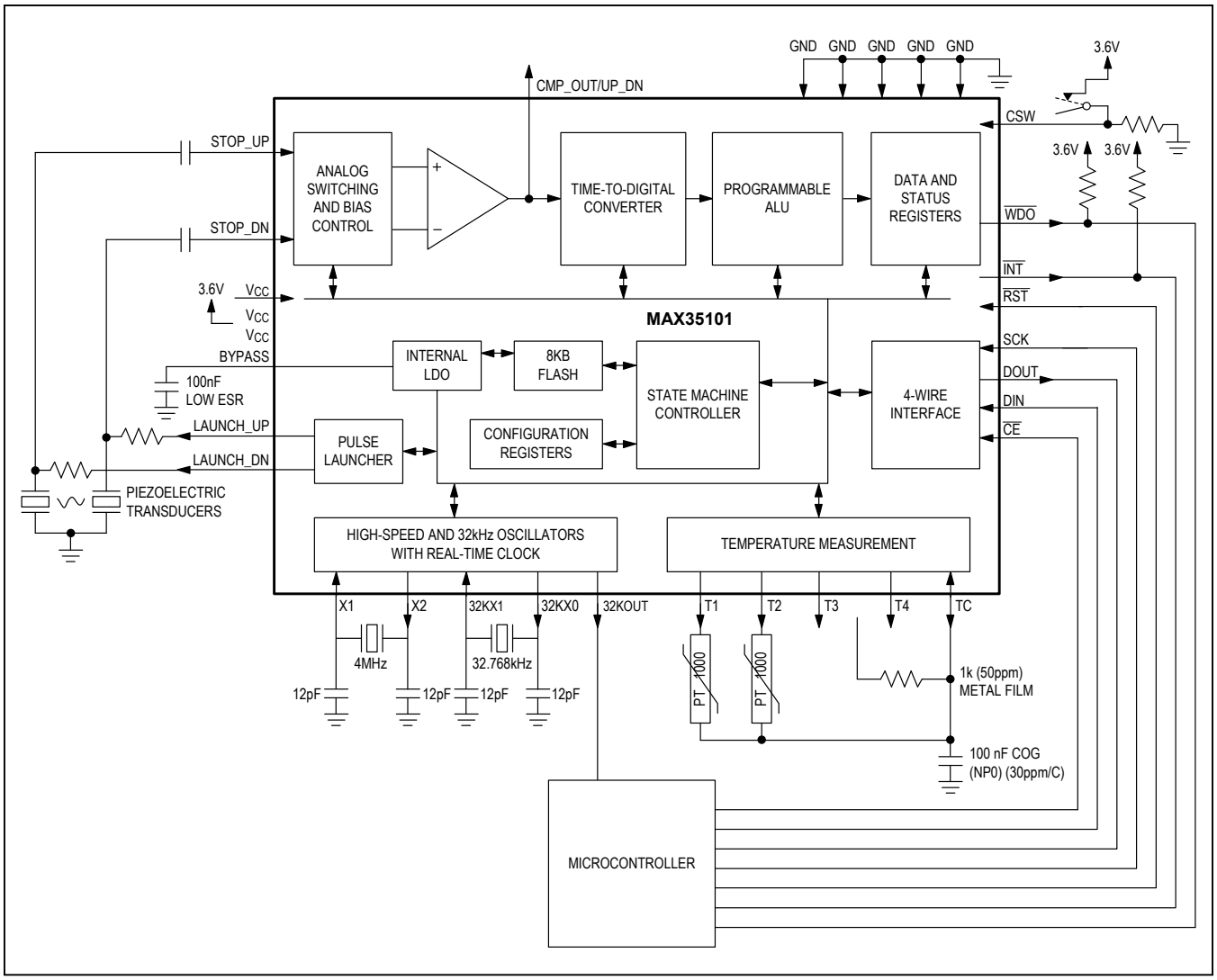
Pin Description (continued)

PIN	NAME	FUNCTION
11	SCK	CMOS Digital Input. Serial peripheral interface clock input.
12	DIN	CMOS Digital Input. Serial peripheral interface data input.
13	DOUT	CMOS Output. Serial peripheral interface data output.
14	$\overline{RST}$	Active-Low CMOS Digital Reset Input
15	$\overline{WDO}$	Active-Low Open-Drain Watchdog Output
16	CSW	CMOS Digital Input. Case Switch. Active-high tamper detect input.
17	T1	Open-Drain Probe 1 Temperature Measurement
18	T2	Open-Drain Probe 2 Temperature Measurement
19	T3	Open-Drain Probe 3 Temperature Measurement
20	T4	Open-Drain Probe 4 Temperature Measurement
21	TC	Input/Output Temperature Measurement Capacitor Connection
23	32KX0	Connections for 32.768kHz Quartz Crystal. An external CMOS 32.768kHz oscillator can also drive the MAX35101. In this configuration, the 32KX1 pin is connected to the external oscillator signal and the 32KX0 pin is left unconnected.
24	32KX1	
26	STOP_DN	Downstream STOP Analog Input. Used for the signal that is received from the downstream transmission of a time-of-flight measurement.
27	STOP_UP	Upstream STOP Analog Input. Used for the signal that is received from the upstream transmission of a time-of-flight measurement.
31	X2	Connections for 4MHz Quartz Crystal. A ceramic resonator can also be used.
32	X1	
—	EP	Exposed Pad. Connect to GND.

Block Diagram



Typical Application Circuit



Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX35101EHJ+	-40°C to +85°C	32 TQFP-EP*
MAX35101EHJ+T	-40°C to +85°C	32 TQFP-EP*

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

T = Tape and reel.

**EP = Exposed pad.*

Chip Information

PROCESS: CMOS

Package Information

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
32 TQFP-EP	H32E+6	21-0079	90-0326