Universal Transducer Interface (UTI)
Evaluation Board

SMARTEC

1. Introduction

This Application Note describes an evaluation board for the UTI. The UTI is a complete front-end interface for many types of passive sensors, such as resistive, resistive-bridge and capacitive sensors. The UTI converts low-level sensor signals to a period-modulated microcontroller-compatible signal. By the application of continuous auto-calibration a high accuracy, of up to 13 bits, is obtained. Full data of the UTI is available in the UTI specification sheet and should be consulted in conjunction with this Application Note when using the Evaluation Board.

The evaluation board is equipped with a microcontroller (Microchip PIC16C73A). An RS232 interfacing chip offers serial communication between the microcontroller and, for instance, a personal computer. A 20 MHz crystal completes the on-chip oscillator of the microcontroller. Two voltage regulators (78L05) provide the 5 V, DC supply voltages for the UTI, and the microcontroller and the RS232 interfacing, respectively.

The evaluation-board block diagram is shown in Figure 1, while a full circuit diagram and a photograph of the evaluation board are shown in Figure 2 and Figure 3, respectively.
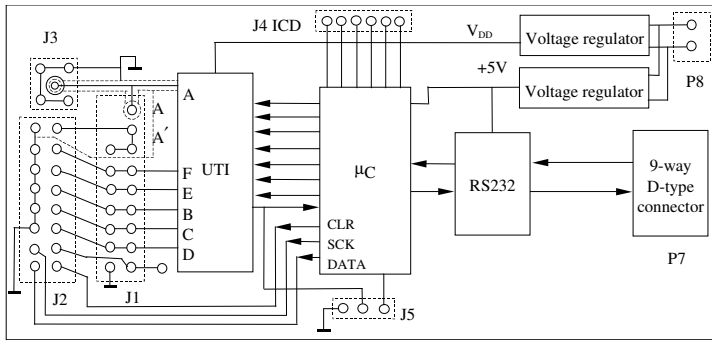
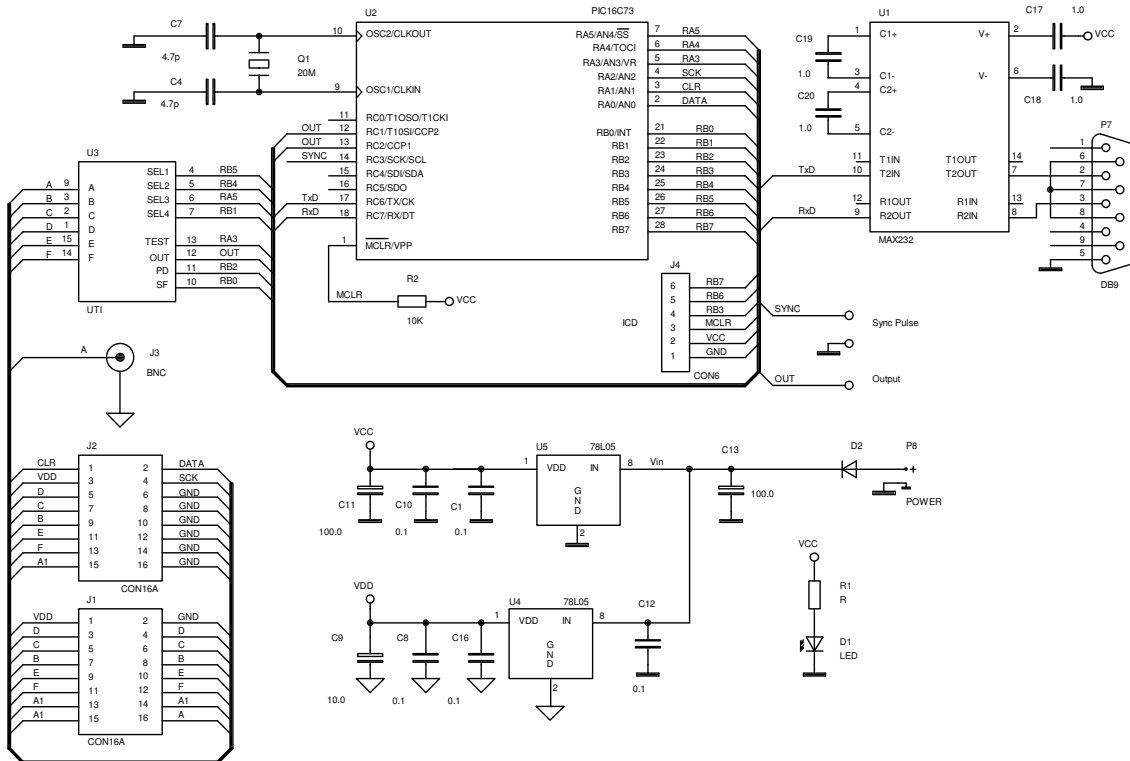

Figure 1 Functional block diagram.

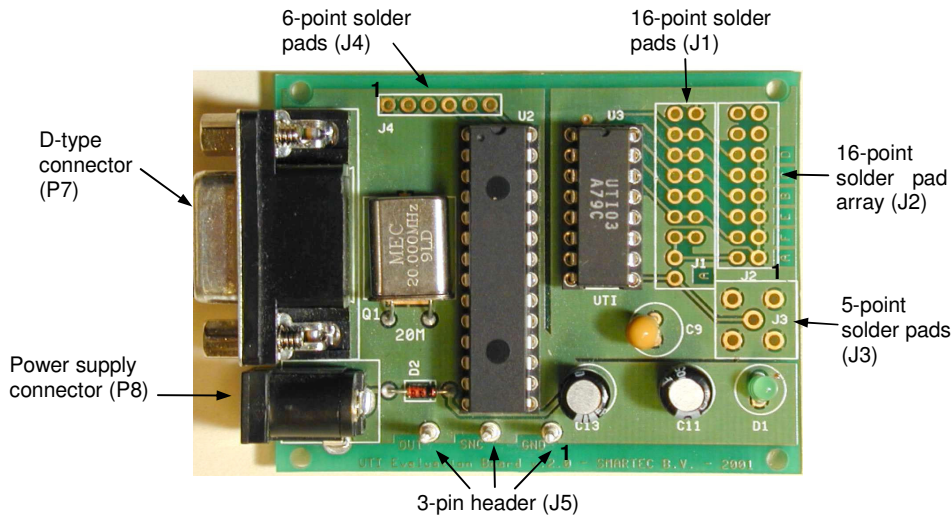*Figure 2 Circuit diagram of the UTI evaluation board.*

Figure 3 A photograph of the UTI evaluation board.

2. Operating the UTI evaluation board

Functions

The evaluation board can be used for all functions of the UTI. The setting of the operating mode is performed by the microcontroller. Moreover, the microcontroller also measures the output signal from UTI and communicates with the outside digital world.

Power supply

Two on-board voltage regulators (78L05) provide the internal supply voltages of 5 V. The board requires an external DC supply voltage in the range of 7 V to 15 V.

3. Connections to the board

Evaluation board interfacing

Connection to the UTI evaluation board is implemented with six connectors/connecting pads:

J2   16-point solder pad array for connection of the sensing, reference and biasing elements
J3   5-point solder pads for connection of capacitive sensing elements
J4   6-point solder pads for connection to the ICD reprogramming module
J5   3-pin header to monitor UTI with an oscilloscope
P7   9-way D-type connector for communication with a PC (standard serial cable)
P8   Socket for connection of power supply

Figures 4, 5, 6, 7 & 8 show the pin/pad connections.

The soldering-pad arrays, J2 and J3, are used for mounting flat cable wires, sockets, or external components. This enables the connection of to connect external sensing, reference and biasing elements. In the CMUX mode of the UTI, the on-board microcontroller provides the control signals (CLR, DATA and SCK) for an optional, external multiplexer, via the soldering pad J2. For detailed information about the CMUX mode, please consult the UTI specification sheet.
In the capacitive modes of the UTI the measurement system is very sensitive to signals that are capacitively coupled with the input A, including capacitive-coupled interference signals. To provide selective detection of the desired signals only, for the connection to input A, a shielded or coaxial cable wire must be used. For this purpose pad J3 provides a connection for a coaxial plug. In other UTI modes, it is allowed to connect input node A using unshielded wire. In these modes, a wired connection is made between the soldering pads A′ and A″ (Figure 1). For the connections of various sensors, it is advised to consult the UTI specification sheet. The order of the J2 soldering pad array is shown in Figure 4.

The output signal of the UTI can be monitored, using an oscilloscope, connected via header J5 (Figure 6). Besides the output signal this header also provides a trigger signal for the oscilloscope.

The soldering pads are also used to mount the required external reference and biasing components. These components are chosen in accordance with the UTI mode. For instance, in the Pt100 mode of the UTI, the user has to connect a current-limiting resistor R_{BIAS} and a reference resistor R_{ref}, using soldering pad J2. For the other modes, please consult the UTI specification sheet. When J3 is not used, pads A to A' of pad array J2 have to be connected by wire.

1 to 6	GND	Evaluation-board ground
7	SCK	For MUX use
8	DATA	For MUX use
9	CLR	For MUX use
10	V_{DD}	Power supply
11	D	Sensors connection of UTI
12	C	Sensors connection of UTI
13	B	Sensors connection of UTI
14	E	Sensors connection of UTI
15	F	Sensors connection of UTI
16	A'	Sensors connection of UTI

Figure 4 J2 pad configuration.

1	Evaluation-board ground
2	+5 V Power supply output
3	MCLR
4	RB3
5	RB6
6	RB7

Figure 5 J4 pin configuration.

1	Evaluation-board ground
2	Trigger signal
3	Output signal of UTI

Figure 6 J5 pin configuration.
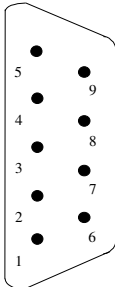
1	NC	Not connected
2	T1OUT	Serial data input
3	R1IN	Serial data output
4	NC	Not connected
5	GND	Evaluation-board ground
6	NC	Not connected
7	NC	Not connected
8	NC	Not connected
9	NC	Not connected

Figure 7 P7 pin configuration.

1	Power supply
2	Evaluation-board ground

Figure 8 P8 pin configuration.

4. Running the UTI interfacing software

There are many ways to display evaluated results, such as the terminal program under Windows and the LabView program. The following shows two of them.

4.1 Executable LabView

Included in the UTI development kit is a PC-compatible disk, which contains the software for controlling and evaluating the performance of the UTI using the serial port of a PC. There are three files, named: EVAL-UTI.arj, ARJ.exe and SERPDRV, respectively, on the contribution disk. The file SERPDRV is a serial-port-driver file. The file EVAL-UTI.arj is a freshened file of EVAL-UTI.exe, and ARJ.exe is a file manager.

To use the software, the user must have an IBM-compatible PC, with Windows 95 or later installed.

These three files on the contribution disk have to be copied to a subdirectory, for instance, EVAL-UTI, in the hard disk of your PC. After that, the EVAL-UTI.arj should be extracted by running ARJ.exe under DOS or Windows. This can be performed by running *arj e eval-uti.arj.* Then, the file EVAL-UTI.exe is extracted.
When working under Windows and using the FILE MANAGER you can simply double click on EVAL-UTI.EXE to start the evaluation program. When the program starts up a front panel window appears.

There exist five control items: *MODE*, *Serial port No*., *Reference*, *SPEED* and *Average Index*. Further, there are a few indication items: *Real-time value* and Graphic chart of the measured results, *Std Deviation, Average value* and *Meas. time*.

The UTI evaluation software allows the user to program and gather samples from the UTI evaluation board via the serial port of the PC. The port number they wish to use is selected by using the item, *Serial port No.*. The item *MODE* is used to select the mode of the UTI and *SPEED* to set the UTI in a slow or a fast mode.

The item *Reference* is used to set the reference signal value corresponding to the value of a reference capacitance or a reference resistance. For example, when the evaluation board is used to measure the signal from a Pt100 and a reference resistor of 100.00 Ω is used, the item *Reference* should be set to 100.00.
The item *Average Index* is used to set the number of measurements to be averaged. A large number of measurements results in lower noise, but also increases the measurement time.

The output information

Real-time value digitally displays the measurement result. For instance, for the measurement of a Pt100, the measured resistor value of the Pt100 is displayed, and for the measurement of the potentiometer, the relative value is displayed.
Meanwhile, a graphic chart displays the real-time value by a red line.

The item *Average Value* indicates the average value of a variable number of measurements indicated by the *Average Index*.

The item *Std Deviation* indicates the standard deviation of the evaluation board for a variable (by *Average Index*) number of the measurements.

Table 1 lists the displayed measurement results for each UTI mode.
The item *Meas. time* indicates the measurement time for one complete measurement. F or instance, to measure a capacitance by using mode C23 of UTI, the *Meas. time* is the total time to measure the three periods, T_{off}, T_x and T_{ref} (see UTI specification sheet).

To Start Measurement

Double clicking the button $\Rightarrow$ at the top-left corner of the front-panel window will start the measurement. After a few seconds the results are displayed at the monitor.

4.2 Terminal under Windows

The program **Terminal** (or **Hyper terminal**) under Windows can easily display the measurement results via the serial port of the PC. The configuration of **Terminal** (or **Hyper terminal**) is: 8 data bit, 1 stop bit and No parity error check. The microcontroller will automatically select the baudrate by sending a @ sign to the evaluation board. So, in order to have a communication between the microcontroller and the PC, first the sign @ is send to the microcontroller.

Once the communication between the microcontroller and the PC is actuated, by typing "H", "h" or "?", you can get on-line help. With this on-line help, it is easy to manage the evaluation board and to display the result.

The displayed data under the **Terminal** (or **Hyper terminal**) is Hexadecimal. The data, which corresponds to the time interval of each phase of the UTI output signal. Using the counting function of the microcontroller, with a counting frequency of 5 MHz, the time intervals are measured accurately.

5. On-board reprogramming the microcontroller with the ICD

Together with the evaluation board also the microcontroller software is supplied. This software enables the evaluation of the sixteen basic modes of the UTI. Yet, for specific applications, it is possible that it is needed to modify the software. This is the case, for instance, when the UTI is used in combination with an external multiplexer, to perform multiple-capacitance measurements (see section 6). For easy on-board reprogramming of the microcontroller, the evaluation board provides a 6-pad soldering array (J4 see Figure 5) to mount a six-pole connector for the ICD module (In Circuit Debugger). This module is available from Microchip and can be ordered with Smartec. In order to use the ICD, the microcontroller should have the ICD capability. For this option, for instance, the PIC16F873 or PIC16F876 can be used.

6. Multiple-capacitance measurement

A large number of capacitances can be measured using the CMUX mode of the UTI together with an external multiplexer, such as Smartec's MUX03. The number of measured capacitances is not limited. For detailed information on the MUX03, please consult the MUX03 specification sheet.

With a single external MUX03 the evaluation board provides the possibility to measure up to nine capacitances. The evaluation board generates the three control signals (CLR, DATA and SCK) for the external multiplexer. When the program **Terminal** (or **Hyper terminal**) under Windows is used to display the measurement results, after sending the character '3' for selection of the CMUX mode, a character between '1' and '9' (HEX 31 to 39) should be sent to specify the number of capacitances to be measured. When this character is ignored, the system will use the default value ('9'), which means that nine capacitors are measured.

Attention:
Do not forget to switch on the power supply of the evaluation board before starting the measurement.

Mode	Result 1	Result 2	Result 3
0	$(C_{DA}\text{-}C_{BA})/(C_{CA}\text{-}C_{BA})C_{ref}$	$(C_{EA}\text{-}C_{BA})/(C_{CA}\text{-}C_{BA})C_{ref}$	$(C_{FA}\text{-}C_{BA})/(C_{CA}\text{-}C_{BA})C_{ref}$
1	$(C_{DA}\text{-}C_{BA})/(C_{CA}\text{-}C_{BA})C_{ref}$	$\times$	$\times$
2	$(C_{DA}\text{-}C_{BA})/(C_{CA}\text{-}C_{BA})C_{ref}$	$(C_{EA}\text{-}C_{BA})/(C_{CA}\text{-}C_{BA})C_{ref}$	$(C_{FA}\text{-}C_{BA})/(C_{CA}\text{-}C_{BA})C_{ref}$
3	See section 6		
4	$(C_{DA}\text{-}C_{BA})/(C_{CA}\text{-}C_{BA})C_{ref}$	$\times$	$\times$
5	$R_{CD}/R_{AB}R_{ref}$	$R_{BC}/R_{AB}R_{ref}$	$\times$
6	$R_{CD}/R_{AB}R_{ref}$	$R_{BC}/R_{AB}R_{ref}$	$\times$
7	$R_{CD}/R_{AB}R_{ref}$	$R_{BC}/R_{AB}R_{ref}$	$R_{DF}/R_{AB}R_{ref}$
8	$R_{CD}/R_{AB}R_{ref}$	$R_{BC}/R_{AB}R_{ref}$	$R_{DF}/R_{AB}R_{ref}$
9	V_{CD}/V_{AB}	$\times$	$\times$
10	V_{CD}/V_{AB}	$\times$	$\times$
11	V_{CD}/V_{AB}	$\times$	$\times$
12	V_{CD}/V_{AB}	$\times$	$\times$
13	V_{CD}/V_{EA}	$R_{AB}/R_{BF}R_{ref}$	$\times$
14	V_{CD}/V_{EA}	$R_{AB}/R_{BF}R_{ref}$	$\times$
15	V_{BF}/V_{EF}	V_{CF}/V_{EF}	V_{DF}/V_{EF}

Note: $\times$: No measurement.

Table 1. The displayed measurement results for various modes.