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Eval Kit Manual

PCap04

Standard Board

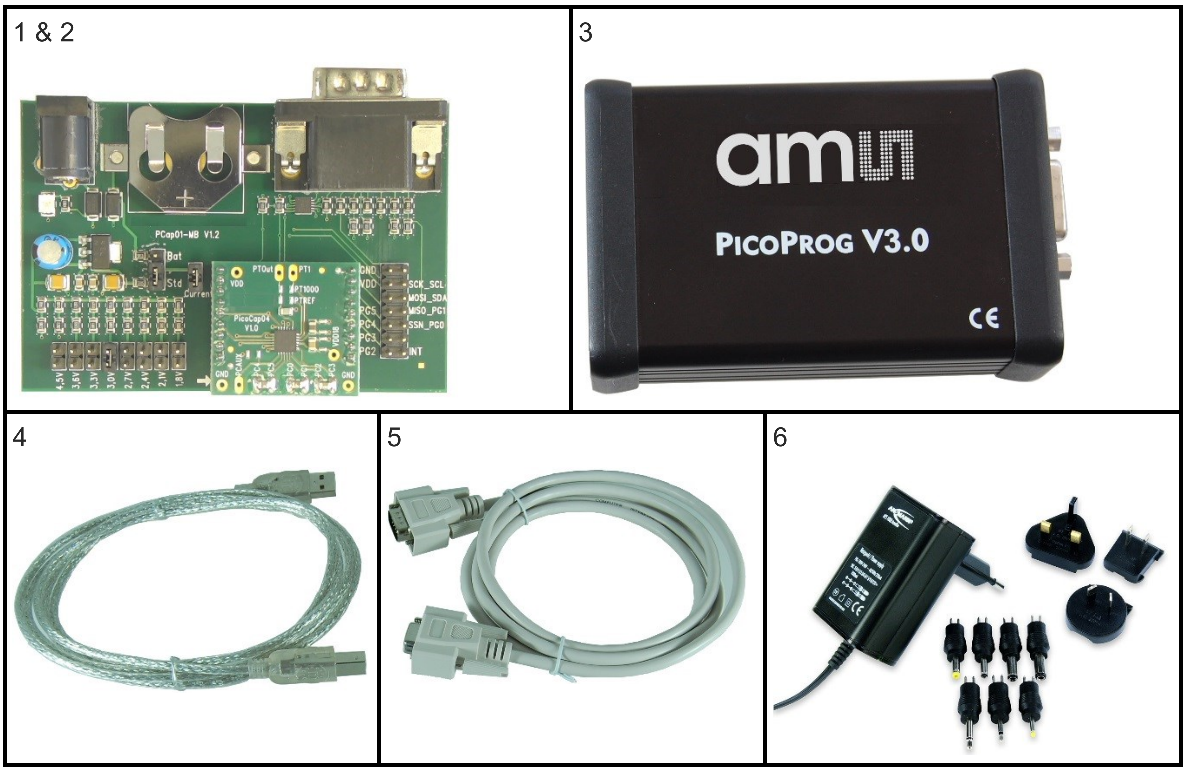
PCAP04-EVA-KIT

Content Guide

1 Introduction

The PCAP04-EVA-KIT evaluation system provides a complete system for generally evaluating the PCapØ4 IC. It is supplied with a main board, a plug-in board, a Windows based evaluation software, assembler software and the PICOPROG V3.0 programming device. The PCapØ4 evaluation board is connected to the PC‘s USB interface through the PICOPROG V3.0 programming device. The previous generation PICOPROG V2.0 programming device may also be used with the PCAP04-EVA-KIT.

Figure 1: Kit Content



Pos.	Item	Comment
1	PCapØ1-MB	Motherboard
2	PCapØ4-EVA-BOARD	Plug-in board based on PCapØ4 in QFN24 package
3	PICOPROG V3.0	Programmer and interface box
4	USB cable	Connects PICOPROG V3.0 to PC
5	High density DSUB15 cable	Connecting Evaluation board to programmer (optionally)
6	Wall power supply unit	9 V

The evaluation kit offers user-friendly operation of the PCapØ4 single-chip solution for capacitance measurement. This kit can be used to evaluate the capacitance measurement, temperature measurement and the pulse generation capabilities of the PCapØ4 chip. The kit also includes a CD-

ROM containing software and data sheets. However, it is strongly recommended to use the latest data sheets and GUI software or get them on request.

2 Quick Start Guide

In this section, we described how to set up quickly the PCAP04-EVA-KIT and establish basic operation and make measurements.

2.1 Install the Software

It is crucial to install the software before connecting the evaluation kit to your computer. A default driver loading of your OS may interfere with correct installation.

- Download the latest zipped software installation package to the desired directory.
- Unzip the package to the desired directory.
- Open “setup.exe” from the unzipped directory.
- Follow the instructions on the screen.

2.2 Install the Hardware:

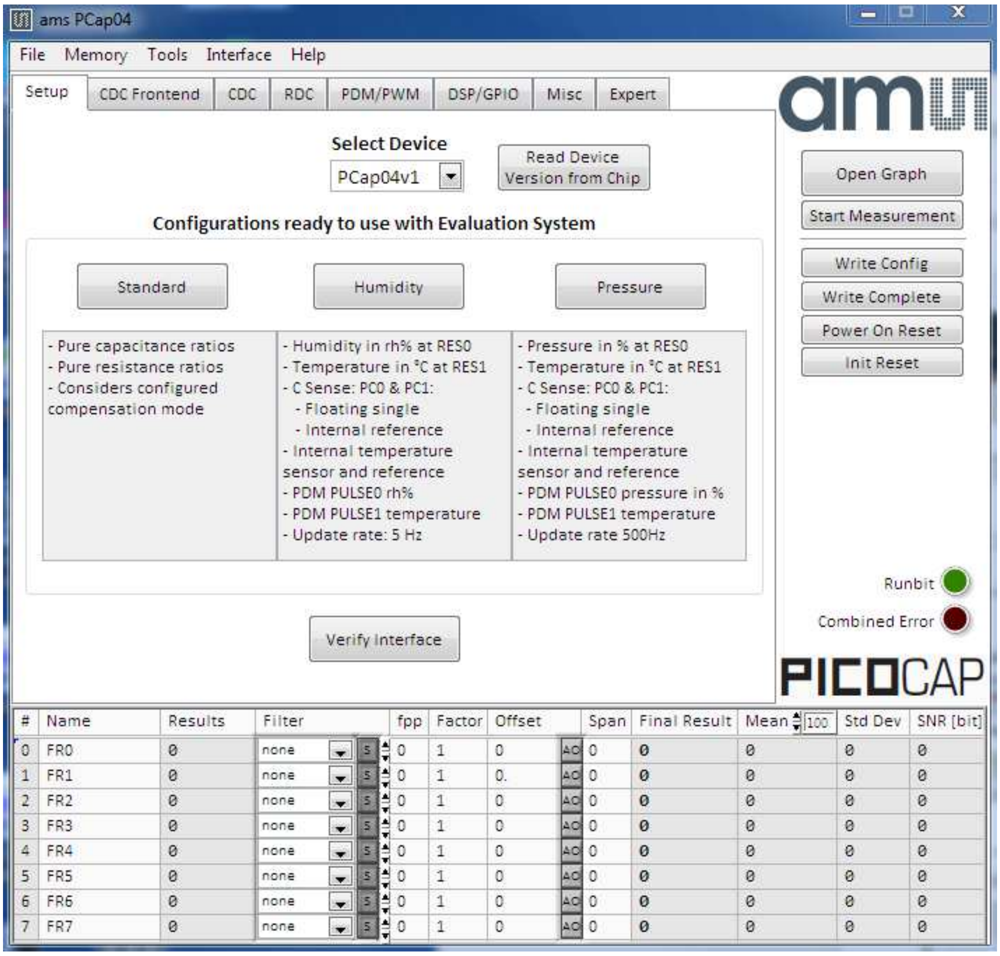
- Install the software before proceeding with this step!
- Connect your computer with the PICOPROG V3.0 using USB cable.
- Connect PICOPROG V3.0 and the evaluation kit motherboard using the DB15 interfaces
- Mount the plug-in board on the corresponding socket on the motherboard.
- Set the power supply unit to 7.5 V output.
- Connect the motherboard to power via the power supply unit. The green LED on the EVA kit motherboard should be on.

Figure 2: Connected PCAP04-EVA-KIT

2.3 Quick Start for Initial Measurements

From the "Start" menu, go to "All Programs" and then to the "acam" directory. Double click the "PCap04 Frontpanel" icon to begin execution of the evaluation kit software. The following screen should appear:

Figure 3: Setup page



Click the "Verify Interface" Button to confirm communication with PICOPROG V3.0 is working:

Figure 4: Verify Message

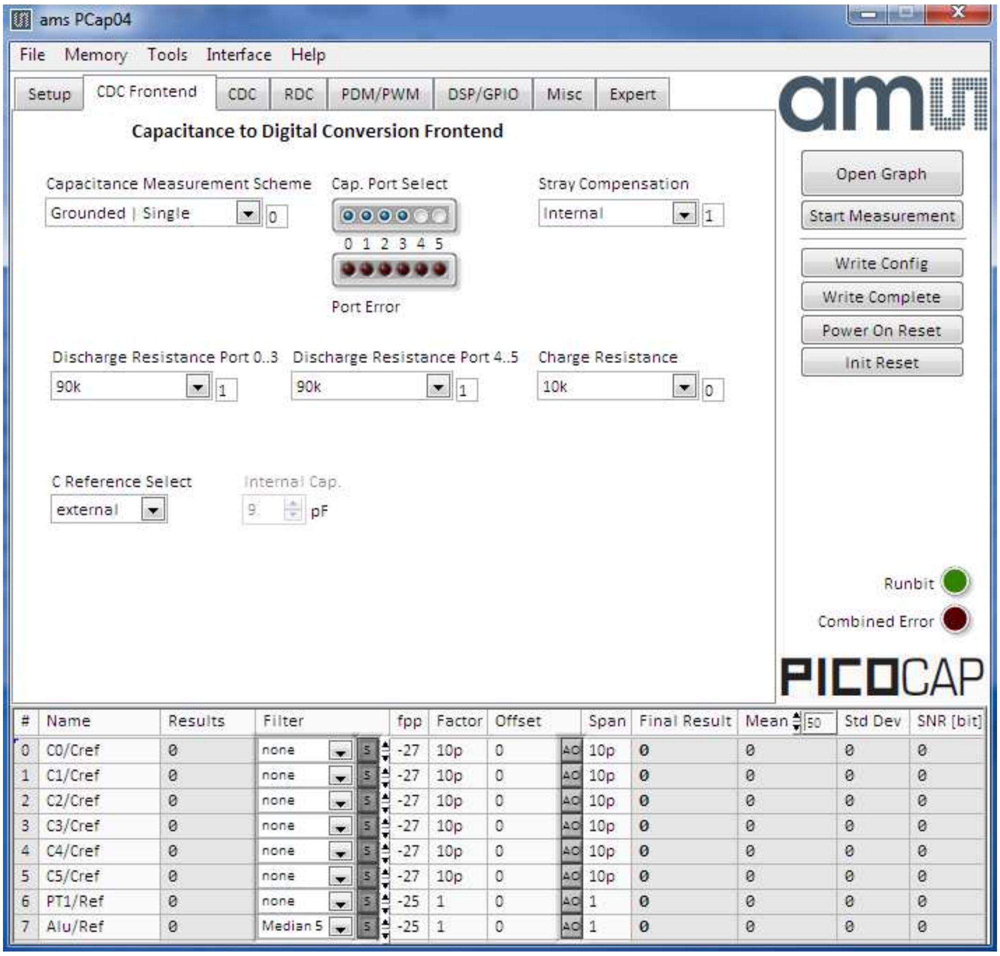
The PCap04 plug-in board is pre-assembled with ceramic capacitors to emulate capacitive sensors. These capacitors, each 10 pF in value, are connected to the 6 ports PC0 to PC5.

To begin measurements using these preinstalled components, it is necessary to make the following adjustments on the “CDC Frontend” tab:

1. “Capacitive Measurement Scheme” section should be set to “Floating | Single”.
2. All the capacitance ports should be turned on using the Cap. Port. Select buttons
3. The Stray Compensation setting should be set to “Both”.

The resulting settings under the CDC tab should look like this:

Figure 5: CDC Frontend page at the start

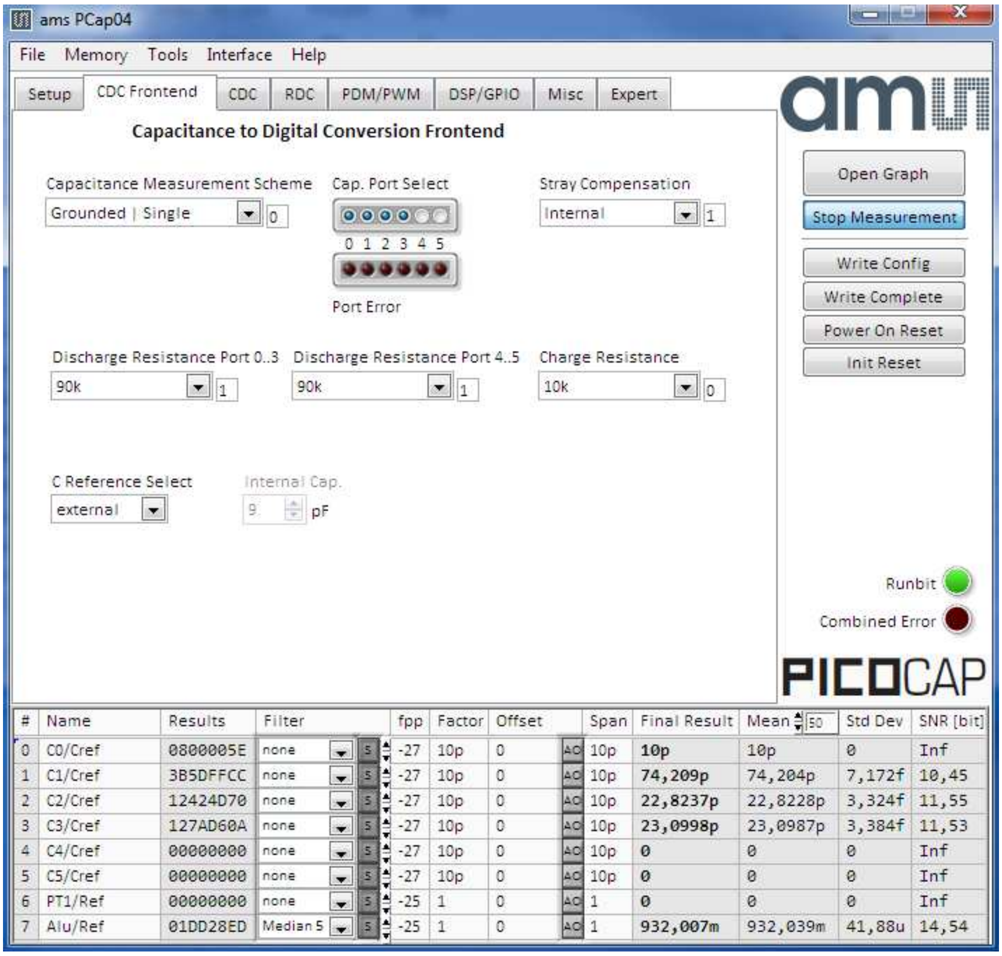


To begin measurements, on the right side of the window, click the following buttons in the order listed:

1. “Power On Reset”
2. “Write Complete”
3. “Start Measurement”

Measurements should now be running and your screen should resemble the following:

Figure 6: CDC Frontend page in use



The C1 and C2 values should be continually updating but remain within a reasonably small standard deviation as shown.

At this point if the above steps have been successfully completed basic operation of the EVA kit should be achieved. The following sections provide a detailed description of the hardware and software for advanced operation.

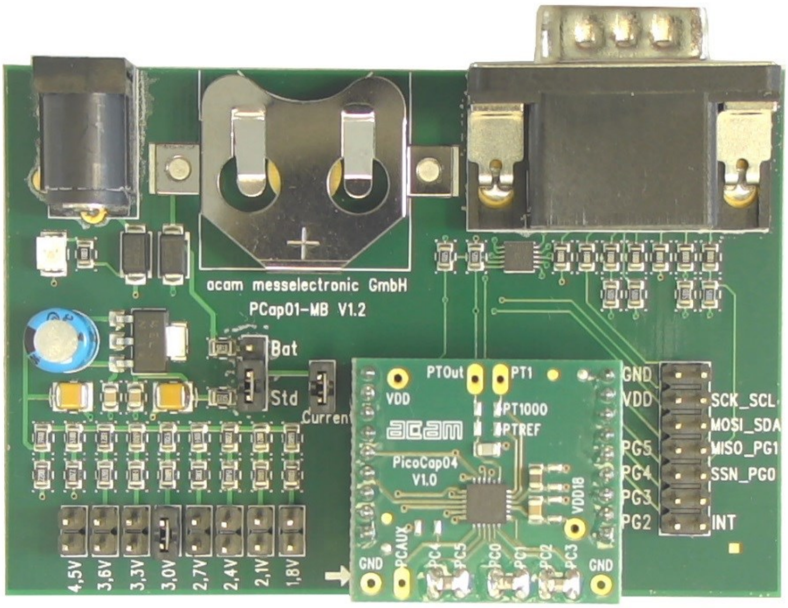
3 Hardware Description

3.1 Connecting Capacitors and Resistors

This evaluation kit can be used for evaluating capacitance measurement by connecting capacitive sensors. Further, it can be used for evaluating temperature measurement by connecting external temperature sensitive resistors or for generating quasi analog voltage (pulse width/density modulated) that is dependent on the sensor connected to the system.

Depending on the purpose of evaluation, a modification has to be made to the same plug-in board. Following is a picture of the Mother board with the plug-in board.

Figure 7: The evaluation kit's motherboard and plug-in board



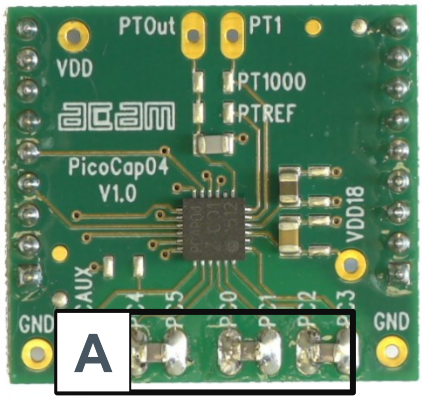
The following sections describe the modifications for each application in detail.

3.2 Hardware Architecture

3.2.1 PCAP04 BOARD

For the purpose of evaluating the capacitance measurement using PCapØ4, the plug-in board is pre-assembled with ceramic capacitors to emulate capacitive sensors. These capacitors, each 10 pF in value, are connected to the 6 ports PC0 to PC5. They are connected as single sensors in floating mode, i.e. each capacitor is connected between 2 ports, and hence there are 3 x 10 pF on-board capacitors. Please refer to section 3 of the PCapØ4 data sheet for more information on how to connect capacitors to the chip. In case using external reference, the capacitor connected between ports PC0 and PC1 is taken as the reference capacitor.

Figure 8: Details of the plug-in board (A=three C0G ceramic capacitors)



In the process of evaluation, when you are comfortable with interpreting the measurement results from the chip, these fixed capacitors can be replaced with the actual capacitive sensors of your application.

If you want to connect your capacitive sensors in grounded mode, then GND points are provided at the two ends of the board, where the sensor ground connections ought to be soldered.

The typical value of the capacitive sensors that can be connected to the evaluation kit lies in the range of 30 pF to 3.5 nF. The reference capacitor should be in the same order of magnitude as the sensor. Depending on the value of the sensor, the value of the internal resistor for performing the measurement has to be selected. For the pre-assembled 10 pF capacitors, an internal discharge resistor of 90 kΩ works well. See section 3 of the PCapØ4 data sheet on how to select the value of the internal discharge resistor.

3.2.2 Temperature Measurement

Temperature measurement or other resistive tasks may also be of interest for the user of this kit. The evaluation kit offers this possibility through the RDC (resistive-to-digital converter) ports. An on-chip thermistor coupled with an on-chip temperature-stable reference resistor made of polysilicon is sufficient for observing the temperature measurement capability of the PCapØ4 chip.

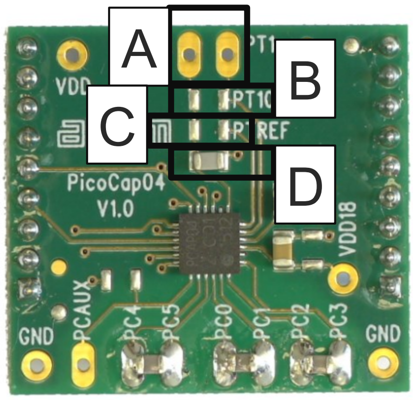


Figure 9 Temperature sensor connection pads

Pos.	Item	Comment
A	Port PT1 for second external temperature sensor	not supported by the standard firmware
B	Port PT0 for external temperature sensor	
C	Port PT2 for external reference resistor	
D	10 nF COG	

However, there is a possibility to connect the reference resistor and the thermistor externally to the chip, too. In case of external resistors, the temperature-stable reference resistor ought to be connected at port PT2REF on the plug-in board. The board allows you to connect the external thermistor, e.g. a PT1000 sensor at port PT0 (or PT1, not supported yet by the standard firmware).

In any case, for the temperature measurement, an external capacitor 10 nF C0G has to be connected to the chip; it is already pre-assembled on board.

3.2.3 Pulse Code Generation

Any of the capacitance or temperature measurement results from the PCapØ4 chip can be given out as a pulse width modulated or pulse density modulated signal. This output can be filtered to generate an analog output signal that can be used for further controlling.

These pulse width or pulse density codes can be generated at Ports PG0, PG1, PG2 or PG3 (in block A). Since ports PG0 and PG1 are used for the SPI Interface in the board, the hardware allows to get a valid pulse width/density modulated signal on PG2 or PG3. However, when I2C communication mode is used the pulsed signals can be optionally obtained on the ports PG0 and PG1.

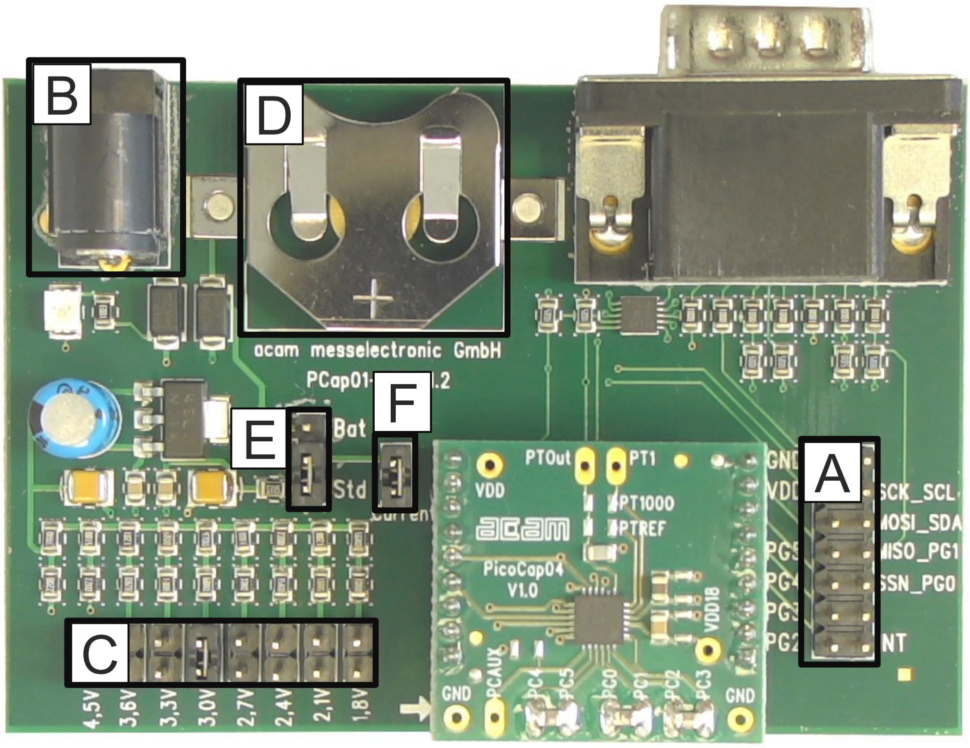


Figure 10 General purpose interface ports PG0 to PG3 in block A

3.2.4 Motherboard

The motherboard connects to the PICOPROG V3.0 programmer. It serves the various power options. It can be powered via wall plug supply (B), the voltage being set from 1.8 V to 4.5 V by jumpers (C). Further, it supports a battery power option (D). The power options are switchable via jumper (E). Power present is indicated by a green LED.

There is a jumper ‘Current’ on the mother board (F). The current consumption of the PCapØ4 chip during operation can be directly measured from these jumper terminals.

All interface signals and general purpose I/O signals can be monitored by means of a separate jumper in block A.

4 Software Description

4.1 Initialization

Configuration files, Firmware, Settings and calibration data are subsumed in a project (.prj) file. When opening a project file then automatically the configuration and firmware data will be transferred to the chip and the chip is initialized.

Step 1: The first to do after starting the evaluation software is to read the device version from Chip by pressing the button or to select the supported PICOCAP device on the setup page. In the initial phase start with our standard firmware that calculates the capacitance ratios and resistance ratios. It automatically recognizes the operation mode and takes care of the set number of capacitors and the kind of connection. But it does no further processing.

Step 2: If you want to change from the default SPI to I2C interface, please select under Interface --> Bus --> I2C. The LED on the PICOPROG V3.0 programmer should now turn red. When the LED does not glow at all, then it indicates that the interface is faulty.

Step 3: By pressing the ‘Standard’-button, the standard project file will be open.

You also may load your own project file.

Step 4: Open Graph window and press ‘Start Measurement’.

4.2 Graphical User Interface

Next, the main front panel comes up. Overall, the graphical user interface offers various windows for on-line configuration, for parameter and calibration data setting, and of course for the graphical and numerical display of the measurement data. The various windows will be explained in this chapter.

4.2.1 Front Panel

This is the main window. On the right side, the front panel shows six general buttons:

Open Graph	Open a window for graphic representation of measurement data
Start Measurement	Start or stop a running measurement
Write Config.	Transfer once more, the present settings in the evaluation software to the chip (in case of doubt)
Write Complete	Transfer the complete firmware, calibration data and configuration to the chip
Power On Reset	After Power up reset, ‘Write Config.’ may be necessary.
Init Reset	With an init reset, the chip is re-initialized with respect to its frontend and processor.

4.2.1.1 Setup Page

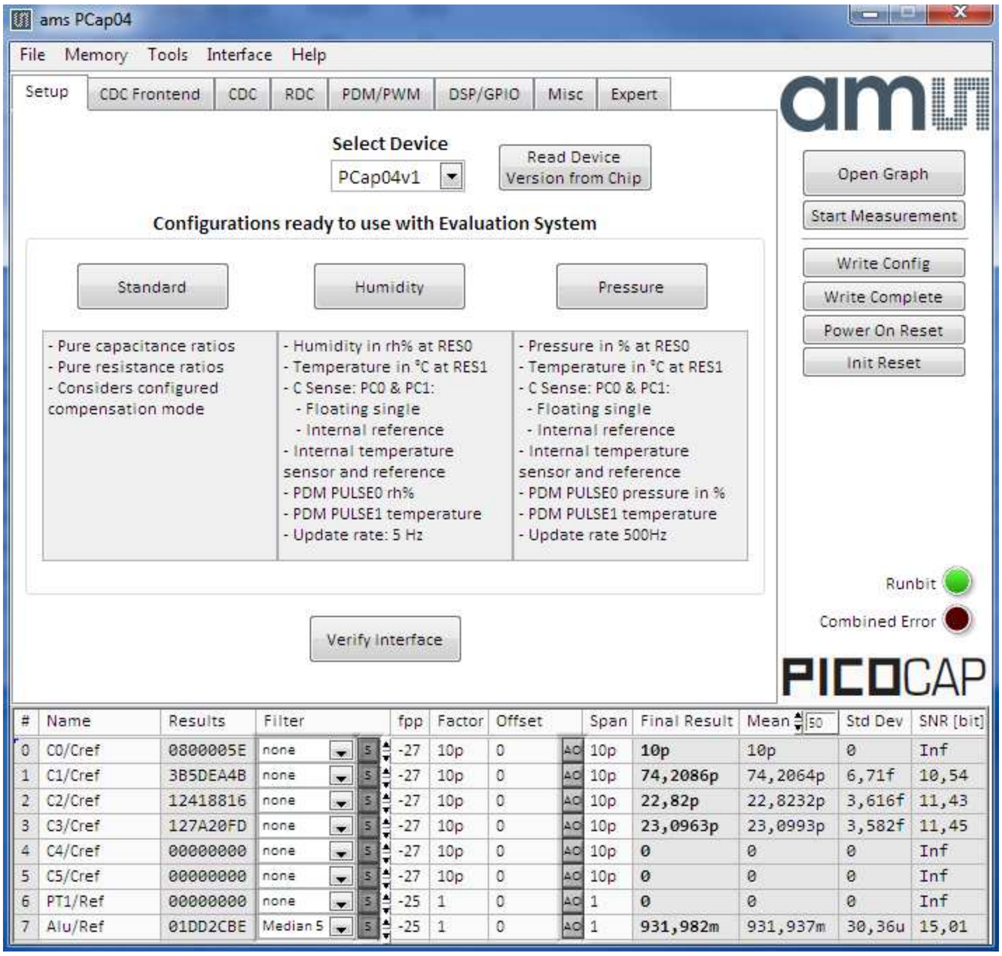


Figure 11 Setup page

Options on ‘Setup’ page:

Select Device	Select the PICOCAP device which you use. <PCap04v0> means silicon version “Z” <PCap04v1> means release silicon version “v1”
Read Device Version from Chip	Reads the device version from chip
Standard	Opens the <*Selected Device*>_standard.prj project file with configuration and standard firmware.
Humidity	Opens the <*Selected Device*>_humidity.prj project file with configuration and linearization firmware.
Pressure	Opens the <*Selected Device*>_pressure.prj project file with configuration and linearization firmware.

Verify Interface	When everything is in order, then pressing this button will indicate the release version number of the software and of the PICOPROG V3.0 Firmware. It also confirms with 'Memory read/write: OK' if a supported PICOCAP device is present.

The lower part of the window is used for real-time numerical display of the measurement results. In principal it shows the content of the read registers. The content itself depends on the firmware. Figure 1-16 shows the content as it is given with the standard firmware. The first six rows show the capacitance ratios, the last two rows show the temperature result (resistance ratio or linearized temperature).

The tab has 12 columns of information, defining labels, data format, resolution specification (white background) and results (grey background). The information in the white fields increase convenience of reading and is stored in the project files (*.prj). All number may get a character to indicate the well-known prefixes for denoting the factor in thousands ('p', 'f', 'a', 'k'...).

Name	Label for the register content, depends on the firmware.
Results	Raw hex data display of the result register content. The column before shows the width. The button column after shows whether the result is signed or unsigned.
Filter	Selection of various software filters like Sinc (rolling average) and Median (non-linear filter).
fpp	This column shows the size of the fractional part of the fixed point number and the necessary shift. Depends on the firmware.
Factor	The factor is a scaling factor that allows to scale the result according to the reference capacitor. Factor = '1' gives back the initial capacitance ratio in column 'Final Result'.
Offset	Offset to be added or subtracted in the evaluation software.
Auto Offset	By pressing [AO], the software re-calculates the 'Offset', setting back the 'Final Result' to 0
Span	Number that defines the maximum span of the sensor. Is relevant only for the calculation of the resolution in column SNR [bit].
Final Result	Display of the final result, scaled by 'Factor' and the 'Offset' added.
Mean	Display of the mean value. The sample size can be selected.
Std.Dev	Standard deviation of the 'Final Result'.
SNR [bit]	Signal-to-Noise ratio in bit, calculated as 'Span'/ 'Std.Dev.'

4.2.1.2 CDC Frontend Page

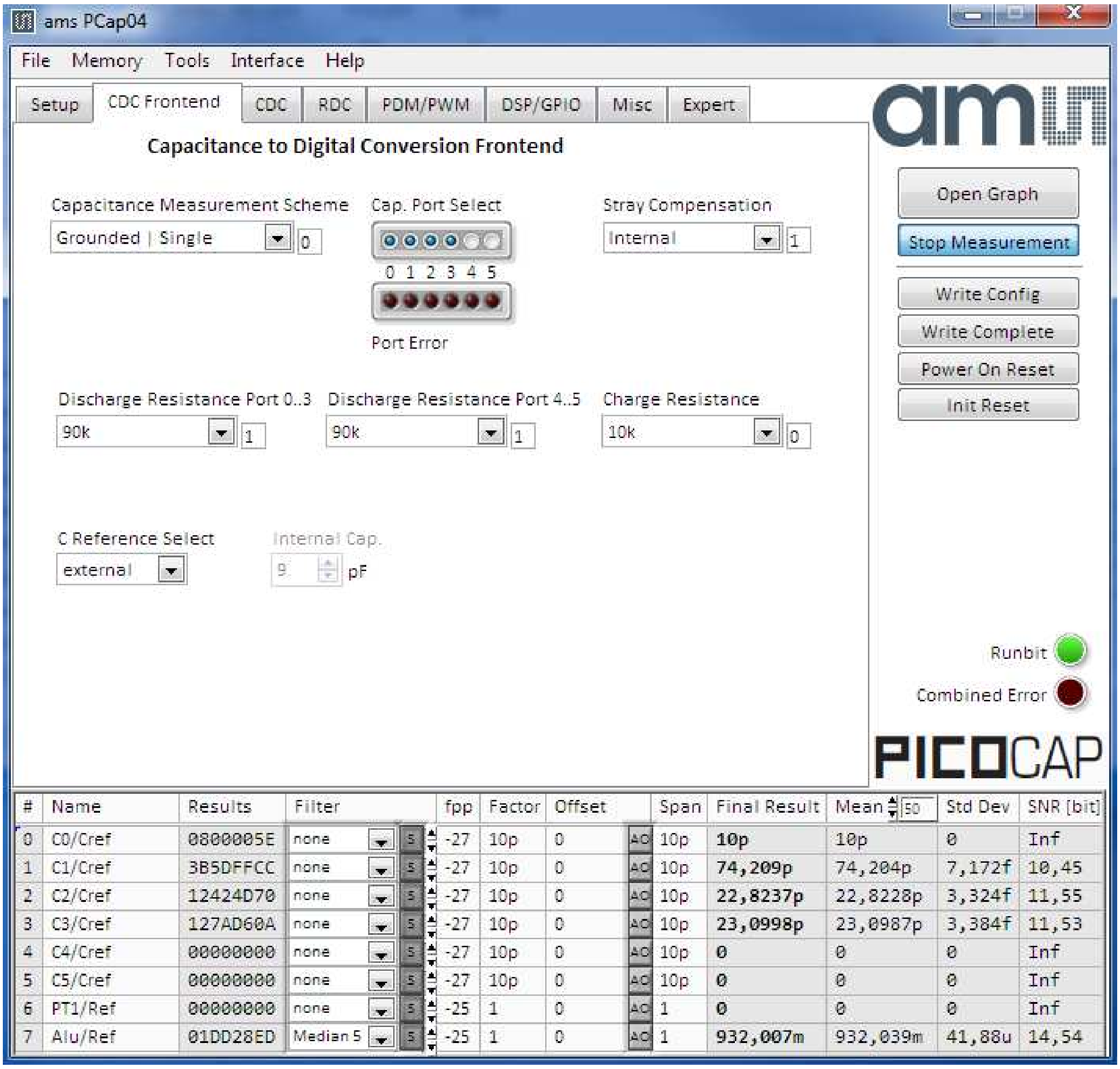


Figure 12 CDC Frontend page

Options on ‘CDC Frontend page:

Capacitance Measurement Scheme	**Grounded | Single** – Single capacitive sensor connected between a port and ground. **Grounded | Differential** – Differential capacitive sensor connected between 2 ports with the middle tap of the sensor connected to ground. **Floating | Single** – Single capacitive sensor connected between 2 ports. **Floating | Differential** – Differential capacitive sensor connected between 2 ports with the middle tap of the sensor connected to another 2 ports.
Cap. Port Select	Select which capacitive ports have to be measured (Ports 0-5), i.e. at which ports the sensors have been connected in hardware.
Stray Compensation	**None** – No compensation **Internal** – One additional measurement performed through only the chip-internal stray capacitance with respect to ground. **External** – One additional measurement per port pair, performed through a parallel connection of the capacitance at the two ports with respect to ground. **Both** – Both internal and external compensation together.
Discharge Resistance Port 0..3	Selects the value of the internal resistance (180k, 90k, 30k, 10k) for measurements on port PC0 to PC3 through which the discharge cycles during measurement are to be performed. This value has to be selected in accordance with the capacitance value of the sensor.
Discharge Resistance Port 4..5	Selects the value of the internal resistance (180k, 90k, 30k, 10k) for measurements on port PC4 to PC5 through which the discharge cycles during measurement are to be performed. This value has to be selected in accordance with the capacitance value of the sensor.
Charge Resistance	Choice of one out of 4 on-chip charging resistors (180k, 10k) for the CDC. Permitting to limit the charging current and avoiding transients.
C Reference Select	Switching between external and internal reference capacitance.
Internal Cap	Selection of internal reference capacitance value. (0..31pF)

4.2.1.3 CDC Page

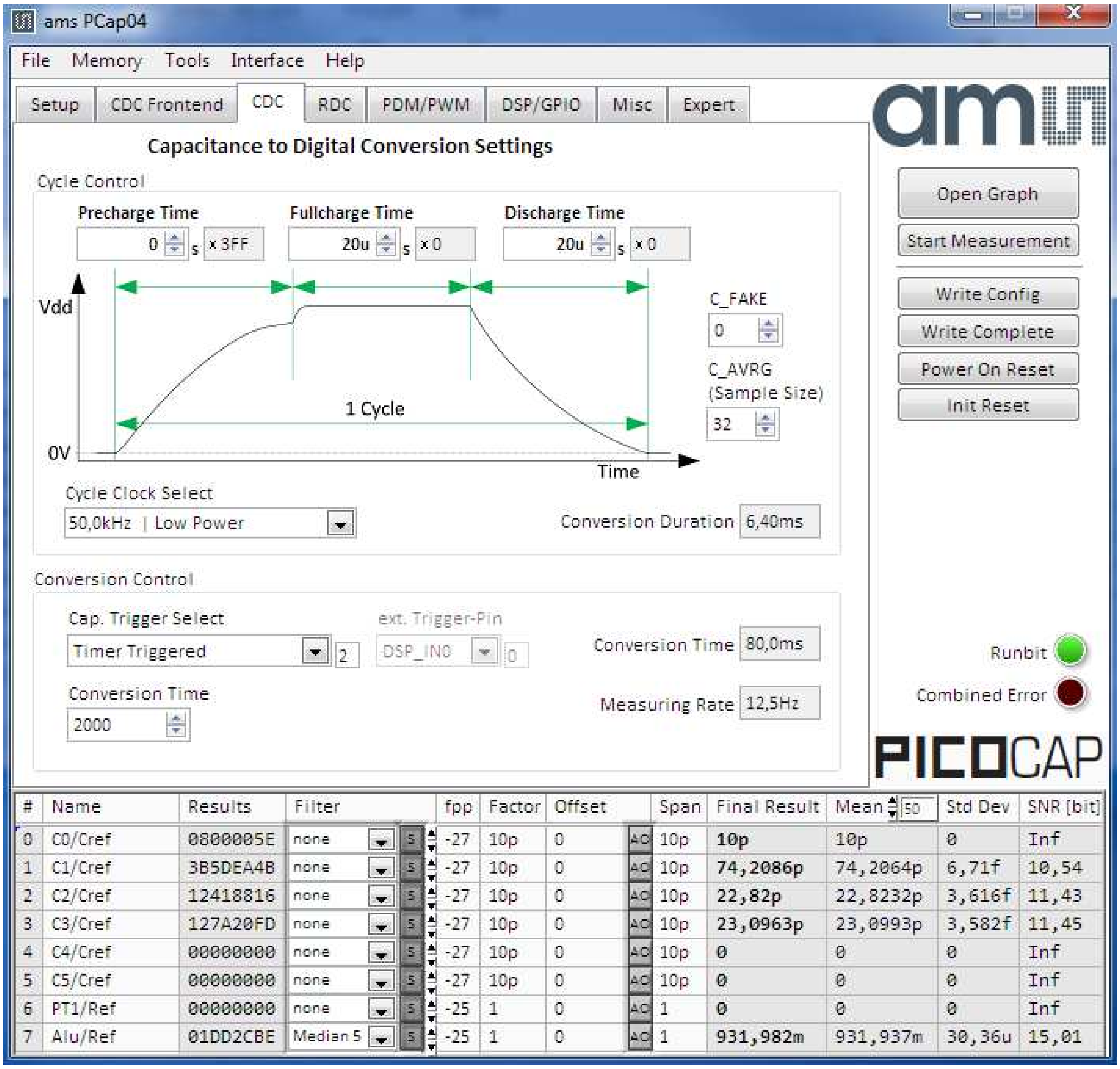


Figure 13 CDC page

Options on ‘CDC page:

Cycle Control

Precharge Time	Time to charge via resistor for current limitation, can be set in multiples of the cycle clock
Fullcharge Time	Time for final charge without current limitation, can be set in multiples of the cycle clock
Discharge Time	Time to discharge the capacitor, can be set in multiples of the cycle clock
C_FAKE	Number of fake measurements per measurement cycle. Performing fake measurements may help in reducing noise.

C_AVRG	Enables averaging the measurement results over multiple measurement cycles. Setting to 1 → No averaging, Setting to any number N, will result in averaging over N measurement cycles for generating one measurement result. (0..8191)
Cycle Clock Select	**50,0kHz | Low Power** – Single capacitive sensor connected between a port and ground. **500kHz | High Speed/4** – Differential capacitive sensor connected between 2 ports with the middle tap of the sensor connected to ground. **2,00MHz | High Speed** – Single capacitive sensor connected between 2 ports.
Conversion Duration	Displays the entire conversion duration per cycles for averaging and fake measurements.
C_TRIG_SEL	Selects the source that triggers the start of a capacitance measurement **Continuous** – Continuous measurement, self-triggering. Recommended when no temperature measurement is made in parallel. **Read Triggered** – Triggered by read out **Timer Triggered** – Depending on the setting the 'Conversion Time'. Generally recommended setting → less prone to error conditions. **Timer Triggered (Stretched)** – Depending on the setting the CONV_TIME. The parameter is used as sequence period. **Pin triggered** – Triggered by external Pin, selectable from option ext.Trigger-Pin **Opcode Triggered | Off** – Started by SPI Command 0x8C **Continuous (exp.)** – (not recommended)
Ext. Trigger-Pin	Used to select the pin to be used as the source of trigger for the capacitance measurement. NOTE: In the delivered EVA board, the pins DSP_IN0 and DSP_IN1 are part of the SPI communication interface, hence only DSP_IN2 and DSP_IN3 selections are relevant.

Conversion Control

CONV_TIME	Sets the conversion time in multiples of twice the period of the low-frequency clock
Conversion Time	Displays the entire conversion time per measurement.
Measuring rate	Displays the frequency at which capacitive measurement data is transferred from the DSP to the interface (SPI or I2C).

4.2.1.4 RDC Page

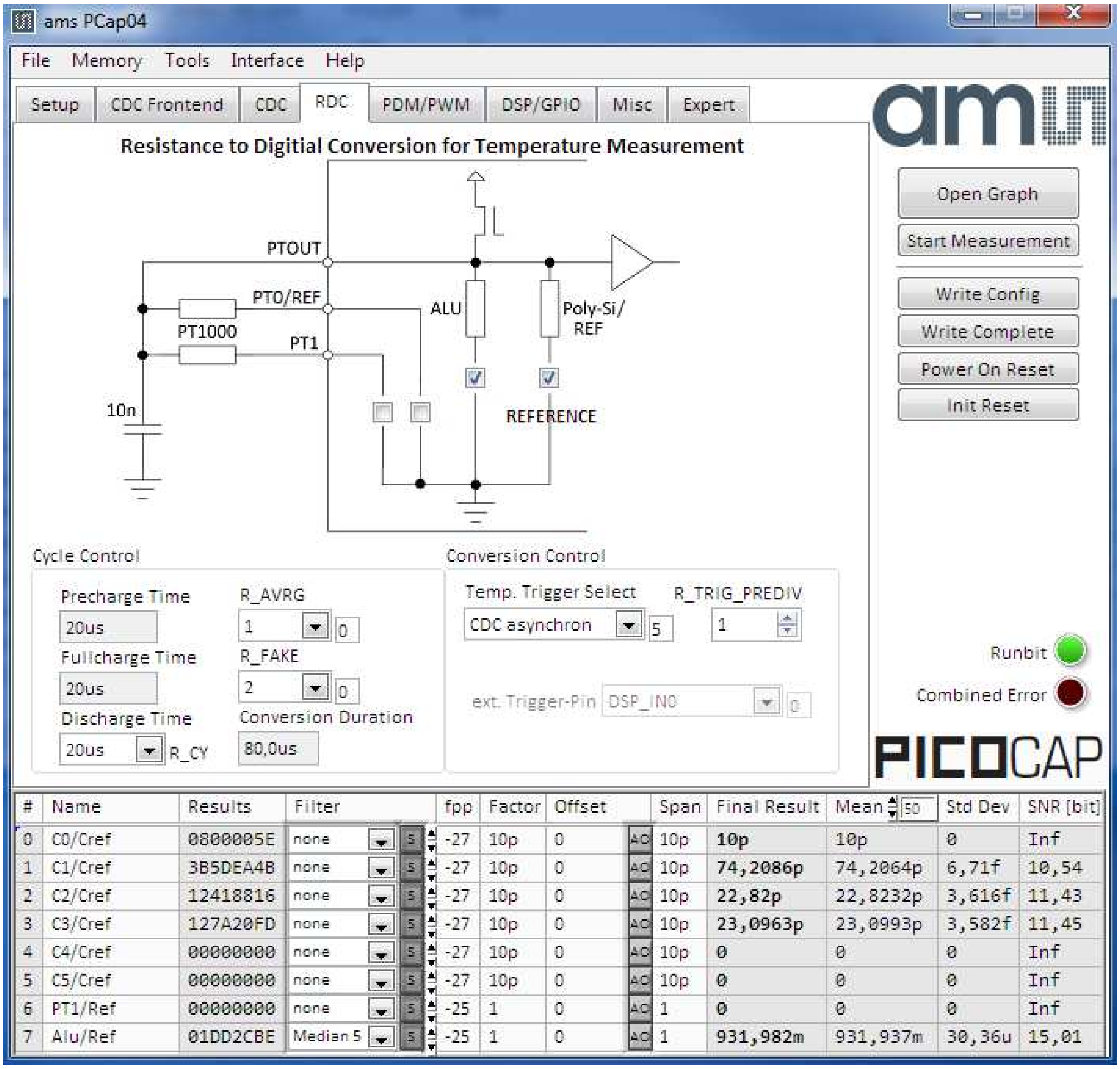


Figure 14 RDC page

Options on 'RDC' page:

Temp.Sensor0	To select a thermistor connected to port PT0/REF for temperature measurement. This could be e.g. an external PT1000.
Temp.Sensor1	To select a thermistor connected to port PT1 for temperature measurement.
Temp.Sensor2	To select either the internal aluminum (ALU) thermistor for temperature measurement.
Reference	To select either the internal Poly-Si thermistor or an external reference resistor at port PT0/REF for temperature measurement.

Cycle Control

Precharge Time	Displays the precharge time. It depends on R_OLF_DIV.
Fullcharge Time	Displays the fullcharge time It depends on R_OLF_DIV.
Discharge Time	Set the discharge time. It depends on R_OLF_DIV.
R_AVRG	Set averaging for temperature measurement.
R_FAKE	Set number of fake measurements per temperature measurement cycle.
Conversion Duration	Displays the entire conversion duration per cycles for averaging and fake measurements.

Conversion Control

Temp. Trigger Select	Selects the source that triggers the start of a temperature measurement **Off**: Default setting when no temperature measurement is wanted. In this case, a temperature measurement can still be started by SPI Command 0x8E. **OLF_CLK**: Triggered by Low-frequency oscillator. **Pin-Triggered**: Triggered by external Pin, selectable from option ext.Trigger-Pin **CDC asynchronous**: Depending on the setting in the 'T_TRIG_PREDIV' counter on the RDC page. The DSP is triggered by the RDC end of conversion. If RDC rate is less than CDC rate the DSP is triggered directly from the CDC for inactive RDC conversions. **CDC synchronous**: Depending on the setting in the 'T_TRIG_PREDIV' counter on the RDC page. The DSP is triggered by the RDC end of conversion. Assuming that RDC rate is less than the CDC rate, the inactive RDC conversions are replaced by a delay.
R_TRIG_PREDIV	For CDC and OLF options the RDC measure rate can be reduced by setting a divider.
Conversion Time	Displays the entire conversion time per measurement.
Measuring Rate	Displays the frequency at which capacitive measurement data is transferred from the DSP to the interface (SPI or I2C).
Ext. Trigger-Pin	Used to select the pin to be used as the source of trigger for the capacitance measurement. NOTE: In the evaluation board, the pins DSP_IN0 and DSP_IN1 are part of the SPI communication interface, hence only DSP_IN2 and DSP_IN3 selections can be used.

4.2.1.5 PDM / PWM Page

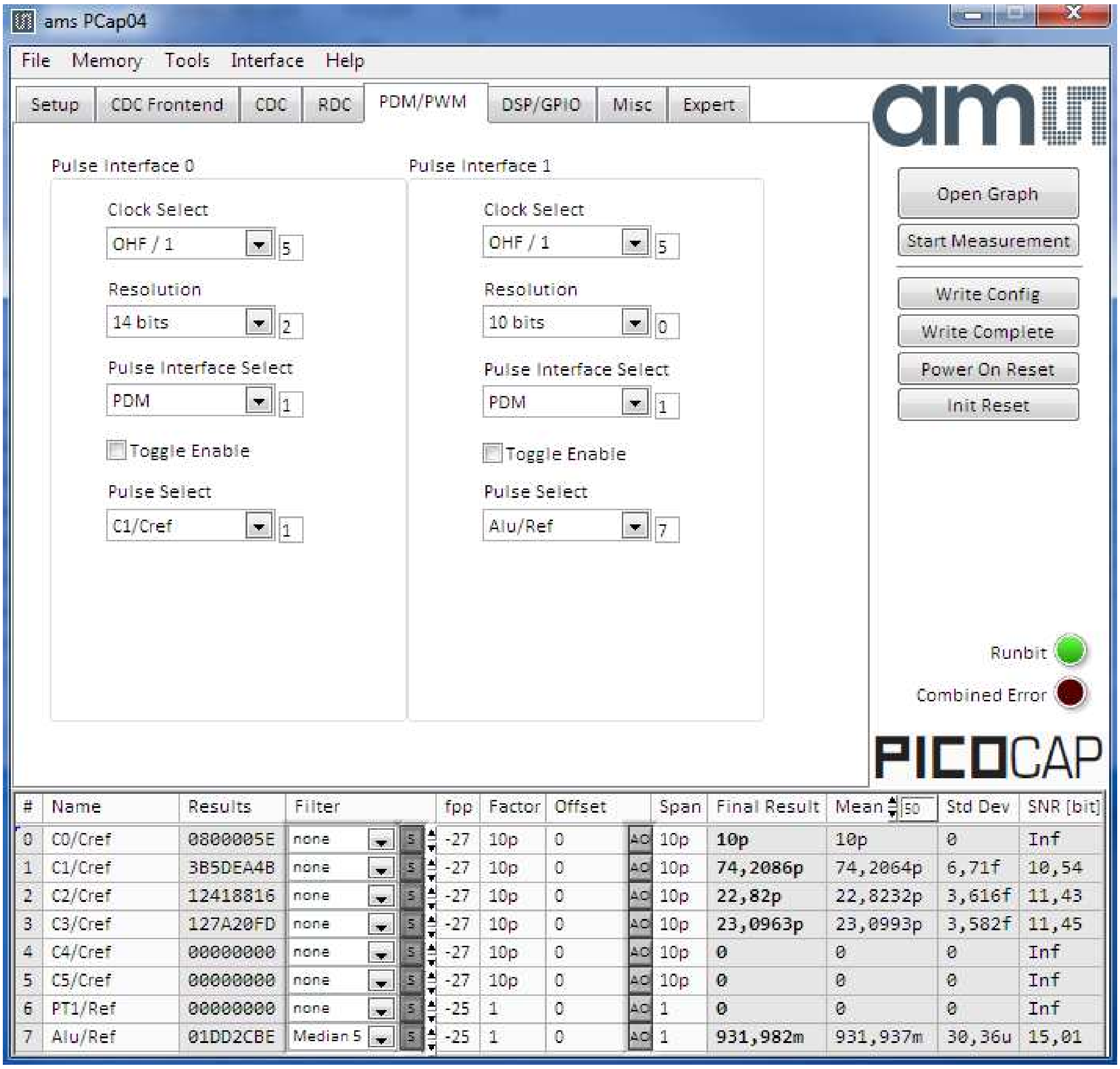


Figure 15 PDM/PWM page

Options on 'PDM / PWM' Page:

Clock Select	Selects the clock frequency to be used for the PWM/PDM generation.
Resolution	Resolution of the output in bits. This resolution also determines the pulsed output range.
Pulse Interface Select	Select the pulse interface – Pulse Width Modulated Output (PWM) or Pulse Density Modulated (PDM) Output. Of the two, the PDM is the recommended interface. With PWM option, 100 kHz clock and 10-bit resolution the resulting PWM output frequency = (100 kHz / 1024) ~ 100 Hz.

Toggle Enable	activates toggle flip flop at Pulse Interface Output, especially for PDM to create 1:1 duty factor
Pulse Select	Select the measurement result which has to be given out as pulsed output – any of the capacitance or temperature measurement results.

4.2.1.6 DSP/GPIO Page

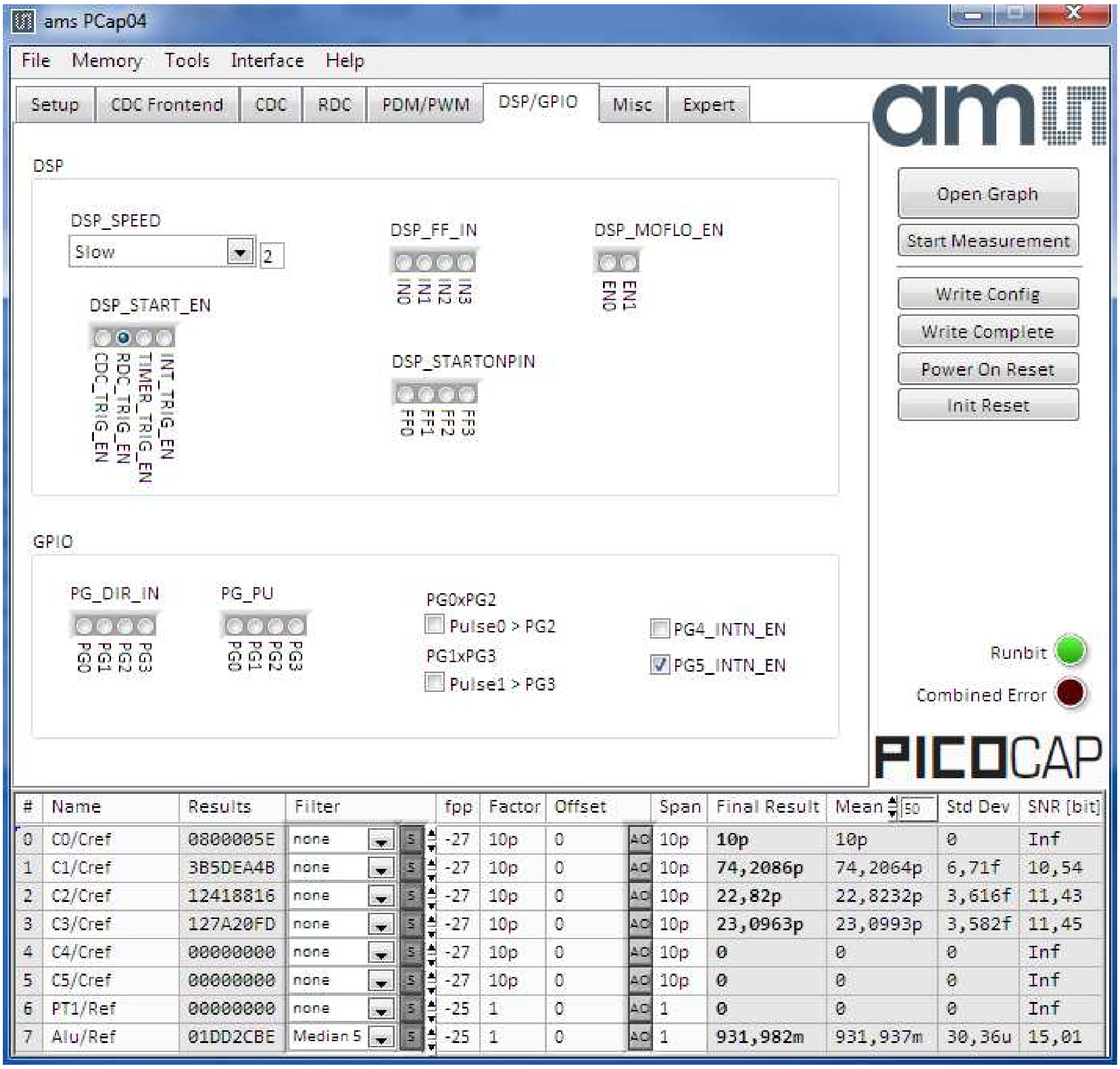


Figure 16 DSP/GPIO page

Options on 'DSP/GPIO' Page:

DSP

DSP_SPEED	Select the DSP Speed. Choose between Fastest, Fast, Slow and Slowest.
DSP_FF_IN	Pin mask for latching flip-flop activation (PG0 to PG3)
DSP_MOFLO_EN	Activates anti-bouncing filter in PG0 and PG1 lines
DSP_STARTONPIN	Not supported by standard firmware The DSP can be started externally by a signal on a pin; these buttons select the pin that has to be sensed for detecting the start signal.
DSP_START_EN	Mask for activating various trigger sources for starting the DSP

GPIO

PG_DIR_IN	To configure the ports PG0-PG3 as input (otherwise output)
PG_UP	To enable the internal pull up on the ports PG0-PG3
PG0_X_PG2	Possible only when the selected interface for communication is IIC. Interchange PortG0 with PortG2. This is useful when the Pulsed output is needed on Port PG0 instead of PG2.
PG1_X_PG3	Possible only when the selected interface for communication is IIC. Interchange PortG1 with PortG3. This is useful when the Pulsed output is needed on Port PG1 instead of PG3.
PG4_INTN_EN	Map the Interrupt output from chip, INTN to Port PG4. This setting is useful for 24 pin QFN package, because the dedicated INTN pin is absent in this version.
PG5_INTN_EN	Map the Interrupt output from chip, INTN to Port PG5. This setting is useful for 24 pin QFN package, because the dedicated INTN pin is absent in this version.

4.2.1.7 Misc. Page

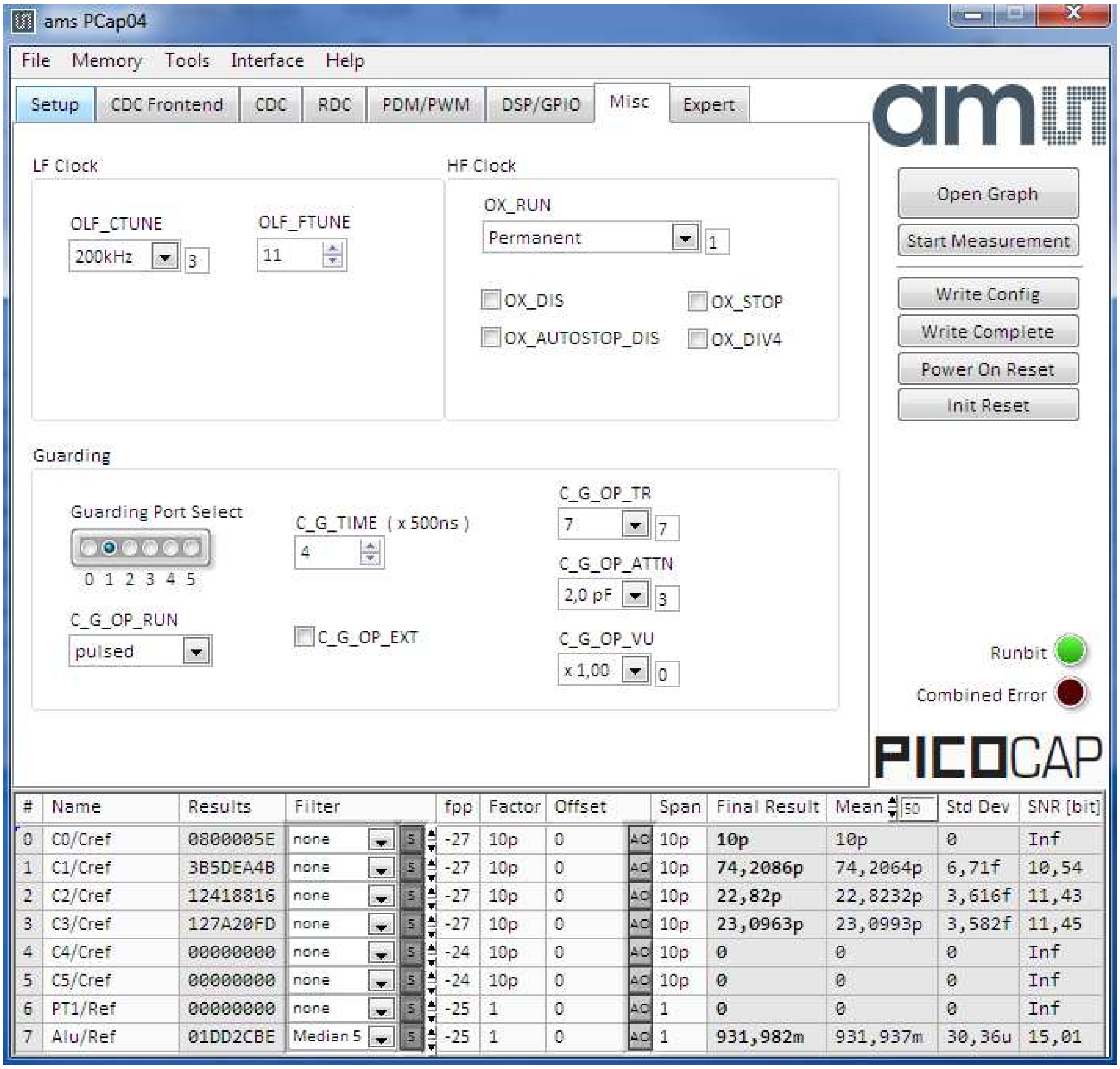


Figure 17 Misc. page

Options on 'Misc.' Page:

LF Clock

OLF_CTUNE	Coarse-tune the low frequency clock. (10kHz, 50kHz, 100kHz, 200kHz)
OLF_FTUNE	Fine-tune the low frequency clock. (0..15)

HF Clock

OX_RUN	Controls the permanency or the latency of the OX generator. Latency means an oscillator settling time before a measurement starts.