1. INTRODUCTION

Quartz pressure/temperature transducers are widely used in the oil industry for measuring downhole pressure and temperature with very high accuracy. Quartzdyne (www.quartzdyne.com) is the leading manufacturer of quartz transducers, of which there are two types: traditional Frequency Output Transducers (sometimes referred to as analog) and the more recent Digital Transducers, which are accessed via an I²C interface.

The AVA-07 Quartz Transducer Counter offers a simple solution for converting a traditional frequency output transducer into a digital transducer. It measures pressure and temperature frequencies and returns the results through a Quartzdyne compatible I2C interface. It can be thought of as a functional equivalent to Quartzdyne's counter FPGA contained in a Digital Transducer. However, the AVA-07 is not pin compatible and there are also some functional limitations regarding the I²C interface. The AVA-07 is not intended as a replacement part inside a damaged Digital Transducer, but as an interface between a Frequency Output Transducer and a data acquisition system designed for Digital Transducers.

2. FUNCTIONAL DESCRIPTION

The AVA-07 is based on a 8051 microcontroller. The AVA-07 is clocked by the 7.2MHz transducer reference and measures pressure and temperature frequencies via its internal timers/counters.

The AVA-07 is configured via three wire links. Two of the links (A1, A2) determine the I²C address, so that up to four circuits can be connected to a common I²C bus. The third link (MODE) selects between two acquisition modes.

If the MODE link is removed, the AVA-07 employs a fixed gate time of 1sec over which pressure and temperature frequencies are counted. However, the AVA-07 produces an updated result every 91ms, i.e. the 1sec gate time can be thought of as a sliding acquisition window that shifts every 91ms.

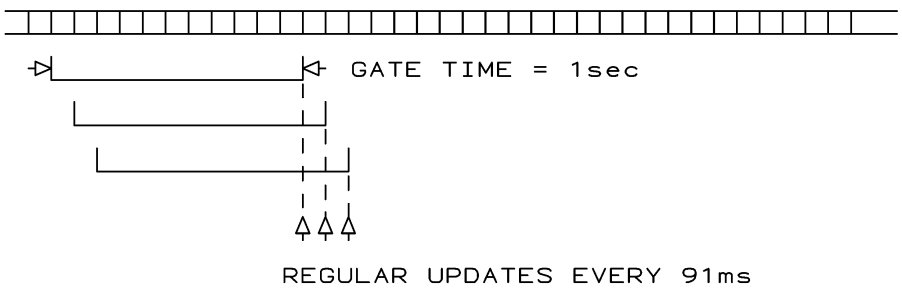

Figure 1: Sliding Acquisition Window

If the MODE link is inserted, the gate time is not fixed, but is automatically adjusted between 91ms and 2.8sec according to the I²C query rate.

The AVA-07 measures pressure and temperature frequencies continuously and always returns the most recent update when queried via the I²C Interface. In contrast to a Digital Quartzdyne Transducer, the AVA-07 counters never overrun. Therefore no dummy reads are required, even at very slow query rates.

3. APPLICATION CIRCUITS

The AVA-07 is available in a PLCC44 or a QFP44 package. In its most basic configuration no further components are required, except for a 100nF decoupling capacitor across the supply rail. However, depending on signal coupling and cable length some additional components may be required as shown below.

Note that Fig.2 and Fig.3 show the PLCC package pinout, while Fig.4 and Fig.5 show the QFP package pinout. It is essential that the 100nF decoupling capacitor is connected in the shortest possible way to the GND and VCC pins of the device.

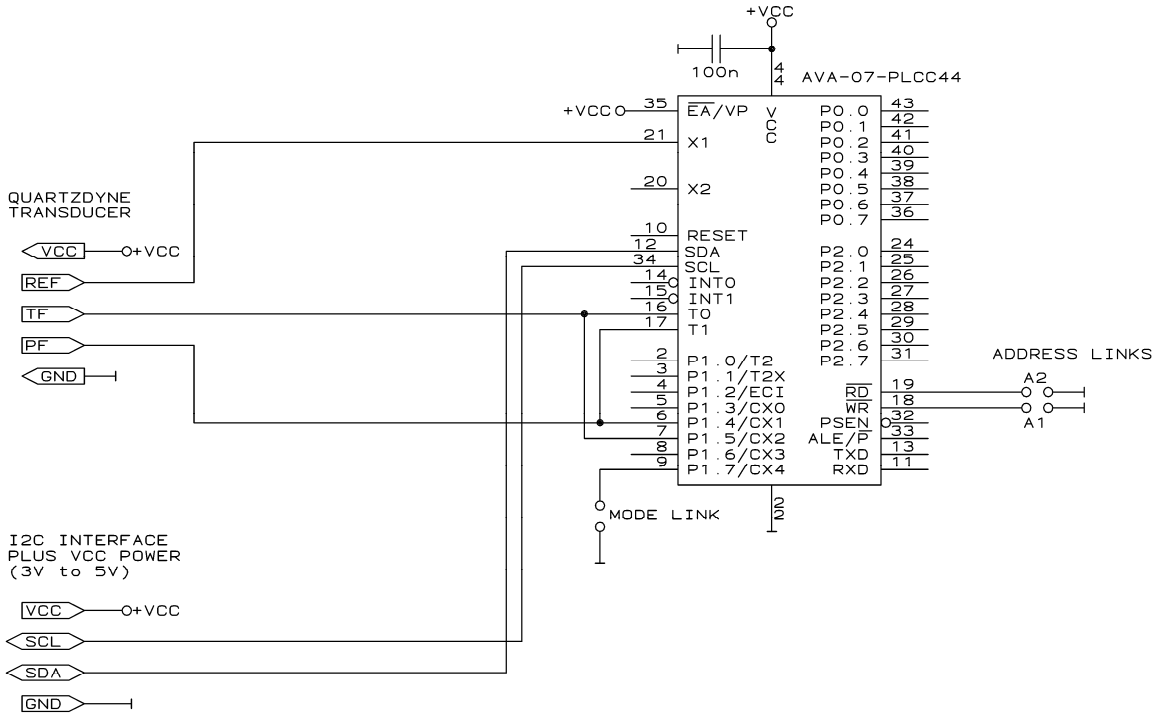

Figure 2: Basic application circuit. Suitable for DC coupled transducer signals and short connection leads only (0.2m max at transducer end, 1m max at I²C end).

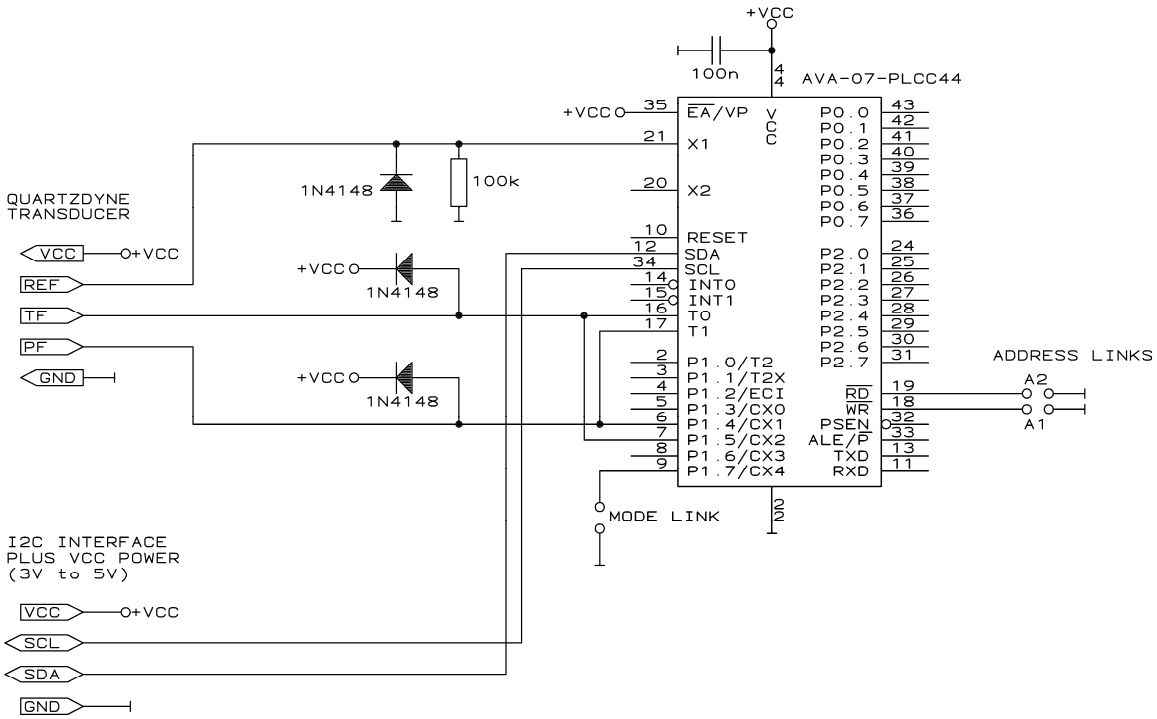

Figure 3: Application circuit with biasing for AC or DC coupled transducer signals. VCC and GND connections of the biasing components should be routed directly to the 100nF decoupling capacitor. Transducer and interface leads should be kept as short as possible (0.2m max at transducer end, 1m max at I²C end)

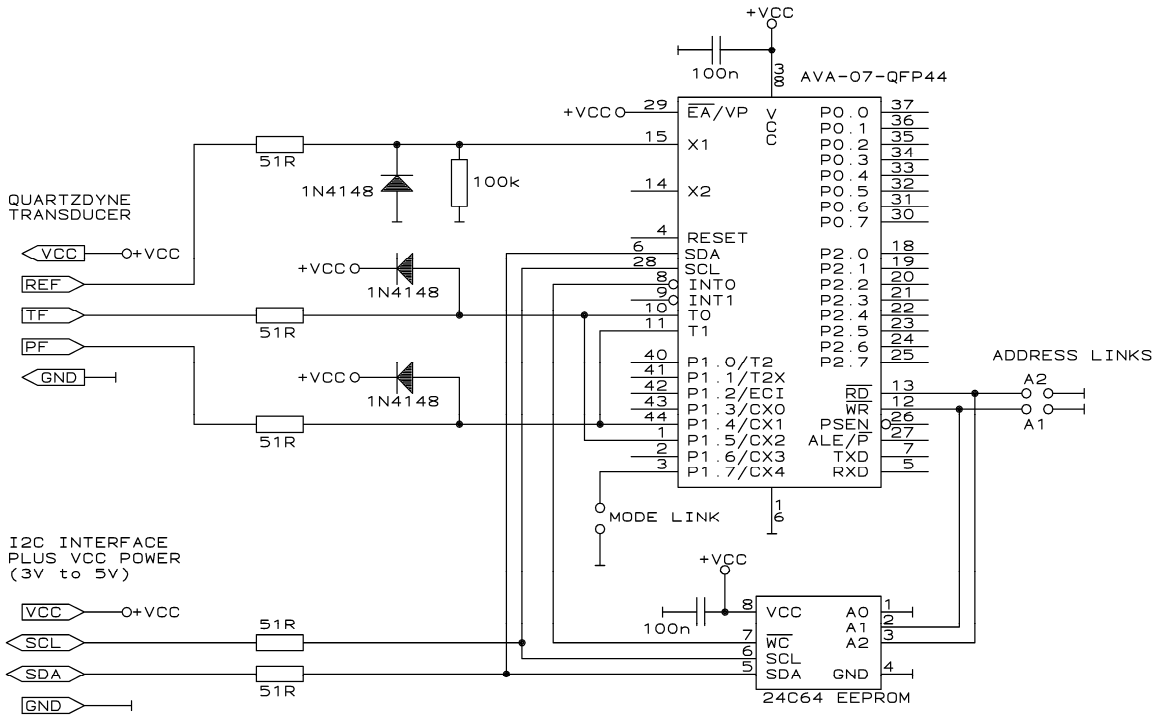

Figure 4: Application circuit with biasing for AC or DC coupled transducer signals, terminated with 51R series resistors for use with slightly longer cables (0.5m max at transducer end, 2m max at I²C end). Includes serial EEPROM for storing calibration coefficients.

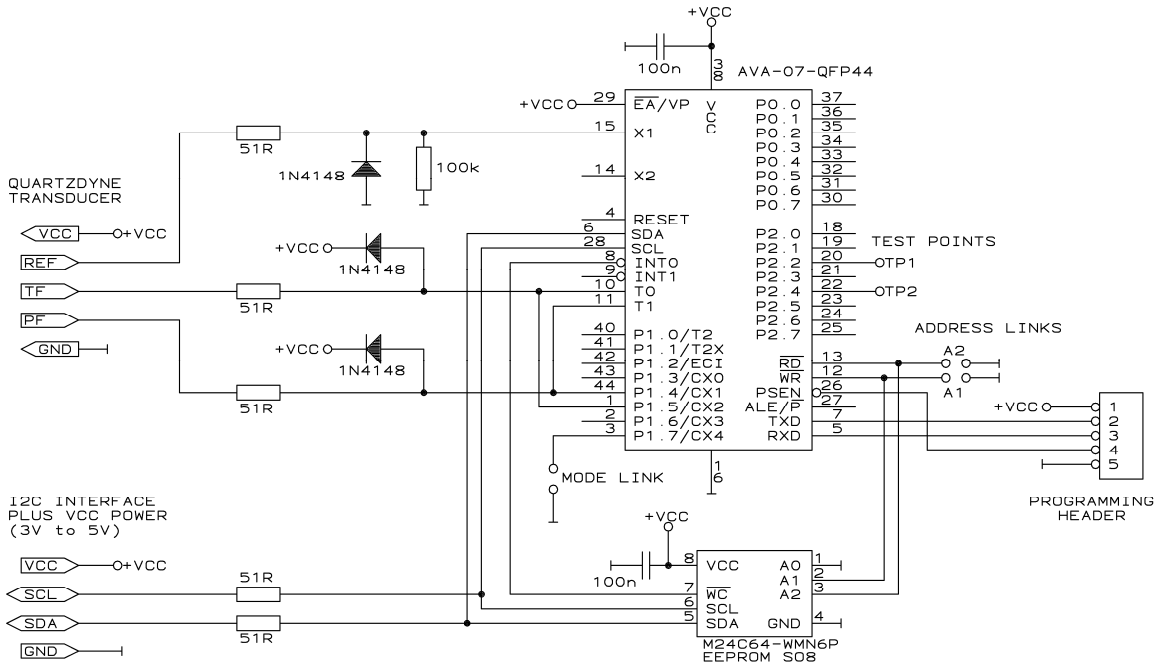

Figure 5: Schematic of the Demo Board (AVA-07-DEMO), available ready built on FR4 circuit board.

Figure 6: AVA-07-DEMO board measuring 2.75" x 0.7" (69.85mm x 17.78mm).

4. I²C INTERFACE

The implementation of the I²C Interface in Digital Quartzdyne Transducers is somewhat unusual, as it occupies two separate device addresses, one for pressure and one for temperature. This places a significant restriction on the implementation in a microcontroller with byte wide I²C support.

Most microcontrollers, including the 8051 used in the AVA-07 can only respond to a single device address at any given time, i.e. the microcontroller can be configured to respond to a pressure query or to a temperature query, but not to both at the same time.

As a work around, the AVA-07 alternates between two I²C device addresses. It starts up configured to respond to a pressure query. If it is queried for temperature, it does not respond in that state. If it is queried for pressure, it returns the latest reading and then

reconfigures itself for a temperature query. The AVA-07 assumes that a pressure query is always followed by a temperature query and vice versa.

The AVA-07 does support a control byte write access, but only if address bit A0 matches the current device address configuration. A0 is marked as X (don't care) in the Quartzdyne user manual, i.e. a control byte write access may be issued with A0=0 or A0=1. If the control byte write access follows a pressure query, then A0 should be 1. If the control byte write access follows a temperature query, then A0 should be 0. Otherwise the write access will not be recognised. To ensure that a control byte access is successful, it can be issued twice, once with A0=0 and once with A0=1. A control byte access does not alternate the address configuration and therefore does not interfere with the normal sequence of pressure and temperature queries.

A control byte write access sets a flag, causing the following read access to return the status byte or the FPGA identifier instead of temperature or pressure data. However, the AVA-07 only responds if configured for the correct device address at the time of the query. Therefore, a FPGA identifier query can only work after a temperature query and a status byte query only after a pressure query. Neither the FPGA identifier query nor the status byte query alternate the address configuration and therefore do not interfere with the normal sequence of pressure and temperature queries.

Writing to the control byte is needed to clear the write protection line (pin-7) of the serial EEPROM shown in Fig.4 and Fig.5. This is only required, if the contents of the EEPROM is to be changed. Reading from the EEPROM does not involve the control byte. Access to the EEPROM itself is not affected by the limitations of the AVA-07. The EEPROM has its own device address and operates independently.

Table 1: I²C Summary

I²C Command	**Condition**	**Result**
Pressure query	After power-up or preceded by a temperature query	Pressure data is returned
	Preceded by a pressure query	No response
Temperature query	Preceded by a pressure query	Temperature data is returned
	After power-up or preceded by a temperature query	No response
Write to control byte with A0 = 0	After power-up or preceded by a temperature query	Control byte is written
	Preceded by a pressure query	No response
Write to control byte with A0 = 1	Preceded by a pressure query	Control byte is written
	After power-up or preceded by a temperature query	No response
Status byte query	Preceded by a pressure query	Status byte is returned
	After power-up or preceded by a temperature query	No response
FPGA identifier query	After power-up or preceded by a temperature query	FPGA identifier is returned
	Preceded by a pressure query	No response

I²C Command	Condition	Result
Read from EEPROM	Always	EEPROM data is returned
Write to EEPROM	Write protection cleared through control byte access	Data is written to EEPROM
	Write protection is not cleared	Data is not written to EEPROM

Due to the I²C restrictions described above, it is not possible to guarantee that the AVA-07 will by default work with any acquisition system that works with Digital Quartzdyne Transducers.

However, the AVA-07 has been tested to work with the AVA-03 Digital Quartzdyne Tester and also with Quartzdyne's Q-Link interface, and generally should work with any equipment that generates alternating pressure and temperature queries.

If in doubt, please contact Avanti for guidance.

Note that a complete 4-channel Frequency Transducer to Q-Link interface (Model No. AVA-08) is also available, which includes 3V to 5V step up circuitry to support legacy transducers.

5. RESOLUTION

The resolution of the pressure / temperature measurement depends on the gate time used by the internal counters. Depending on the MODE link, the gate time is either fixed at 1sec or self-adjusting between 91ms and 2.8sec according to the I²C query rate. The table below summarises the resolution that can be expected for a number of different gate times.

Table 2: Resolution versus Gate Time

Gate Time	Typical frequency resolution (at 50kHz)	Worst case frequency resolution (at 70kHz)	Typical pressure resolution of 10k transducer (2.7Hz per psi)	Typical pressure resolution of 16k transducer (2.4Hz per psi)
0.091 sec	0.1526 Hz	0.2137 Hz	0.0565 psi	0.0636 psi
0.182 sec	0.0763 Hz	0.1068 Hz	0.0283 psi	0.0318 psi
0.273 sec	0.0509 Hz	0.0712 Hz	0.0188 psi	0.0212 psi
0.364 sec	0.0382 Hz	0.0534 Hz	0.0141 psi	0.0159 psi
0.455 sec	0.0305 Hz	0.0427 Hz	0.0113 psi	0.0127 psi
1.001 sec	0.0139 Hz	0.0194 Hz	0.0051 psi	0.0058 psi
1.456 sec	0.0095 Hz	0.0134 Hz	0.0035 psi	0.0040 psi
2.002 sec	0.0069 Hz	0.0097 Hz	0.0026 psi	0.0029 psi
2.821 sec	0.0049 Hz	0.0069 Hz	0.0018 psi	0.0021 psi

6. SPECIFICATION

Supply Voltage	2.7V – 5.5V (absolute maximum)
Supply Current (excluding transducer)	2.45mA @ 3.0V 2.85mA @ 5.0V
Counting Reference	F_{REF} / 2 = 3.6MHz
Update Rate	91ms
Gate Time	91ms – 2821ms (MODE link inserted) 1001ms (MODE link removed)
Package Options	PLCC-44 and QFP-44
Temperature Rating	The device has a manufacturer's rating of 85°C. Oven testing at 165°C is ongoing and the device is still working fine after 6 months so far.

7. CAUTION

- Double check wiring before powering up.
- Do not exceed the maximum supply voltage of 5.5V. Use a current limited power source if possible.
- Do not apply power without a transducer or transducer simulator connected.
- Avoid touching component pins and PCB pads to minimise the risk of damage through electrostatic discharge (ESD).

8. ACKNOWLEDGEMENTS AND FURTHER INFORMATION

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

I²C is a trademark of NXP Semiconductors (formerly Philips).
Specifications and application notes can be downloaded from their web-site at http://www.nxp.com
The following document is of particular interest:
i2c.bus.specification.pdf = I²C Specification and User Manual Rev.03 / 2007

Avanti Part Number: AVA-07- Avanti Serial Number: 0001

Tested: