Universal Sensors and Transducer Interface with Extended Temperature Range

USTI EXT

FEATURES

- **29 measuring modes and one generator mode**
- **2 channels for frequency and period measurements**
- **Frequency (time)-to-digital conversion for many types of sensors and transducers**
- **Interfacing for resistive (including platinum (Pt), cuprum (Cu) resistors and thermistors (Ni)), capacitive sensing elements and resistive bridges**
- **Frequency range from 1 Hz up to 7.5 MHz without prescaling and 120 MHz with prescaling;**
- **Programmable accuracy (relative error) for frequency (period) conversion from 1 % to 0.0005%**
- **Relative quantization error is constant in all specified frequency range**
- **Non-redundant conversion time**
- **Scalable resolution**
- **Internal reference clock 16 MHz @ 16 MHz quartz oscillator**
- **Quartz-accurate automated calibration**
- **3-wire serial interface (SPI compatible)**
- **2-wire interface (I^2C compatible)**
- **RS232/485 serial interface**
- **Master and slave communication modes**
- **Frequency generator mode 8 MHz with quartz crystal stability**
- **Operating temperature range -55 ºC to +150 ºC**

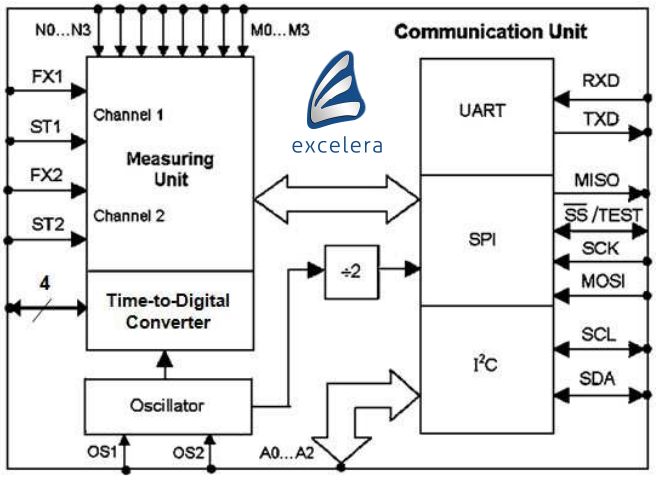
APPLICATIONS

Physical and Chemical Sensor Systems
Digital Sensors, SoC, SiP
Smart and Intelligent Sensors and Systems
Industrial and Process Control
Data Acquisition Systems
Instrumentations
Customer Electronics
Automotive

GENERAL DESCRIPTION

The Universal Sensors and Transducers Interface (USTI-EXT) is a fully digital CMOS integrated circuit based on novel patented methods for frequency, period, its ratio, duty-cycle and phase-shift measurements. This IC has similar metrological performance as Excelera's UFDC-1M-16 and same functionalities as the USTI IC but can work in extended operation temperature range from - 55 ºC to +150 ºC.

FUNCTIONAL BLOCK DIAGRAM



The IC converts frequency-time parameters of signals into digital, and provides interface to microcontroller, DAQ or sensor system to read these digital results.

The USTI-EXT has 29 measuring and one generating modes. The measuring mode can be hardware-selected by using four selection external pins M0-M2 and the relative error by using four selection pins N0-N2 (RS232 master communication mode). The mode and accuracy can be also selected by using any of three possible interfaces (slave communication mode). A communication interface type (RS232, SPI or I^2C) can be automatically selected according to the circuit connection.

MEASURING MODES

- Frequency, f_{x1} 1 Hz – 7.5 MHz directly and up to 120 MHz with prescaling
- Period, T_{x1} 150 ns – 20 s
- Phase shift, φx 0 - 360^0 at f_{xmax} = 500 kHz at 50 % duty-cycle
- Time interval between start – and stop-pulse, τ_x
- 2 µs – 250 s
- Duty-cycle, D.C. 0 – 1 at $f_{xmax} \leq 500$ kHz
- Duty-off factor, Q 10-8 – 8.106 at $f_{xmax} \leq 500$ kHz
- Frequency difference, $f_{x1} - f_{x2}$ with sign recognition, 0 – 7.5 MHz
- Period difference, $T_{x1} - T_{x2}$ with sign recognition, 0 – 20 s
- Frequency ratio, f_{x1}/f_{x2} 7×10^{-9} – 1.4×10^8
- Period ratio, T_{x1}/T_{x2} 7.5×10^{-9} – 1.33×10^8
- Rotation speed, $n_x = (f_x \times 60)/Z$, where Z is the number of encoder teeth

- Pulse width, t_p 2 µs – 250 s
- Space interval, t_s 2 µs – 250 s
- Pulse number (events) counting, N_x 0 – 4×10^9
- Frequency deviation absolute D_{A1}, 0 – 7.5 MHz
- Frequency deviation relative D_{R1}, 0 – 100 %
- Resistance, R_x 12 Ω to 10 MΩ with average relative error ±0.55 % and ±0.012 % error at splitting of the range into sub ranges
- Capacitance, C_x 60 pF to 100 µF with average relative error ±0.05 % and ±0.85 % the worst case relative error
- Resistive bridges, B_x must not include any internal components other than 4 arms forming a bridge
- Operating temperature range -55 ºC to +150 ºC
- Storage temperature range -65 °C to +150 °C

NOTE: The USTI EXT can also work with any voltage and current output sensors. It this case, any voltage–to-frequency converter (VFC) can be used. The accuracy of such system will be determined by sensor accuracy as well as by VFC accuracy.

ACCURACY

The USTI has programmable relative error from 1 to 0.0005 % in all specified range of frequencies for frequency and period measurements. This error is constant and does not depend on the measuring frequencies in all frequency ranges. The USTI has non-redundant conversion time. The higher conversion accuracy needs longer conversion time. However, it is non-redundant for any selected accuracy and frequency. For time interval, phase shift, pulse width and space measurements the relative error is determined mainly by measurand and can be calculated according to the following equation:

$$\delta_q = \frac{1}{16\cdot10^6\cdot t_x}\times100\ \%,$$

where t_x is the appropriate measuring value of t_p, t_s or τ_x depending on the mode.

COMMUNICATION MODES

The USTI can work as an independent measuring unit (master mode), controlled by any external microcontroller (or embedded into a sensor), DAQ board or PC (slave mode). In the master mode, the conversion accuracy and measurement mode should be selected by external switches. In this mode the USTI works only through the RS232 interface in a unidirectional mode. In the slave mode (with an external microcontroller), all measuring modes and programmed accuracy can be set up by a data bus or through communication I/O ports of master microcontroller. This allows us use the USTI as a simple peripheral circuit for a microcontroller. A bidirectional data exchange is possible with any of three interfaces RS232, SPI or I2C. The USTI works as a standard element in different systems with I2C bus architecture, or can be controlled through the RS232 or SPI interfaces. The choice of interface can be performed automatically depend on the circuit connections.

The selection of communication interface is performed automatically based on the state of IS1 and IS2 inputs at the power switch on:

IS1	IS2	Communication Interface
0	0	SPI slave
0	1	I2C slave
1	0	RS232 master
1	1	RS232 slave

CHARACTERISTICS

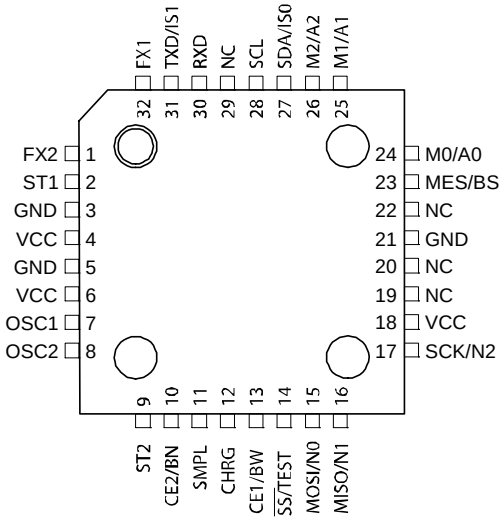
- Single power supply, V: 4.5 – 5.5
- External reference frequency, MHz: 16
- Internal reference frequency, MHz: 16
- Conversion time: 6.25 µs to 0.32 s
- Supply current (at 16 MHz, 4.5 V, 25 ºC), mA: < 12
- Operating temperature range - 55 ºC to +150 ºC (AEC-Q100 Grade0)
- Storage temperature range -65 °C to +150 °C

PIN-OUT AND HOUSING

The USTI-EXT is available in 32-lead 7 x 7 mm Body Size, 1.0 mm Body Thickness, 0.8 mm Lead Pitch small Thin Profile Plastic Quad Flat Package (TQFP); and 32-pad, 5 x 5 x 1.0 mm Body, Lead Pitch 0.50 mm, 3.10 mm Exposed Pad, Micro Lead Frame Package (MLF).

PIN FUNCTION DESCRIPTIONS

TQFP/MLF TOP VIEW



NOTE: Bottom Pad for MLF Package Should be Soldered to Ground.

This device can also be supplied in wafer form. Please contact Excelera, S. L. sales office for detailed ordering information and minimum quantities.

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For more detailed information, specifications and application notes the following document are strongly recommended: *Universal Sensors and Transducers Interface (USTI): Specification and Application Note.*

PIN FUNCTION DESCRIPTIONS

Name	Pin Descriptions
VCC	Supply voltage
GND	Ground
FX1, ST1	Input channel 1
FX2, ST2	Input channel 2
OSC1, OSC2	Oscillator
M0, M1, M2	Mode selection (see table)
N0, N1, N2	Accuracy selection (see table)
A0, A1, A2	Address of I^2C slave (for I^2C bus communication)
TEST	Calibration signal
SCK	SPI Bus Master clock Input
MISO	SPI Bus Master Input/Slave Output
MOSI	SPI Bus Master Output/Slave Input
SS	SPI Bus Master Slave select
SCL	Two-wire (I^2C compatible) Serial Bus Clock Line
SDA	Two-wire (I^2C compatible) Serial Bus Data Input/Output Line
RXD	UART Input
TXD	UART Output
IS0,IS1	Interface mode selection
BN	North port of bridge
BW	West port of bridge
BS	South port of bridge
CE1	Calibration element 1
CE2	Calibration element 2
CHRG, MES, SMPL	R_x and C_x measurement pins

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