PIC card manual

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This document describes the PIC card developed for the FERN replacement proxy.

Suggested production testing

The biggest hurdle producing the PIC cards is that shorts or polarity mishaps in the supply rails are hard to troubleshoot when all powersupply components are mounted.

The following assemply sequence is recommended:

1. Mount all SMD components
2. Measure the ground resistance of the +5V supply rail by measuring the resistance across the solder pads for C106 while maintaining correct polarity. Correct resistance is expected to be well above 1kΩ.
3. Measure the ground resistance of the +12V supply rail the same way using the solder pads for C105
4. Measure the ground resistance of the +5V protection rail the same way using the solder pads for Z101.
5. Mount all components except:
    1. Z101
    2. Q101
    3. Q102
    4. Q103
    5. Q401
6. Attach +5V bench supply to Q102 solder pads. Pin2 = GND, pin3 = +5V. Max current draw should be less than 50mA.
7. Disconnect bench supply, mount Q401 attach bench supply again, current draw should still be less than 50mA.
8. Disconnect bench supply
9. Mount Q103
10. Attach +12V bench supply to Q101 solder pads, measure current draw to less than 50mA
11. Detach +12V supply, mount Q102, attach +12V supply again, measure current draw to less than 50mA
12. Detach +12V supply, mount Z101, attach +12V supply again and measure current draw to less than 100mA

13. Detach +12V supply
14. Mount Q101
15. Attach +24V supply to J101, measure current draw to less than 100mA
16. Detach +24V supply. Attach Soekris NET4801 computer via J102. Reattach +24V supply and check current draw less than 500mA.

Assembly is then complete.

Cables between PIC and Soekris NET4801

PIC J401	**NET4801 JP5**	**Signal name**
1	2	MCLR/VPP
2	4	PGM
3	5	PGC
4	6	PGD
5	11	GND
6	N/C	SDC
7	N/C	SDA
8	N/C	SDO

PIC J102	NET4801 JP10	Signal Name
1	1	GND
2	2	GND
3	3	VPWR
4	N/C	N/A
5	N/C	N/A
6	N/C	N/A

Loading Firmware into PIC

With the soekris attached with all three cables, log in via ethernet or serial port and run the following command:

```
/etc/icsp -v /etc/pic18f8720.hex
```

Testing PIC card with onboard test functions

The PIC cards built in test functions can be used via the serial port, with or without the Soekris computer.

Without the soekris computer, connect a straight-through male-female cable from a Pcs serial port and start a terminal program with 9600,N,8,1.

With the Soekris attached, execute the following command on the Soekris:

```
tip com2
```

Proceed as follows:

- Type `<Enter>CLR<Enter>`
- The PIC card should respond with `OK_CLR`. If this does not happen, check connections, power and firmware download.
- If at any point you make a typing mistake and the PIC responds with `ERR`(something) use the `<Enter>CLR<Enter>` sequence to clear the error condition.
- Check loaded firmware version: `ID<Enter>` the reply should be a string like "`REV  1.20 PIC18F8722 64 Pins 40 MHz TEMP`"
- Test I/O pins for shorts and opens with the `PORTTEST<Enter>` command. Follow the instructions. Check the "`bad pins =`" summaries at the end for any pins with trouble.
- If any pins are showing trouble, a squarewave suitable for an oscilloscope can be generated on a pin by entering "`BUZZ $pin<Enter>`". Check the pin for shorts to GND and +5V protectionr rail first to avoid damage to the PIC18F8722 chip.

I/O configuration

The only restrictions on the 64 I/O pins of the PIC card is as follows:

> Only pin 1-16 can be used as Analog inputs and only in sequence from lower to higher. It is possible to configure for instance pin 1-8 as analog inputs, but not pin 1-8 and pin 10 at the same time unless pin 9 is also an analog input.
>
> Pin 60 and 61 are used also for the downloading of firmware, if these are used for real-world interfacing, connector J401 should not be connected to the Soekris. This will prevent firmware updates.
>
> Pins 62-64 may also be used for I2C extensions via J402.

All input pins have a 10kΩ (1%) pull-down resistor which can act as the lower leg of a voltage divider for analog inputs. Please notice that in order to get full 10 bit resolution from the A/D converter a shunt capacitor and calibration will likely be needed.

Calibration of Analog Reference Voltage

The PIC card uses a Maxim MAX6350 voltage regulator to generate a +5.000V ± 1mV reference voltage for the A/D converters in the PIC18F8722 chip.

The actual voltage can be measured across C7 (mounted approximately halfway between the MAX6350 and the PIC18F8722). At least a 5 digit voltmeter is required for this, although gross errors can be detected with normal table instruments.

Notice that C4 mounted right next to C7 carries the normal +5V supply rail which has a ±5 tolerance.

For high precision analog measurements in low-noise setups, MeasureD can be calibrated with the measured value of the analog reference voltage:

```
pic18 $instance vref $voltage
```

Attaching DS18B20 temperature sensors

Maxim/Dallas semiconductors DS18B20 temperature sensors can be attached to any I/O pin of the PIC card, but requires a 2.2kΩ pull up resistor to a +5V supply. The easiest way to do this is to configure a neighbor I/O pin as ”pullup” (this is a shorthand for ype=DOUT + state=high).

Pin 1 and pin 3 of the DS18B20 connects to GND and pin 2 to the I/O pin and pull up resistor.

Coax cable is recommended for cabling these sensors due to the low capacitance per meter and because mounting the DS18B20 at the end of the coax is pretty simple: center pin to center wire, outher pins to screen, wrap in shrink tubing or similar.

PIC card serial commands

Each of the commands available on the serial port of the PIC card is described briefly below. Under normal circumstances the MeasureD program will use these to control and interrogate the PIC card, but during testing and debugging they can also be issued manually from a serial terminal (emulator).

All commands receive a specific reply if they are accepted or ”ERR # xxx aaaaa” if they were not.

”CLR”

This clears an error condition. Error conditions persist and all other commands than ”CLR” are ignored while an error condition exists. On reset, watch-dog timeout or power-on the PIC card starts out in an error condition to be sure to alert MeasureD of the state change.

”ID”

Prints version information for the loaded microcode like this:

REV 1.20 PIC18F8722 64 Pins 40 MHz TEMP

The information it contains are the following:

- ”REV” -- response marker for ID command
- ”1.20”-- CVS version of the source for the microcode
- ”PIC18F8722” -- Microcontroller device identitiy
- ”64 Pins” --number of I/O pins on device
- ”40 Mhz” -- clock frequency of device.
- Optional features:

”TEMP” -- DS18B20 temperature sensor support.

”SHOW”

Prints ”DATA” as response marker followed by the numerical reading or state of each I/O pin.

”DEF $pin $mode”

Configures a particular I/O pin for a particular mode. $pin is an integer from one to the number of pins. $mode can be one of:

”AIN” -- Analog input. Readings range from 0...65535

”DIN” -- Digital input. Readings are zero or one.

”CNT” -- Counter. Counts from 0...65535, then rolls over to zero.

”DOUT” -- Digital output. Values are zero or one.

”TEMP” -- DS18B20 Temperature sensor. Readings (in hex):

0x0hhh -- C° = value / 16

0xFhhh -- C° = (value – 65536) / 16

0x8000 – reading timeout.

0x8001 – CRC error.

0x8002 – Conversion error in device.

0x8003 – Line not pulled up during reset pulse.

0x8004 – Line stuck low during reset pulse.

0x8005...0x80ff – No presence pulse during reset pulse.

0xc0hh – Wrong device family (hh, should be 0x28).

”CONF $pin”

Reports the configuration of a particular pin as follows: ”DEF $pin $mode” for DOUT pins the current state of the pin is appended, for TEMP pins the 64 bit address of the attached sensor is reported.

”SET $pin $value”

Set the state of a DOUT pin to $value. Reponds with ”STAT $pin DOUT $value”

”AVG $avg”

Sets the averaging factor for analog input measurements. $avg must be zero to six included. The value, if larger than zero is used as the shift in a exponential averaging function, the default is six. The averaging works as oversampling and will give the analog inputs higher either better resolution than ten bits or less noise than otherwise. Zero disables averaging and the

raw reading is returned, this is useful to judge the amount of input noise.

Response is ”AVG_OK $a $r” where $a is the averaging factor in bits and $r is the dithering value.

”ADCON2 $v”

Configure a value for the ADCON2 register in the PIC which affects the timing of the analog input conversions (lower six bits only). See the PIC18F8722 datasheet for more information. Response is ”ADCON2_OK $v”.

”TEMPRES $v”

Set the resolution of DS18B20 temperature conversion. $v must be one of 0...3 (incl). See the DS18B20 datasheet for more information. Response is ”TEMPRES_OK $x” where $x is the calculated setting for the sensor.

”BUZZ $pin”

Configure pin as DOUT and generate a squarewave tone on it, until user terminates with a <Return>.

”PORTTEST”

Performs test of all pins by directing user to short the four connectors with a jumper cable.

Error codes from PIC card

”ERR CMD unknown”

An unknown command was received and ignored.

”ERR CNF invalid mode”

Pin can not be configured in requested mode. (Only the first sixteen pins can be analog inputs.)

”ERR CNF invalid pin”

Pin number must be 1...64

”ERR CNF invalid state”

”SET” state must be zero or one.

”ERR CNF not dout”

”SET” applies only to DOUT pins.

”ERR NUM overflow”

Number too large.

”ERR RST reset”

Chip reset, poweron or watchdog reset. The value of the PIC18F8722 ”RCON” register will be printed out this will help diagnose instabilites involving unexpected resets.

”ERR RX linelength”

Too much data received without a CR or NL character.

”ERR RX overrun”

Characters received too fast to process.

”ERR TX busy”

Characters received while transmitting result of previous command.