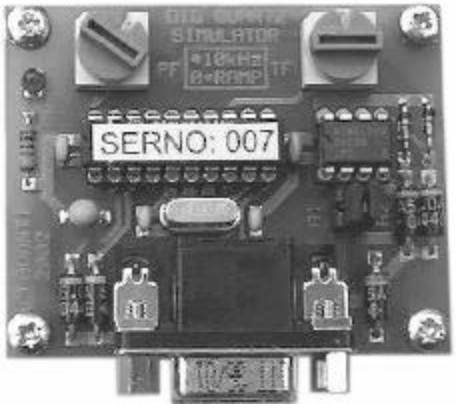
1. GENERAL

The Avanti Digital Quartz Transducer Simulator substitutes a pressure/temperature transducer equipped with a two-wire serial I²C interface. It was designed to be compatible with Quartzdyne's range of digital quartz pressure transducers and facilitates testing of data acquisition systems without the need for real transducers. The simulator also features a special error mode, which simulates erratic I²C behaviour. This is useful for checking how well a data acquisition system recovers from a locked up I²C bus.

2. HARDWARE DESCRIPTION

The simulator consists of a small standalone PCB (circa 50 x 60mm), containing a micro-controller and a serial EEPROM, which are both connected to the I²C bus.
There are two rotary switches (labelled PF and TF) for setting pressure and temperature values and a LED, which flashes whenever the simulator has been polled successfully.
Two jumper links (labelled A1 and A2) are provided for setting the device address, allowing up to 4 devices on the same I²C bus. The address lines are fitted with pull-up resistors and the jumpers make a connection to ground, i.e. a jumper inserted means the address line is low and a jumper removed means the address line is high. The address lines are also available externally via the 9-way D-type socket, so that alternatively the device address can be coded through ground connections on the host-board. The jumper links must be removed for this. The table below shows the pin-out of the D-type socket. The pin-out is also printed on the bottom side of the PCB.



Pin-1	A1
Pin-2	SCL
Pin-3	GND
Pin-4	SDA
Pin-5	+VS (2.7V to 5.5V)
Pin-6	A2
Pin-7	GND
Pin-8	GND
Pin-9	GND

All external connections are over voltage and reverse voltage protected. However, in order to minimise the possibility of damage through ESD, unnecessary touching of component pins and PCB pads should be avoided.

3. I²C INTERFACE

The Avanti Digital Quartz Transducer Simulator supports the following I²C commands. For details refer to the Quartzdyne Digital Transducer Programming Manual.

- Query pressure counter (returns a 32-bit pressure reading)
- Query temperature counter (returns a 32-bit temperature reading)
- Write control byte (enables/disables pressure and temperature counters, locks/unlocks EEPROM write access)
- Query status byte (returns status of pressure/temperature counters and EEPROM write protection bit)
- Query Version-ID (returns a 32-bit version identifier)

The I²C bus was developed by Philips Semiconductors and its specification can be downloaded from their web-site. In its standard version the I²C bus allows a maximum clock/data frequency of 100kHz, i.e. minimum high and low times of clock and data lines must be observed by the master. The I²C protocol also specifies a mechanism called 'clock stretching', which allows slaves to slow down the bus to below 100kHz.

While in the actual Quartzdyne transducer the I²C interface is implemented in an FPGA (i.e. entirely in hardware), the Avanti simulator employs a micro-controller with bit-level I²C support (i.e. a mixture of hardware and firmware). This means that the Avanti simulator is slightly less forgiving with respect to I²C timing issues. In particular 'clock stretching' must be recognised by the master if running at high speed. This happens automatically if the host-micro uses a dedicated I²C port. However, if the I²C interface in the host is 'bit-banged' using two ordinary port pins for SCL and SDA, the host firmware should check explicitly for 'clock stretching'. This is quite simple to implement: It only requires the host firmware to make sure the SCL line actually goes high whenever the SCL pin is set high and, if necessary, to wait for this to happen before proceeding.

4. VALUES RETURNED

Pressure and temperature values can be set independently by means of the two rotary switches. For positions 1...8 the returned value is the switch position multiplied by 10kHz, i.e. 10...80kHz. In switch position 0 a ramp is generated, which is repeated every 10 minutes. The pressure ramp starts at 30kHz and ramps upwards at a rate of 1Hz per second. The temperature ramp starts at 40kHz and ramps downwards at a rate of -1Hz per second. In switch position 9 the simulator runs in error mode, which generates regular I²C lockups (see paragraph 5 for details).

Switch Position	PF	Raw-Pres returned	TF	Raw-Temp returned
1	10000 Hz	0x005B05B1	10000 Hz	0x005B05B1
2	20000 Hz	0x00B60B61	20000 Hz	0x00B60B61
3	30000 Hz	0x01111111	30000 Hz	0x01111111
4	40000 Hz	0x016C16C1	40000 Hz	0x016C16C1
5	50000 Hz	0x01C71C72	50000 Hz	0x01C71C72
6	60000 Hz	0x02222222	60000 Hz	0x02222222
7	70000 Hz	0x027D27D4	70000 Hz	0x027D27D4
8	80000 Hz	0x02D82D84	80000 Hz	0x02D82D84
9	30000 Hz with regular I²C lockups	0x01111111	40000 Hz with regular I²C lockups	0x016C16C1
0	Ramp 30000...30600 Hz at 1Hz/sec => Sawtooth edge every 10 minutes	Ramp 0x01111111... 0x01168720	Ramp 40000...39400 Hz at -1Hz/sec => Sawtooth edge every 10 minutes	Ramp 0x016C16C1... 0x0166A0B1

The simulator is shipped with coefficients pre-loaded in the EEPROM. These coefficients were taken off a real transducer and therefore produce engineering values, which represent a typical Quartzdyne transducer. Only the serial number and the calibration date were modified to reflect the simulators serial number and date of manufacture. The following table shows the psi and °C values obtained with these coefficients:

PF / TF	10kHz	20kHz	30kHz	40kHz	50kHz	60kHz	70kHz	80kHz
10kHz	-11421.63 psi 236.342 °C	-5648.515 psi 236.342 °C	-252.348 psi 236.342 °C	4842.551 psi 236.342 °C	9711.851 psi 236.342 °C	14431.22 psi 236.342 °C	19076.35 psi 236.342 °C	23722.88 psi 236.342 °C
20kHz	-8745.46 psi 194.991 °C	-3710.684 psi 194.991 °C	1101.552 psi 194.991 °C	5728.189 psi 194.991 °C	10206.17 psi 194.991 °C	14572.43 psi 194.991 °C	18863.92 psi 194.991 °C	23117.58 psi 194.991 °C
30kHz	-6871.39 psi 150.948 °C	-2371.768 psi 150.948 °C	2000.479 psi 150.948 °C	6262.484 psi 150.948 °C	10431.37 psi 150.948 °C	14524.28 psi 150.948 °C	18558.34 psi 150.948 °C	22550.67 psi 150.948 °C
40kHz	-5689.32 psi 98.854 °C	-1569.95 psi 98.854 °C	2476.813 psi 98.854 °C	6459.496 psi 98.854 °C	10386.63 psi 98.854 °C	14266.73 psi 98.854 °C	18108.34 psi 98.854 °C	21919.97 psi 98.854 °C
50kHz	-5089.159 psi 33.349 °C	-1243.407 psi 33.349 °C	2562.94 psi 33.349 °C	6333.302 psi 33.349 °C	10071.10 psi 33.349 °C	13779.75 psi 33.349 °C	17462.68 psi 33.349 °C	21123.30 psi 33.349 °C
60kHz	-4960.809 psi -50.927 °C	-1330.312 psi -50.927 °C	2291.249 psi -50.927 °C	5897.976 psi -50.927 °C	9483.968 psi -50.927 °C	13043.32 psi -50.927 °C	16570.13 psi -50.927 °C	20058.50 psi -50.927 °C
70kHz	-5194.183 psi -159.332 °C	-1768.852 psi -159.332 °C	1694.117 psi -159.332 °C	5167.578 psi -159.332 °C	8624.385 psi -159.332 °C	12037.38 psi -159.332 °C	15379.43 psi -159.332 °C	18623.38 psi -159.332 °C
80kHz	-5679.18 psi -297.226 °C	-2497.196 psi -297.226 °C	803.938 psi -297.226 °C	4156.19 psi -297.226 °C	7491.532 psi -297.226 °C	10741.93 psi -297.226 °C	13839.35 psi -297.226 °C	16715.77 psi -297.226 °C

When queried for the Version-ID, the simulator returns the value 0x0D020302, which reads as Quartzdyne Counter FPGA V3.02.

5. ERROR MODE

The Philips I²C specification doesn't include any timeout mechanism. It is the responsibility of the I²C master to recover from conditions, where the I²C sequence has gone out of synch. This may happen if electrical noise is coupled into the SDA/SCL lines, or if the I²C master is reset while an I²C transfer is in progress, e.g. by a watchdog timer. Also, some of the earlier Quartzdyne transducers didn't always power up in the correct I²C state. This can lead to a situation where the SDA line is stuck low, preventing the master from generating a START or STOP. The I²C bus appears to be locked.

The master can overcome this situation by issuing 9 clock pulses while SDA is released. After a maximum of 9 cycles the slave reaches the point where it reads the acknowledgement from SDA. Since SDA is released, the slave reads this as a NACK and terminates. The master should then finish with a STOP.

The operation of such a bus recovery procedure can be checked by setting the simulator into error mode. If the pressure switch is set to position 9, the simulator locks SDA low after every 10th pressure query. Likewise, if the temperature switch is set to position 9, the simulator locks up after every 10th temperature query.

The 10th query itself is not affected and returns the correct result. However, the simulator ignores the NACK and the STOP at the end of the transfer and expects the master to clock out further data bits. The simulator is in a state as if it was interrupted during a read access, just after putting data bit-6 onto the bus. The data byte is assumed to be 0x0C (00001100), and therefore SDA is held low. A minimum of 7 clock pulses are required to clock out the remaining data bits and assert a NACK. Additional clock pulses after the NACK have no effect.

If both switches (pressure AND temperature) are in position 9, the simulator not only locks up after every 10th pressure and every 10th temperature query, but also powers up in a locked up state. Here the simulator assumes a data byte value of 0x0D (00001101) with SDA stuck at bit-5.

While SDA is stuck low, the simulator turns on the LED. If the I²C driver in the master is implemented properly, no data loss or data corruption should occur in error mode.

6. ACKNOWLEDGEMENTS AND FURTHER INFORMATION

Quartzdyne is a trademark of Quartzdyne Inc.
Information on their range of digital pressure transducers can be downloaded from their web-site at http://www.quartzdyne.com
The following documents are of particular interest:
DigitalTransSpec.pdf - Digital Quartz Pressure Transducer Specifications
DigitalTransProg.pdf - Digital Transducer Programming Manual

I²C is a trademark of Philips Semiconductors Inc.
Specifications and application notes can be downloaded from their web-site at http://www.semiconductors.philips.com
The following documents are of particular interest:
I2C_BUS_SPECIFICATION_3.PDF - The I²C Specification V2.1
I2CBITS.ZIP - Software Implemented I2C Drivers ('bit-banged')

Avanti Part Number: AVA02 Avanti Serial Number: xxxxx

Tested: