

PCap04-EVA-KIT V2.0

Development Kit User Guide

PCAP04-EVA-KIT 2.0

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1 Introduction

The PCap04-EVA-KIT V2.0 evaluation system provides a complete system for generally evaluating the PCap04 IC. It is supplied with a main board, a plug-in board, a Windows based evaluation software, assembler software and the PicoProg Lite communication interface.

The kit includes the following elements:



Figure 1: Elements of the development kit

Please download the software for the kit from <u>https://downloads.sciosense.com/PCAP04</u> and look for the latest revision.

1.1 Ordering Codes

Table 1: Pin description

Ordering code	Part Number	Description
PCap04-EVA-KIT V2.0	220300004	PCap04 LITE board & PicoProg Lite & USB-C cable
PCap04 LITE V1.0 BGRP	220300005	PCap04 evaluation board

2 Quick Start Guide

In this section, we described how to set up quickly the PCap04-EVA-KIT V2.0 and establish basic operation and make measurements.

2.1 Installing 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. <u>https://downloads.sciosense.com/PCAP04</u>
- Unzip the package to the desired directory.
- Open "setup.exe" from the unzipped directory.
- Follow the instructions on the screen.



2.2 Installing the Hardware

- Connect the PicoProg Lite PCB to the computer by means of the USB cable. The green LED should be on.
- Connect the PCap04 LITE to the PicoProg Lite. Two connectors are available, one for SPI communication and one for I2C communication. They are marked accordingly.

2.3 Quick Start for Initial Measurements

In the START menu search for PCap04 or look under program folder ScioSense for the PCap04 software and start it. The software pops up with the following window:

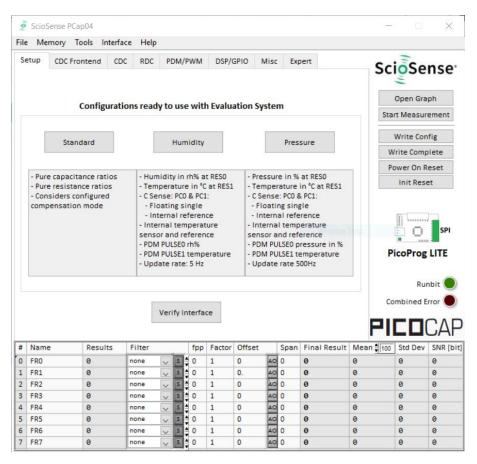


Figure 2: Start page

On the right site a little icon indicates whether a device is connected and whether SPI or I2C is used.

Click the "Verify Interface" button to confirm communication with PicoProg Lite and PCap04 is working:





- C Sense: - Floatin	2 ×	PC1:
- Interna - Internal sensor an - PDM PUL - PDM PUL - Update r	Software Version: 2.0 PicoProg Firmware Version: N/A PicoProg Lite Firmware Version: Memory read/write: failed	rence eratur erence ressur empera DOHz
	ОК	

Figure 3: Verify

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:

10	ScioSense PCap04										×				
File	File Memory Tools Interface Help														
Setup CDC Frontend CDC RDC PDM/PWM DSP/GPIO Misc Expert										6.	E				
	Ca	pacita	nce to l	Digital C	onvers	sion I	Fronter	nd				SC	oSe	nse	
	Capacitance N	leasure	ement So	theme	Cap. Po	rt Sel	ect		Stray	Compe	nsation		Open Graph		
	Grounded Single 🔽 0 OOOOOO Both 🗸 3								Sta	Start Measurement					
	0 1 2 3 4 5										Write Con	fig			
					Port Erro							w	rite Comp	lete	
					PORTER	Dr						Po	ower On R	eset	
	Discharge Re	sistanc	e Port 0.	.3 Disch	narge Re	sista	nce Port	t 45	Charg	e Resi	stance		Init Rese	et	
	180k	\sim	0	180k			~ 0		10k		~ 0				
	C Reference S	elect	Int 0	ernal Caj								Co	icoProg Rur mbined E	nbit 🔵	
#	Name	Resu	lts	Filter		fpp	Factor	Offse	t	Span	Final Result	Mean	Std Dev	SNR [bit	
0	FR0	0	1	none	~ S \$	0	1	0	AO	0	0	0	0	0	
1	FR1	0	1	none	~ S 🛊		1	0.	AO		0	0	0	0	
2	FR2	0		none	✓ S ‡		1	0	AO		0	0	0	0	
3	FR3	0		none	~ S	0	1	0	AO	0	0	0	0	0	
4	FR4	0		none	✓ S ↓	0	1	0	AO	-	0	0	0	0	
5	FR5	0		none	~ S	0	1	0	AO	-	0	0	0	0	
6	FR6	0		none	✓ S	0	1	0	AO	0	0	0	0	0	
7	FR7	0		none	~ S	0	1	0	AO	0	0	0	0	0	

Figure 4: 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:

10	ScioSense PCa	p04											×
File	e Memory To	ols Interfa	ce Help										
S	etup CDC From	ntend CDC	RDC P	DM/P	WM	DSP/0	SPIO I	Misc	Exp	pert	6.	Eco	
	Caj	pacitance to	Digital Co	vers	ion F	ronter	nd				50	ioSe	nse
	Capacitance Measurement Scheme Cap. Port Select Stray Compensation											Open Gra	ph
	Grounded Si	prove	-	000			-	nter		~ 1	Sto	p Measur	ement
												Write Con	fig
			6								V	/rite Comp	lete
			Po	rt Erro	or						P	ower On R	eset
	Discharge Res	istance Port	03 Dischar	Pe Re	sista	nce Port	4 5 0	harg	e Resi:	stance		Init Rese	>t
	90k		90k	Berne		~ 1	-	Ok		~ 0			
	external 🗸	2	pF								Co	Rur mbined E	nbit 🥥 rror 🔵
#	Name	Results	Filter		fpp	Factor	Offset		Span	Final Result	Mean \$ 50	Std Dev	SNR [bit]
0	CO/Cref	080000A	none 🗸	s 🛊	-27	10p	0	AO	10p	10p	10p	0	Inf
1	C1/Cref	0802A898	none 🗸	s s	-27	10p	0	_	10p	10.013p	10.0131p	115.2a	16.41
2	C2/Cref	07F184AC	none 🗸	5	-27	10p	0	AO		9.92929p	9.92932p	95.2a	16.68
3	C3/Cref	07F9A218	none 🗸	5	-27	10p	0	AO		9.96891p	9.96896p	116.2a	16.39
4	C4/Cref	00000000	none 🗸	5	-27	10p	0	AO		0	0	0	Inf
5	C5/Cref	00000000	none 🗸	s 🛊	-27	10p	0	_	10p	0	0	0	Inf
6	PT1/Ref	00000000	none 🗸	S 🛊	-25	1	0	AO	1.200	0	0	0	Inf
7	Alu/Ref	01CA35BD	Median 5 🗸	S	-25	1	0	AO	1	894.941m	894.887m	14.28u	16.1

Figure 5: CDC Frontend page with running measurement

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

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





- 3 Hardware Description
- 3.1 PCap04 Lite Board

3.1.1 Capacitance Measurement

For the purpose of evaluating the capacitance measurement using PCap04, the board is preassembled 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 PCap04 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.

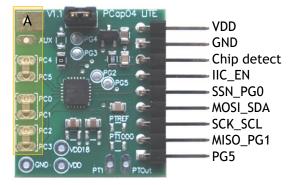


Figure 6: Details of the plug-in board (A=three COG ceramic capacitors)

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 corners 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 k Ω works well. See section 3 of the PCap04 data sheet on how to select the value of the internal discharge resistor.

3.1.2 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 onchip thermistor coupled with an on-chip temperature-stable reference resistor made of polysilicon is sufficient for observing the temperature measurement capability of the PCap04 chip.



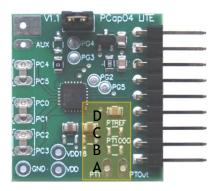


Figure 7: Temperature sensor connection pads

- 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 COG has to be connected to the chip; it is already pre-assembled on board.





1 Software Description

1.1 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 Lite interface 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'.

1.2 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.

1.2.1 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.



1.2.1.1 <u>Setup Page</u>

File	Men	nory T	ools Ir	nterface	Help											
	etup	CDC Fro		CDC	RDC	PDM/F	ww	DSP/C	GPIO I	Misc	Exp	pert	Sc	ioSe	nse [.]	
	Configurations ready to use with Evaluation System Open Graph Standard Humidity Pressure Standard Humidity in rh% at RES0 - Pressure in % at RES0															
- Pure capacitance ratios - Pure resistance ratios - Considers configured compensation mode					- Temp - C Sen: - Floa - Inter - Interr sensor - PDM F - PDM F	 Humidity in rh% at RES0 Temperature in °C at RES1 C Sense: PC0 & PC1: Floating single Internal reference Internal temperature sensor and reference PDM PULSE0 rh% PDM PULSE1 temperature Update rate: 5 Hz 				mper ense oati terna sor a M PL M PL	rature e: PCO & ng sing al refe il temp ind refe JLSEO p	in °C at RES1 & PC1: gle erence erence erence ressure in % emperature		Power On Reset		
					V	'erify In	terfac	e						Run ombined E	nbit) rror) CAF	
#	Name		Resul	ts F	ilter		fpp	Factor	Offset	_	Span	Final Resul	t Mean	Std Dev	SNR [bit	
0	CO/Cre		0	n	one	v 5		10p	0		10p	0	0	0	0	
1	C1/Cre		0	n	one	~ S		10p	0	AO		0	0	0	0	
2	C2/Cre		0			✓ 5		10p	0	AO		0	0	0	0	
3	C3/Cre		0			~ <u>s</u>	-27	10p	0	AO		0	0	0	0	
4	C4/Cre		0			~ <u>s</u>	-27	10p	0	AO		0	0	0	0	
5	C5/Cre		0			~ 5	-27	10p	0		10p	0	0	0	0	
6	PT1/Re Alu/Re		0		one	× 5	-25	1	0	AO	-	0	0	0	0	
7			0	- N	ledian 5 🛛	V S -	-25	1	0	AO		0	0	0	0	

Figure 8 Setup page

Options on 'Setup' page:

Standard	Opens the < Selected Device>_standard.prj project file with configuration and standard firmware.
Humidity	Opens the < <i>Selected Device</i> >_humidity.prj project file with configuration and linearization firmware.
Pressure	Opens the <selected device="">_pressure.prj project file with configuration and linearization firmware.</selected>
Verify Interface	When everything is in order, then pressing this button will indicate the release version number of the software and of the PicoProg Lite / 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 principle it shows the content of the read registers. The content itself depends on the firmware. Figure 8 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.'



1.2.1.2 CDC Frontend Page

	ScioSense	e PCap04										-		\times
il	Memor	y Tools	Interface	e Help										
S	etup CD	C Frontend	CDC	RDC	PDM/F	ww	DSP/C	SPIO N	Aisc	Exp	pert	Sc	ioSe	nse
		Capacita	ince to l	Digital C	onvers	ion I	Fronter	nd					=	
													Open Gra	ph
		pacitance Measurement Scheme Cap. Port Select Stray Compensation										5		
	Grounde	d Single	~	0	000			In	nterr	nal	~ 1	Sto	p Measure	ement
					012								Write Con	fig
					999							W	Irite Comp	lete
					Port Erro	or							ower On R	
		-										P		
	-	e Resistan			harge Re	1.	nce Port			e Resi	stance		Init Rese	et
	90k	~	1	90k			~ 1	10	Dk		~ 0			
	C Referen	nce Select	Int 9	ernal Ca								P	icoProg	SPI LITE
		(Constraint)										Co	Rur ombined E	LITE
#		(Constraint)	9			fpp	Factor	Offset		Span	Final Result	。 PI	Rur	
	external	Res	9 ults	ţ, pF		fpp -27	Factor 10p	Offset 0		2/12/22	Final Result 10p	。 PI	Rur ombined Er	
0	external	Rest	9 ults 1 0000A r	pF Filter			1000 C 1000	0.010.0181	- Annual Property lies	10p		Co PI Mean \$ 50	Rur ombined Er	LITE
0	external Name C0/Cref	Rest 0800 0800	9 ults 0000A 2A898	Filter			10p	0	AO	10p 10p	10p	Co PI Mean ‡50 10p	Rur ombined Er C C C C Std Dev 0	LITE
# 0 1 2 3	external Name C0/Cref C1/Cref	Resu 0800 0800 075	9 ults 1 0000A r 2A898 r 184AC r	Filter none	S 2 2		10p 10p	0	AO AO	10p 10p	10p 10.013p	Cc PII Mean ‡50 10p 10.0131p	Rur ombined El Std Dev 0 115.2a	LITE hbit mor SNR (b) Inf 16.41 16.68
0 1 2 3	external Name C0/Cref C1/Cref C2/Cref	Resu 0880 0880 07F 07F	9 ults 1 0000A 1 2A898 1 184AC 1 9A218 1	Filter none none		-27 -27 -27	10p 10p 10p	0 0 0		10p 10p 10p 10p	10p 10.013p 9.92929p	Cc PII Mean €50 10p 10.0131p 9.92932p	Rur ombined Er Std Dev 0 115.2a 95.2a	LITE hbit mor SNR (b) Inf 16.41 16.68
0 1 2 3 4	external Name C0/Cref C1/Cref C2/Cref C3/Cref	Resul 0880 07F 07F 000	9 ults 1 0000A 1 2A898 1 184AC 1 9A218 1 00000 1	Filter none none none		-27 -27 -27 -27 -27	10p 10p 10p 10p	0 0 0 0		10p 10p 10p 10p	10p 10.013p 9.92929p 9.96891p	Ca Mean (50 10p 10.0131p 9.92932p 9.96896p	Rur embined Ei Std Dev 0 115.2a 95.2a 116.2a	LITE
0 1 2	external Name C0/Cref C1/Cref C2/Cref C3/Cref C3/Cref	Rest 0880 07F1 0000 0000	9 ults 1 00000A r 2A898 r 184AC r 9A218 r 00000 r	Filter none none none none none		-27 -27 -27 -27 -27 -27	10p 10p 10p 10p 10p	0 0 0 0 0		10p 10p 10p 10p 10p	10p 10.013p 9.92929p 9.96891p 0	Ca Pain 10p 10.0131p 9.92932p 9.96896p 0	Rur ombined E Std Dev 0 115.2a 95.2a 116.2a 0	LITE hbit mor SNR (b Inf 16.41 16.68 16.39 Inf

Figure 9 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 03	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 45	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. (031pF)



1.2.1.3 <u>CDC Page</u>

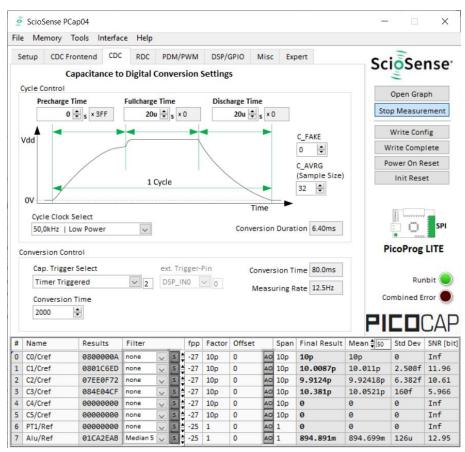


Figure 10 CDC page

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 \rightarrow No averaging, Setting to any number N, will result in averaging over N measurement cycles for generating one measurement result. (08191)							
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).



1.2.1.4 <u>RDC Page</u>

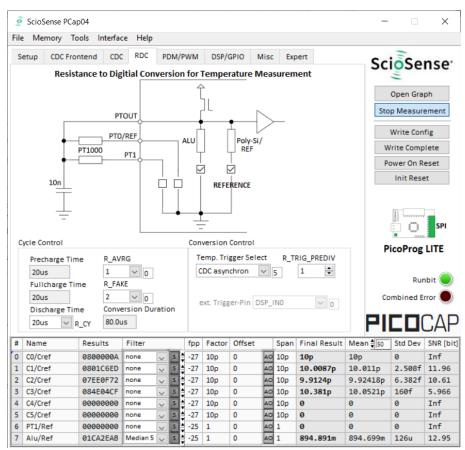


Figure 11 RDC page

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 aluminium (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.



3.1.2.1 <u>PDM / PWM Page</u>

ile		Cap04													
1992	Memory	Tools I	nterface	Help											
Se	etup CDC Fr	rontend	CDC	RDC	PDM/P	WM	DSP/G	PIO N	Misc	Exp	ert	Sc	ioSe	nse	
	Pulse Interfa	ce 0			Pul	se In	terface 1						-		
	Clock	Select					Clock Se	lect					Open Gra	ph	
off v 0 Resolution							off		~	0		Sto	p Measure	ement	
							Resolut	ion	ferrand .				Write Con	fin	
								ION		_					
	10 bit	s	~ 0	_			10 bits		~	0		V	/rite Comp	lete	
	Pulse	Interface	Select				Pulse In	terface	Sele	ct		P	ower On R	eset	
	PDM		~ 1]			PDM		~	1			Init Reset		
	Tog	gle Enab	le				Torr	e Enable							
		Select							-				R .		
			-	_		Pulse Select							10 m	SPI	
	C1/Cre	ef	~ 1				Alu/Re	f	\sim	7				511	
												P	icoProg	LITE	
													Run	bit 🤇	
												C	mbined E	TOT	
													monieu e		
														2 4	
														'/\	
														JA	
•	Name	Resu	lts	Filter		fpp	Factor	Offset		Span	Final Result		Std Dev		
	Name C0/Cref	Resul		Filter	V 5		Factor 10p	Offset 0	AO	10p	Final Result				
)	- 12 100 To	100000	000A	none	> 5		1.20021	0.000	40	10p		Mean \$ 50	Std Dev	SNR [Inf	
)	CO/Cref	0800	000A C6ED	none	> > 5 5 5		10p	0	AO AO	10p 10p	10p	Mean \$ 50	Std Dev	SNR [Inf 11.9	
) L 2	CO/Cref C1/Cref	0800 0801	000A C6ED 0F72	none	> 5 5		10p 10p	0 0	40 40	10p 10p	10p 10.0087p	Mean 50	Std Dev 0 2.508f	SNR [Inf 11.9 10.6	
	C0/Cref C1/Cref C2/Cref	0800 0801 07EE	000A C6ED 0F72 04CF	none none	~ S		10p 10p 10p	0 0 0		10p 10p 10p 10p 10p	10p 10.0087p 9.9124p	Mean 50 10p 10.011p 9.92418p	Std Dev 0 2.508f 6.382f	SNR [Inf 11.9 10.6	
0 1 2 3 4	C0/Cref C1/Cref C2/Cref C3/Cref	0800 0801 07EE 084E	000A C6ED 0F72 04CF 0000	none none none		-27 -27 -27 -27 -27 -27	10p 10p 10p 10p	0 0 0 0	40 40	10p 10p 10p 10p 10p	10p 10.0087p 9.9124p 10.381p	Mean = 50 10p 10.011p 9.92418p 10.0521p	Std Dev 0 2.508f 6.382f 160f	SNR [Inf 11.9 10.6 5.96	
0 1 2 3 4	C0/Cref C1/Cref C2/Cref C3/Cref C3/Cref	0800 0801 07EE 084E 0000	000A C6ED 0F72 04CF 0000	none none none none	~ S	-27 -27 -27 -27 -27 -27	10p 10p 10p 10p 10p	0 0 0 0 0		10p 10p 10p 10p 10p 10p 10p	10p 10.0087p 9.9124p 10.381p 0	Mean \$50 10p 10.011p 9.92418p 10.0521p 0	Std Dev 0 2.508f 6.382f 160f 0	SNR [Inf 11.9 10.6 5.96 Inf	

Figure 12 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.





3.1.2.2 DSP/GPIO Page

File	Memory	Tools In	terface	e Help										
		Frontend	CDC	RDC	PDM/	'PWM	DSP/G	PIO	Misc	Exp	pert	Sc	ioSe	nse [.]
D	SP												Open Gra	nh
	DSP_SPEE		-		DSP	FF_IN		D	SP_M	OFLO_	EN	Sto	op Measur	
	Slow	~	2			00			D					
	DSP ST	ART_EN			NO	IN3			EN1				Write Con	fig
	0.00											V	Vrite Comp	lete
	CORD	Z			DSP	START	ONPIN					P	ower On R	eset
	CDC_TRIG_EN	TRIC											Init Rese	et
G	PIO PG_DIR_I	N PG	_PU			PGOxPO	32					P	icoProg	LITE
	0000 PG1 PG2					PG1xP0	se0 > PG				_INTN_EN _INTN_EN	Ce	Rur ombined E	nbit 🥥 rror 🔵
#	Name	Result	rs.	Filter		fpp	Factor	Offset		Span	Final Result	PI Mean \$ 50		SNR (bi
0	C0/Cref	08000	ADO	none	~ S	-27	10p	0	AO		10p	10p	0	Inf
1	C1/Cref	08010			× 5	-27	10p	0	AO		10.0087p	10.011p	2.508f	11.96
2	C2/Cref	07EE0	F72		~ S	-27	10p	0	AO	10p	9.9124p	9.92418p	6.382f	10.61
3	C3/Cref	084E0	4CF	none	~ S	-27	10p	0	AO	10p	10.381p	10.0521p	160f	5.966
4	C4/Cref	00000	000	none	~ S	-27	10p	0	AO	10p	0	0	0	Inf
5	C5/Cref	00000	000	none	~ S	-27	10p	0	AO	10p	0	0	0	Inf
6	PT1/Ref	00000	0000	none	~ S	-25	1	0	AO	1	0	0	0	Inf
	Alu/Ref	01CA2	EAR	Median 5	~ S	-25	1	0	AO	1	894.891m	894.699m	126u	12.95

Figure 13 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.





3.1.2.3 <u>Misc. Page</u>

10	ScioSense PCap	o04									-		×
File	e Memory To	ols Interfa	ce Help										
	etup CDC From	ntend CD0	RDC	PDM/P		DSP/0	GPIO	Misc	Exp	pert	Sc	ioSe	nse [.]
L	F Clock				HFO	lock							
	OLF_CTUNE	01	F_FTUNE			OX_RUN	4					Open Gra	ph
	_	1 7				Off			\sim	0	Sto	p Measur	ement
		<u> </u>					IS			OX STOP		Write Con	fig
						 0X_A		OP_DI	_	OX_DIV4	W	/rite Comp	lete
										_	P	ower On R	eset
												Init Rese	et
G	Guarding Guarding Por 0 1 2 3 4 C_G_OP_RUN permanent	5	C_G_TIMI 0 € □C_G_O)ns)		0 C_G_ 0,5 p C_G_ x 1,0	OP_AT oF _ OP_VU 0 _	0 TN 0		ca PI	ombined E	nbit) rror) CAP
#	Name	Results	Filter		fpp	Factor	Offse	_	Span	Final Result	•	Std Dev	SNR [bit]
0	CO/Cref	080000A	-	~ S	-27	10p	0		10p	10p	10p	0	Inf
1	C1/Cref	0801C6ED	-	✓ 5 ‡	-27	10p	0		10p	10.0087p	10.011p	2.508f	11.96
2	C2/Cref	07EE0F72		✓ 5 ‡		10p	0	AO		9.9124p	9.92418p	6.382f	10.61
3	C3/Cref	084E04CF		~ S		10p	0	AO		10.381p	10.0521p	160f	5.966
4	C4/Cref	00000000		~ S	-27	10p	0	AO		0	0	0	Inf
5	C5/Cref	00000000		✓ 5		10p	0		10p	0	0	0	Inf
6	PT1/Ref Alu/Ref	00000000 01CA2EAB	none Median 5	✓ S ↓	-25 -25	1	0			0 894.891m	0 894,699m	0 126u	Inf 12.95
1	Alu/Kei	OICAZEAB	wedian 5	× 2.	-25	1	0	AO	1	054.091M	094.099M	1200	12.95

Figure 14 Miscellaneous page

Options on 'Miscellaneous' page:

LF Clock	
OLF_CTUNE	Coarse-tune the low frequency clock. (10kHz, 50kHz, 100kHz, 200kHz)
OLF_FTUNE	Fine-tune the low frequency clock. (015)
HF Clock	
OX_RUN	Controls the permanency or the latency of the OX generator. Latency means an oscillator settling time before a measurement starts.
OX_DIS	Disable the OX clock.
OX_AUTOSTOP_DIS	Disables the automatic stop function of the OX generator between the individual measure sequences.
OX_STOP	Stop the OX-generator
OX_DIV4	OX clock frequency := raw freq./4





Guarding	
Guarding Port Select	Individual Guard enable to each Port PC0PC5
C_G_OP_RUN	permanent – Guarding OP is permanent activated (additional power consumption) pulsed – Guarding OP set to sleep mode between CDC conversions
C_G_TIME	Controls the pre-charge phase
C_G_OP_EXT	Switch between internal guarding OP and an optional external OP
C_G_OP_TR	Trim power consumption of guarding OP.
C_G_OP_ATTN	Capacitive attenuation of Guarding OP.
C_G_OP_VU	OP Gain (from Sense Port to Guard).

3.1.2.4 Expert Page

Please modify the settings on the Expert page only in consultation with ScioSense Support team.

3.1.3 Front Panel Menus

3.1.3.1 File Menu

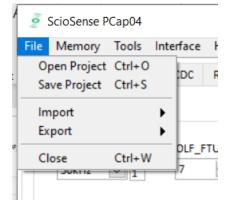


Figure 15 File Menu

Open Project	Open project file *.prj that subsumed the firmware and configuration filenames and the settings and Calibration data
Save Project	Here you can save your own project file.
Import	Import configuration (*.cfg), calibration data (*.dat) or firmware. Note: Any import will modify the active project file! Save the project file under a new name.
Export	Here you can export Config (*.cfg), Calibration (*.dat), Memory (*.dat) or Firmware (*.hex), separately





Close

Close the evaluation software

3.1.3.2 <u>Memory Menu</u>

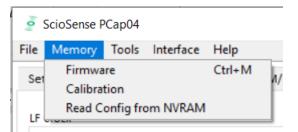


Figure 16 Memory Menu

Firmware	Opens the window to download the firmware. (section 4.2.3.1)
Calibration	Opens the Calibration window (section 4.2.3.2)
Read Config from NVRAM	Reads back the configuration information from the NVRAM and overwrites those of the GUI.

3.1.3.3 Tools Menu

🧧 ScioSense PCap04									
File	Me	mory	Tools	Interface	Help				
Set	etup CDC		√ Run	ent Ctrl+R					
			Grap	Ctrl+G					
LF Clock			Reg	Ctrl+F					
	OLF	-CTUN		arize	Ctrl+L				
	50kHz		Asse	Ctrl+A					

Figure 17 Tools Menu

Run Measurement	Start the measurement
Graph	Opens the window for graphical display of the various measurement results (section 4.2.3.4)
Registers	Opens the Register window (section 4.2.3.5)
Linearize	Opens the Linearize window
Assembler	Opens the assembler



3.1.3.4 Interface Menu

🧧 Scios	Sense P	Cap04					
File Me	mory	Tools	Interface	Help			
Setup	CDC	Fronten	Bus Devices))	N
Gene	General CDC		USB PicoPro	Ctrl+U		ŀ	

Figure 18 Interface Menu

Bus	Select between SPI and I2C interface
USB	Opens the USB Communications window with PicoProg V3.0 Settings and the possibility to send opcodes

3.1.3.5 Help Menu

ł	🥭 Scio	Sense	PCap04	4					
l	File Me	mory	Tool	s In	terface	Help			
	Setup CDC Frontend				CDC		p Contents eck Errors	F1	G
	Gene	ral	CDC TD		Line	Ab	out	F12	
1									_

Figure 19 Help Menu

Help Contents	Opens the help window
Check Errors	Opens the error message window if there is an inconsistency after plausibility check.
About	Version

After each change in settings, the evaluation software automatically performs a plausibility check in the background. If a setting is not allowed or doesn't fit with the setting of the other parameters, the faulty setting is highlighted in red color.





- 3.1.4 Special Windows
- 3.1.4.1 Firmware Window

In the 'Firmware' Window the write data can be edited.

If the NVRAM is read ('Read' button), the content is automatically compared with the 'Write Data' window content. If contents are equal this will be indicated by a green illuminated LED.

																		6
irmware	Calibratio	n	Mi	sc. C	alib	orati	on	C	omp	lete	Me	mor	y					
		Wri	te D	ata		PCa	p04	/1_li	inea	rize	_v1.	hex						
Ope	n File	1.0					6C							5D		BO	00	^
Relo	ad File	00 84	B1 48	01 20	92 24		B2	02 7F	78	20 8F	6B 6A	B6 D4	00 41	00 FA	87 7A	00 E7	43	
		54	E9	44	10		6A	FD	45	84	01	21	44	6A	F2	43	7A	
Remov	e 'FF' at End	E2	44	20		7A		43		44	21	F4	E9	E7	43	E9	44	
		70	C5	E1 67	43	E0 67	3A 76	7A 77	66	E1 99	43 FD	7A 7B	01	F3		41 E1	20	-
		1.1	D4	E7	43	E9	44	7A	C5	El	43	49	EO	34	7A	C2	El	
ddress	Longth	43	7A	CF	E8	E6	41	2C	8A	7A	CO	E1	43	EO	3A	02	6A	
	Length	D7		AB			Cl	D8		43		44	7A	DF	FF		FF	
0	d 1024	FF 43	E3 E9	41	1C AA	43 ED	46 7A		46 E1	32 43	44 E0	E9 3A	13 7A	7A CF	C1 E3	E0 E6	E6	
		F1	44	29	EO	DB	CO	27	ES	C1	DS	24	3E	02	6A	FD	41	
W	/rite	42	5C	49	5C	AA	07	7A	CO	44	E3	44	E5	44	02	7A	Cl	
	ead	-	43		-			100		C7	C9	27	0C		E3	45		
к	eau	45	Cl	CA	E6	43	E9	44	7A	C2	El	43	7A	CC	F8	E6	41	1
		Rea	ad D	ata											Da	ta e	qual	C
																		^
irmware	Version																	
Product (Group																	
Program	Туре																	
4																		
Version																		

Figure 20 Firmware Window

Open File	Select and open a firmware file (.hex) or import firmware from a project file. The content is shown in the 'Write Data' window.
Reload File	Reload the last opened firmware file (.hex). The content is shown in the 'Write Date' window again.
Read	Pressing this button, the content of the NVRAM is read and shown in the 'Read Data' window. In 'Address' and 'Length' you can specify how many bytes you want read, starting at which address.
Write	Writes the firmware into the chip's NVRAM. The status of the write process is indicated by the green bar. The successful end is indicated by a pop-up window. For verification we recommend to read back the NVRAM afterwards and compare it with the source.



Firmware Version	In the firmware, a specific address is reserved to save 3 byte information about the
	application and the version of the software. The coding is specified in the header file of the
	supported PICOCAP device, for example: <i>pcap_standard.h.</i> The header file is found in the
	library directory of the assembler.

CONTENTS PAGE

3.1.4.2 Calibration Window

The NVRAM provides the possibility to store data like linearization coefficients, division steps, alert levels etc.. This way, one and the same firmware can be used for various types of sensors.

The Calibration data are part of the project file. After opening a project, the Calibration data need to be written manually. Therefore please open the "Memory / Calibration" menu and then press "Write" or use the 'Write Complete' button.

irmw	are	Calibration	Misc. Calibra	tion	Comp	lete Mem	iory		
Calil	orati	on N	lo. of Calibration	Nalue:	s 55	÷S	tart Addre	ss d 800	
#	Na	me	Value	fpp	s/u	Length	Address	Value (hex)	^
0	pi0	_result0	0	8	s	4	800	00000000	
1	pi0	_result1	100	8	s	4	804	00006400	
2	pi0	_pulse0	0	0	u	2	808	0000	
3	pi0	_pulse1	16.383k	0	u	2	810	3FFF	
4	pi1	_result0	-40	8	s	4	812	FFFFD800	
5	pi1	_result1	125	8	s	4	816	00007D00	
6	pi1	_pulse0	0	0	u	2	820	0000	
7	pi1	_pulse1	16.383k	0	u	2	822	3FFF	
8	xi_	at_ccp1	0	26	s	4	824	00000000	
9	xi_	at_ccp2	1	26	s	4	828	04000000	
10	ci_	at_ccp1	0	26	u	4	832	00000000	
11	ci_	at_ccp2	1	26	u	4	836	04000000	
12	cc3	2	0	0	s	4	840	00000000	
13	cn_	div32	0	0	u	1	844	00	
14	cc2	2	0	0	s	4	845	00000000	
15	cn_	div22	0	0	u	1	849	00	
16	cc1	2	0	0	s	4	850	00000000	
17	cn_	div12	0	0	u	1	854	00	
18	cc0	2	0	0	s	4	855	00000000	
19	cn_	shift2	0	0	s	1	859	00	
20	cc3	1	0	0	s	4	860	00000000	
21	cn_	div31	0	0	u	1	864	00	
22	cc2	1	0	0	s	4	865	00000000	
23	cn	div21	0	0	u	1	869	00	V

Figure 21 Calibration Window

Import Linearization Data	Imports Linearization Data from "Linearize / Pulse" window
Write	Writes the data into the chip's NVRAM.
Read	Pressing this button, the Linearization Data are read from the NVRAM and shown in the tab.





3.1.4.3 <u>Misc. Calibration Window</u>

This window shows miscellaneous calibration bits at address d'956-d'959 (4 byte). The meaning of the content strongly depends on the firmware.

Misce # 0 1 2 3 4	Ilaneous Calibratio	O Bits a	# 16 17	Mame d 959	000000000000000000000000000000000000000		
0 1 2 3	Name	0	16 17	Name	0		
1 2 3		0	17		0		
2 3		Õ			0		
3					O		
		0	18		0		
4		0	19		0		
		0	20		0		
5		0	21		0		
6		0	22		0		
7		0	23		0		
8		0	24		0		
9		0	25		0		
10		0	26		0		
11		0	27		0		
12		0	28		0		
13		0	29		0		
14		0	30		0		
15		0	31		O		
				× 000000	00		
				Write			
				Read			

Figure 22 Misc. Calibration Window

Write	Writes the data into the chip's NVRAM.
Read	Pressing this button, the bits are read from the NVRAM and shown in the tab.



3.1.4.4 <u>Complete Memory</u>

irmware	С	alibr	ation	N	Misc.	Calib	oratio	n	Com	plete	Mer	nory					(
v	Vrite	Men	nory														
0	24	05	AØ	01	20	6C	42	5C	48	B 3	02	91	5D	7F	80	00	
16	00	B1	01	92	ØE	B2	02	78	20	6B	86	00	00	B7	00	00	
32	84	48	20	24	90	00	7F	20	8F	6A	D4	41	FA	7A	E7	43	1
48	54	E9	44	10	41	6A	FD	45	84	01	21	44	6A	F2	43	7A	l
64	E2	44	20	CD	7A	CØ	43	E1	44	21	F4	E9	E7	43	E9	44	
80	7A	C5	E1	43	EØ	ЗA	7A	C2	E1	43	7A	CE	F3	E6	41	2C	
96	70	22	67	66	67	76	77	66	99	FD	7B	01	79	C1	E1	24	
112	3E	D4	E7	43	E9	44	7A	C5	E1	43	49	EØ	34	7A	C2	E1	•
					Writ	e				Store	2				Erase	2	
		y			Writ	e				Store	e						
R	ead	Mem			Writ	e				Store	2				Erase ta ec		
R	ead	Mem 00	lory	00	Writ	e 00	00	00	00	Store	00	00	00				
				00			00	00	00			00	00	Da	ta ec	lnal	
0	00	00	00		00	00				00	00			Da 00	ta ec	ual 00	
0 16	00 00	00 00	00	00	00	00 00	00	00	00	00 00	00	00	00	Da 00	ta ec	00	
0 16 32	00 00 00	00 00 00	00 00 00	00 00	00 00 00	00 00 00	00	00	00	00 00 00	00 00 00	00	00 00	Da 00 00	ta ec	ual 00 00	
0 16 32 48	00 00 00	00 00 00	00 00 00	00 00 00	00 00 00	00 00 00	00 00 00	00 00 00	00 00 00	00 00 00 00	00 00 00	00 00 00	00 00 00	Da 00 00 00	ta ec 00 00 00	00 00 00 00	
0 16 32 48 64	00 00 00 00	00 00 00 00	00 00 00 00	00 00 00 00	00 00 00 00	00 00 00 00	00 00 00	00 00 00	00 00 00	00 00 00 00	00 00 00 00	00 00 00	00 00 00	Da 00 00 00 00	ta eo	ual 00 00 00 00	

Figure 23 Complete Memory Window

Write	Writes the complete NVRAM.
Store	The complete data transfer from Memory (volatile) to FLASH (non-volatile) is performed by a STORE
Erase	During this ERASE procedure, first the complete NVRAM will erased (set to zero) and afterwards the MEM_LOCK bits will be cleared.
Read	Pressing this button, the complete NVRAM are read and shown in the tab.
Recall	This means that the complete Memory is copied from the FLASH (non-volatile) to the Memory (volatile). After a power-on reset, a recall is processed.





3.1.4.5 Graph Window

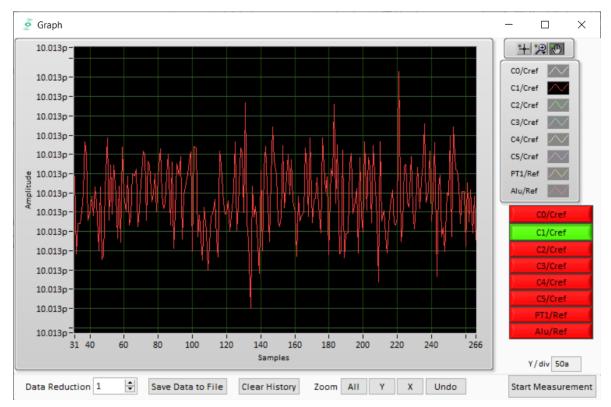


Figure 24 Graph Window

The data to be displayed are selected in the field at the bottom right. The labels in the buttons are the same as in the diagnostics window. To display data press the corresponding button so that it gets green. Top right of the 'Graph' Windows are various options for automatic zoom in/out, center or scale in other ways. Below the graph are various automatic zoom functions for the x-axis and the y-axis.

Y-Zoom will be chanced with the keys [+], [-] and X-Zoom with the keys [*], [/]. With the cursor control keys $[\leftarrow]$, $[\rightarrow]$, $[\uparrow]$, $[\downarrow]$ is it possible to move the graph.

The data displayed can be stored into a text file. For long-term investigations it is possible to reduce the data displayed and stored. The field 'Data Reduction' allows to define the level of data reduction.

3.1.4.6 <u>Registers Window</u>

These windows display the configuration data in hexadecimal format as they are currently used. Also the result registers' content is shown in hexadecimal format, but updated only when the button is pressed. Finally, the various status bits are shown.



Write Registers Results Register 3, 2, 1, 0 × 1058001D Register 7, 6, 5, 4 × 200F0010 Register 11, 10, 9, 8 × 0007D000 Register 15, 14, 13, 12 × 03FF0800 Register 23, 22, 21, 20 × 30500100 Register 31, 30, 29, 28 × 08500473 Register 35, 34, 33, 32 × 40470008 Register 39, 38, 37, 36 × 71000000 Register 43, 42, 41, 40 × 00080000 Register 47, 46, 45, 44 × 0100000	호 Registe —	
Register 3, 2, 1, 0 × 1058001D Register 7, 6, 5, 4 × 200F0010 Register 11, 10, 9, 8 × 0007D000 Register 15, 14, 13, 12 × 03FF0800 Register 19, 18, 17, 16 × 00002400 Register 23, 22, 21, 20 × 30500100 Register 31, 30, 29, 28 × 0882005A Register 35, 34, 33, 32 × 40470008 Register 43, 42, 41, 40 × 0008000 Register 47, 46, 45, 44 × 0100000	Write Registers R	esults
Register 7, 6, 5, 4 × 200F0010 Register 11, 10, 9, 8 × 0007D000 Register 15, 14, 13, 12 × 03FF0800 Register 19, 18, 17, 16 × 00002400 Register 23, 22, 21, 20 × 30500100 Register 31, 30, 29, 28 × 08500473 Register 31, 30, 29, 28 × 0882005A Register 39, 38, 37, 36 × 7100000 Register 43, 42, 41, 40 × 00080000 Register 47, 46, 45, 44 × 01000000		Register
Register 11, 10, 9, 8 × 0007D000 Register 15, 14, 13, 12 × 03FF0800 Register 19, 18, 17, 16 × 00002400 Register 23, 22, 21, 20 × 30500100 Register 27, 26, 25, 24 × 08500473 Register 31, 30, 29, 28 × 0882005A Register 39, 38, 37, 36 × 71000000 Register 43, 42, 41, 40 × 00080000 Register 47, 46, 45, 44 × 01000000	Register 3, 2, 1, 0	× 1058001D
Register 12, 12, 2, 3, 6 Register 15, 14, 13, 12 X Register 19, 18, 17, 16 X 00002400 Register 23, 22, 21, 20 X 00002400 Register 23, 22, 21, 20 X 00002400 Register 27, 26, 25, 24 X 08500473 Register 31, 30, 29, 28 X 0882005A Register 35, 34, 33, 32 X 40470008 Register 39, 38, 37, 36 X 71000000 Register 43, 42, 41, 40 X 00080000 Register 47, 46, 45, 44	Register 7, 6, 5, 4	× 200F0010
Register 19, 18, 17, 16 × 00002400 Register 23, 22, 21, 20 × 30500100 Register 27, 26, 25, 24 × 08500473 Register 31, 30, 29, 28 × 0882005A Register 35, 34, 33, 32 × 40470008 Register 43, 42, 41, 40 × 00080000 Register 47, 46, 45, 44 × 0100000	Register 11, 10, 9, 8	× 0007D000
Register 23, 22, 21, 20 × 30500100 Register 27, 26, 25, 24 × 08500473 Register 31, 30, 29, 28 × 0882005A Register 35, 34, 33, 32 × 40470008 Register 39, 38, 37, 36 × 71000000 Register 43, 42, 41, 40 × 00080000 Register 47, 46, 45, 44 × 01000000	Register 15, 14, 13, 12	× 03FF0800
Register 27, 26, 25, 24 × 08500473 Register 31, 30, 29, 28 × 0882005A Register 35, 34, 33, 32 × 40470008 Register 39, 38, 37, 36 × 71000000 Register 43, 42, 41, 40 × 00080000 Register 47, 46, 45, 44 × 01000000	Register 19, 18, 17, 16	× 00002400
Register 31, 30, 29, 28 × 0882005A Register 35, 34, 33, 32 × 40470008 Register 39, 38, 37, 36 × 71000000 Register 43, 42, 41, 40 × 00080000 Register 47, 46, 45, 44 × 01000000	Register 23, 22, 21, 20	× 30500100
Register 35, 34, 33, 32 × 40470008 Register 39, 38, 37, 36 × 71000000 Register 43, 42, 41, 40 × 00080000 Register 47, 46, 45, 44 × 01000000	Register 27, 26, 25, 24	× 08500473
Register 39, 38, 37, 36 × 71000000 Register 43, 42, 41, 40 × 00080000 Register 47, 46, 45, 44 × 01000000	Register 31, 30, 29, 28	× 0882005A
Register 43, 42, 41, 40 × 00080000 Register 47, 46, 45, 44 × 01000000	Register 35, 34, 33, 32	× 40470008
Register 47, 46, 45, 44 × 0100000	Register 39, 38, 37, 36	× 71000000
	Register 43, 42, 41, 40	× 00080000
Register 51, 50, 49, 48 × 00000000	Register 47, 46, 45, 44	× 01000000
	Register 51, 50, 49, 48	× 00000000

🧧 Registe —	
Write Registers	Results
	Results
Res 0 <310>	× 080000A
Res 1 <310>	× 0802A326
Res 2 <310>	× 07F1821D
Res 3 <310>	× 07F990A4
Res 4 <310>	× 00000000
Res 5 <310>	× 00000000
Res 6 <310>	× 00000000
Res 7 <310>	× 01CAF239
	Read Results
Statusreg	
Port Error	
Sunbit	COMB_ERR
CDC active	ERR_OVFL
TENDFLAG	MUP_ERROR
Autoboot busy	RDC_ERR
TESTMODE	SENSE_TESTO
GOO RES FLAG	3

CONTENTS PAGE

Figure 25 Write Registers and Results





3.1.5 Linearize

3.1.5.1 Sensor Characterization

The first step is the characterization of the sensor. Therefore, it is necessary to collect data at several measurement points and at several temperatures.

As mentioned earlier, the data collection should be made of minimum 12 measurements, taken at least at 3 different temperatures. The temperatures should cover the operating temperature range of interest of the final device. The number of calibration points is set at the top left. This is the first thing to be done. Then calibration can begin. Line by line the user can enter the reference values for Z and \square at the various calibration points. Having the cursor in this line it is sufficient to press the acquire button to get the actual ci_ratio result. But of course the value can be entered manually, too.

The graph on the bottom left shows the Z, ϑ distribution of the calibration points. Ideally it should have dots on three different lines covering the operating range of the sensor.

The table on the left shows the calculated calibration coefficients and the graph below shows the deviation due to the mathematical approximation.

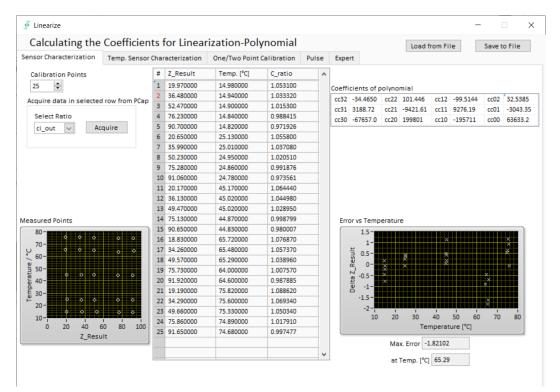


Figure 26 Sensor Characterization



3.1.5.2 <u>Temperature Sensor Characterization</u>

Together with the calibration of the capacitance sensor it is mandatory to calibrate the temperature, too. Whether the internal aluminum sensor is used or an external platinum sensor or any other sensor: they need to be calibrated to get the correct temperature information which is then used as input for the polynomial correction of the capacitance measurement.

The tab "Temperature Sensor Characterization" (Figure 27) offers a tool very similar to the capacitive sensor characterization. The resistance ratio has to be collected at several temperature points. For best approximation 4 calibration points are needed. In case of 2 or 3 calibration points a 2nd respectively a 3rd order polynomial is calculated.

Linearize				-
Calculating the Coefficients for	or Linear	ization-Polynor	nial	al
Sensor Characterization Temp. Sensor Charac		One/Two Point Calibr		
Calibration Points	# Temp. [°	C] R_ratio	^	
2	1 10.0000	1.25859000		tc3 0.00000 Internal Poly
	2 20.0000	1.21503000	-	tc1 351.061 External PT1000
Select Ratio				tc0 -268.932
				Error vs Temperature
-	-		-	
-				≝ 0.5−
-				titio.5-
				-0.5
-	_		-	
-				10 11 12 13 14 15 16 17 18 19 20 Temperature [°C]
-				
-	-		~	Max. Error 0
L			+ -	at Temp. [°C] 10

Figure 27 Temp. Sensor Characterization

On the right side of the tab "Temperature Sensor Characterization" there are two buttons to select default characteristic data for the internal aluminum sensor and a platinum sensor. The aluminum is assumed to be linear in a range of 10 °C to 70°C so only two coefficients are used.

In case the default values are used it is necessary to have at least a two point calibration of the temperature (see next section).





3.1.5.3 One/Two Point Calibration

Once a batch is characterized with respect to the capacitive sensor and the resistive temperature sensor it might be sufficient to perform two-point or even one-point calibration for the rest of the sensors in the batch.

The tab "One/Two Point Calibration" offers a simple GUI to do that. On this page the user enters the reference values for Z and ϑ . CCP1 stands for capacitance calibration point 1 etc.. When the calibration conditions are reached pressing the acquire buttons will read the actual ratios while the theoretical ones are calculated on basis of the linearization coefficients. Together with programmable limits for minimum and maximum this gives an additional set of 12 parameters to be written into the EEPROM.

Calculating the Coefficients for Linearization-Polynomial Load from File Save to File Sensor Characterization Temp. Sensor Characterization One/Two Point Calibration Pulse Expert Sensor Characterization Inde/Two Point Calibration Pulse Expert Expert Note: For most accurate calibration individual sensor calibration points please use this sheet. Capacitance Set Points off Index Set Points I	Linearize							- 0	×
Note: For most accurate calibration individual sensor calibration (capactiance and temperature) is recommended. For lot calibration with only one or two calibration points please use this sheet. Capacitance Set Points off Image: CCP Image: CCP Image:	Calculating t	he Coefficient	s for Linear	ization-Polynomial			Load from File	Save to File	
For lot calibration with only one or two calibration points please use this sheet. Capacitance Set Points off Image: CCP Image: CCP Image: CCP Image: CCP Acquire ci_at_CCP from PCap Image: CCP Image: CCP Image: CCP Select Ratio Acquire CCP1 Image: CCP Image: CCP Image: CCP	Sensor Characterizati	on Temp. Sensor C	haracterization	One/Two Point Calibration	Pulse	Expert			
Temp. [*C] r_hex_at_CCP v_at_CCP v_hex_at_CCP TCP1 0.000000 0 00000000 0 00000000 Acquire r_at_TCP from PCap 02000000 1 02000000 0 02000000 Select Ratio Acquire TCP1 div2_ri1 div2_ri1 0 <t< td=""><td>Ca Ca C C C C C</td><td>lot calibration with pacitance Set Points Z_Result CP1 0.000000 cp2 0.000000 cquire ci_at_CCP from If Select Ratio ci out</td><td>only one or tw off Temp. [°C] 0.000000 0.000000 PCap equire CCP1</td><td>c_hex_a div2_ci1</td><td>use this</td><td>x_at_CCP</td><td>x_hex_at_CCP</td><td>div2_xi1</td><td></td></t<>	Ca Ca C C C C C	lot calibration with pacitance Set Points Z_Result CP1 0.000000 cp2 0.000000 cquire ci_at_CCP from If Select Ratio ci out	only one or tw off Temp. [°C] 0.000000 0.000000 PCap equire CCP1	c_hex_a div2_ci1	use this	x_at_CCP	x_hex_at_CCP	div2_xi1	
	T T Ac	Temp. [°C] TCP1 0.000000 TCP2 0.000000 cquire r_at_TCP from P Select Ratio r out	Cap	000000 020000 div2_ri1	000		00000000		





3.1.5.4 <u>Pulse</u>

🧕 Linearize						- 🗆	\times
Calculating the	Coefficients for Linear	ization-Polynomial			Load from File	Save to File	
Sensor Characterization	Temp. Sensor Characterization	One/Two Point Calibration	Pulse	Expert			
Pulse Interface 0							
Annuine Deputte from	PC						
Acquire Results from	гсар	Coefficients					
Input of Result		pi0_result0	0,00000	0000000			
Humidity / %rH	 Acquire Result 1 	pi0_result1	0,00000	0000000			
Input of Pulse	According Departs 2	pi0_pulse0		0000000			
Pulse_Z	Acquire Result 2	pi0_pulse1	0,00000	0000000			
Pulse Interface 1							
Acquire Results from	PCap.						
Input of Result	(Cop	Coefficients					
theta / °C	Acquire Result 1	pi1_result0		0000000			
Input of Pulse	✓ Acquire Result 1	pi1_result1		0000000			
· · · · · · · · · · · · · · · · · · ·	Acquire Result 2	pi1_pulse0		0000000			
Pulse_theta	✓ Acquire Result 2	pi1_pulse1	0,00000	0000000			

Figure 29 Pulse





3.1.5.5 <u>Expert</u>

As indicated by the name this tab is for experts only. There you set the fixed point position of the result Z. It further displays the numbers of division steps respectively shift operation to achieve the maximum resolution over all calculations.

Those are stored in the NVRAM, too. But they are calculated by the DLL and for information purpose only.

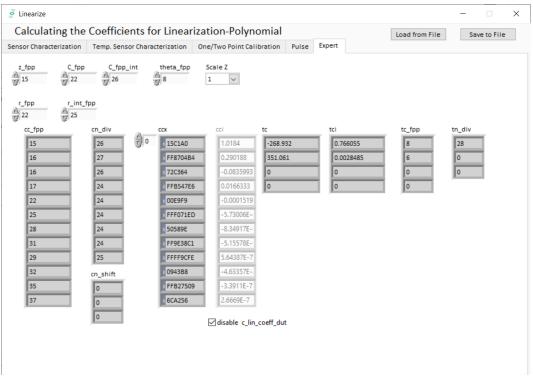


Figure 30 Expert



3.1.5.6 Assembler

<pre>le Edit Find Assembler Help le Edit Find Help Edit Help le Edit Find Help Edit Help Help Edit Help Help Help Help Help Help Help Help</pre>	ile Edit				s_Products\P(-	-51			
Cop04_standard_v1_gpio4.asm	ine cont	Find Assembler Help									
<pre>File: PCap04_standard_vXX.asm Description: ; ; This is the standard firmware that translates the TDC Start and TDC Stop values into ; Col and ROC values. ; ; Further depending on the configuration, the Capacitance and Resistance ratios are ; calculated. From 9 possible results, 8 results are given out in the Result register RES07. ; Further depending on the configuration, the Capacitance and Resistance ratios are ; calculated. From 9 possible results, 8 results are given out in the Result register RES07. ; Pre-requisite : The Resistance Ratios can be calculated for Internal or External sensor and Internal or External Reference. However, for this firmware, following ; should be ensured. ? PT0 - External Sensor ONLY internal or External Reference ought to be selected in the R_PORT_EN_IREF bit of Configuration Register 23. ; Outputs: ? RES6 :: Resistance Ratio for External Sensor at Port PT1, w.r.t. Internal or External reference RES7 : Resistance Ratio for Internal sensor, w.r.t. Internal or External reference ? PULSE0 & PULSE1 : Pulse Outputs #device PCap04v1 CONST FPP_RATIO 27 ; FPP of the Capacitance Ratios result CONST FPP_RATIO 25 ; FPP of the Resistance Ratios result CONST FPP_RATIO 25 ; Port number of the reference Capacitance port (06 for Gr ; PULSE0_CAL 800 ; Address of calibration values for pulse0 output of capacitance const NV_PULSE0_CAL 800 ; Address of calibration values for pulse1 output of capacitance ? CONST NV_PULSE0_CAL 800 ; Address of calibration values for pulse1 output of capacitance ? CONST NV_PULSE0_CAL 800 ; Address of calibration values for pulse1 output of capacitance ? CONST NV_PULSE0_CAL 800 ; Address of calibration values for pulse1 output of capacitance ? CONST NV_PULSE0_CAL 800 ; Address of calibration values for pulse1 output of capacitance ? CONST NV_PULSE0_CAL 800 ; Address of calibration values for pulse1 output of capacitance ? ? ? ? ? ? ? ? ? ? ? ? ?</pre>] 🗁	F 🛛 🗖 🖶 🗧) (} %	🗈 🔓 🗵	ļ!	२, 💸 💌		🕅 🕥 Ç	}		
<pre>File: PCap84_standard_vXX.asm Description: File: PCap84_standard_vXX.asm Description: File: PCap84_standard_vXX.asm Description: File: PCap84_standard_vXX.asm Description: File: PCap84_standard_vXX.asm File: PCap84_standard_vX.asm File: PCap84_st</pre>	PCap04_s	tandard_v1_gpio4.asm									
<pre>5 ; This is the standard firmware that translates the TDC Start and TDC Stop values into 6 ; CDC and RDC values. 7 ; Further depending on the configuration, the Capacitance and Resistance ratios are 8 ; calculated. From 9 possible results, 8 results are given out in the Result register RES07. 9 ; Pre-requisite : The Resistance Ratios can be calculated for Internal or External sensor and Internal or External Reference. However, for this firmware, following 11 ; should be ensured. 12 ; PT0 - External Sensor or External Reference 13 ; PT0 - External Sensor ONLY 14 ; Internal or External Reference ought to be selected in the R_PORT_EN_IREF 15 ; bit of Configuration Register 23. 16 ; Outputs: 17 ; RES65 : Capacitance Ratios for Capacitance Ports PC05 17 ; RES65 : Capacitance Ratio for External Sensor at Port PT1, w.r.t. Internal or External reference 19 ; RES7 : Resistance Ratio for Internal sensor, w.r.t. Internal or External reference 19 ; RES7 : Resistance Ratio for Internal sensor, w.r.t. Internal or External reference 21 ; 22 ; 23 ; Date : 08.04.2016 24 ; Author: VK/OH 25 ; FPP of the Capacitance Ratios result 26 CONST FPP_CRATIO 27 ; FPP of the Capacitance Ratios result 27 #device PCap04v1 28 CONST FPP_RATIO 25 ; FPP of the Resistance Ratios result 29 CONST FPP_RATIO 25 ; FPP of the Resistance Ratios result 30 CONST FPP_RATIO 25 ; FPP of the Resistance Ratios result 31 CONST CREF_PORT_NUMBER 0 ; Port number of the reference Capacitance port (06 for Gr 32 ;</pre>	2;		rd_vXX.asm								
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29 CONST FPP_CRATIO 27 ; FPP of the Capacitance Ratios result 30 CONST FPP_RRATIO 25 ; FPP of the Resistance Ratios result 31 CONST C_REF_PORT_NUMBER 0 ; Port number of the reference Capacitance port (06 for Ga 32 ;	21 ; 22 ; 23 ; 24 ; 25 ;-										
30 CONST FPP_RRATIO 25 ; FPP of the Resistance Ratios result 31 CONST C_REF_PORT_NUMBER 0 ; Port number of the reference Capacitance port (06 for Guidance) 32 ;	21 ; 22 ; 23 ; 24 ; 25 ;- 26	Author: VK/OH									
B1 CONST C_REF_PORT_NUMBER 0 ; Port number of the reference Capacitance port (06 for Gi B2 ; Addresses in the NVRAM B3 ; Addresses in the NVRAM B4 CONST NV_PULSE0_CAL 800 ; Address of calibration values for pulse0 output of capacitan B3 CONST NV_PULSE0_CAL NV_PULSE0_CAL 800 ; Address of calibration values for pulse1 output of capacitan	21 ; 22 ; 23 ; 24 ; 25 ;- 26 27 #d 28	Author: VK/OH device PCap04v1									
32 Addresses in the NVRAM 33 ; 34 CONST NV_PULSE0_CAL 800 ; Address of calibration values for pulse0 output of capacital 35 CONST NV_PULSE1_CAL 84 NV_PULSE0_CAL 85 CONST NV_PULSE1_CAL 800 ; Address of calibration values for pulse1 output of capacital	21 ; 22 ; 23 ; 24 ; 25 ;- 26 27 #0 28 29 CC	Author: VK/OH device PCap04v1 DNST FPP_CRATIO									
333 ; Addresses in the NVRAM 34 CONST NV_PULSE0_CAL 800 ; Address of calibration values for pulse0 output of capacitar 35 CONST NV_PULSE1_CAL NV_PULSE0_CAL + 12 · Address of calibration values for pulse1 output of capacitar	21 ; 22 ; 23 ; 24 ; 25 ;- 26 27 #d 28 29 CC 30 CC	Author: VK/OH device PCap04v1 ONST FPP_CRATIO ONST FPP_RRATIO	25		; FPP of	the Resista	nce Rati	ios result	nce port /A	6 for	6
R5 CONST NV PHUSE1 CAL NV PHUSEA CAL + 12 · Address of calibration values for pulse1 output of canacita	21 ; 22 ; 23 ; 24 ; 25 ;- 26 27 #d 28 29 CC 30 CC 31 CC	Author: VK/OH device PCap04v1 ONST FPP_CRATIO ONST FPP_RRATIO	25		; FPP of	the Resista	nce Rati	ios result	nce port (0.	6 for	G
RS CONST NV PHUSE1 CAL NV PHUSEA CAL + 12 · Address of calibration values for pulse1 output of canacitar	21 ; 22 ; 23 ; 24 ; 25 ;- 26 27 #d 29 CC 30 CC 31 CC 32	Author: VK/OH device PCap04v1 ONST FPP_CRATIO ONST FPP_RRATIO ONST C_REF_PORT_NUMBER	25 Ø	the NVRAM	; FPP of ; Port n	the Resista	nce Rati	ios result	nce port (0.	6 for	G
	21 ; 22 ; 23 ; 24 ; 25 ;- 26 27 #d 28 29 CC 30 CC 31 CC 31 CC 32 ; 33 ;-	Author: VK/OH device PCap04v1 ONST FPP_CRATIO ONST FPP_RRATIO ONST C_REF_PORT_NUMBER	25 0 Addresses in		; FPP of ; Port n	the Resistan umber of the	nce Rati referer	ios result nce Capacitan			
	21 ; 22 ; 23 ; 24 ; 25 ;- 26 27 #d 28 29 CC 30 CC 31 CC 32 33 ;- 34 CC 33 ;- 34 CC	Author: VK/OH device PCap04v1 ONST FPP_CRATIO ONST FPP_RRATIO ONST C_REF_PORT_NUMBER	25 0 Addresses in 800		; FPP of ; Port n ; Addres	the Resistant umber of the s of calibra	nce Rati referer tion val	ios result nce Capacitan lues for pul:	se0 output o	f capaci	tar

Figure 31 Assembler

This is a comfortable editor with syntax highlighting, search and replace, copy and paste functions.

Under menu item "Assembler" the user finds the compile and download options.

Whether the call of these functions was successful or not is indicated by the messages at the bottom of the assembler window.

Debugging is not supported in this software revision.





3.2 Scaling Results

PCap04 in general calculates capacitance ratios. The measured ratios include of course all effects from parasitic capacitances. Nonetheless, in many cases users might be interested in an intuitive understanding the displayed values without making a full calibration run.

The following shows by example how to set Factor and Offset to give a suitable display.

Starting point: 10 pF between PC0 and PC1, 12.2 pF between PC2 and PC3, 8 pF between PC4 and PC5.

In grounded configuration, the chip measures 10pF reference against 10 pF at PC1, 12.2 pF at PC2 and PC3 and 8 pF at PC4 and PC5. In floating configuration 10pF reference is measured against 12.2 pF and 8 pF.

a) Grounded single, no compensation

The capacitance seen includes the port parasitic capacitance as well as the internal "parasitic" capacitance (5 pF to 6 pF), which is dominated by the comparator delay (about 10 pF).

The base capacitance is then not 10 pF but 25 pF. Thereof 15 pF are Offset which can be subtracted.

#	Name	Results	Filter		fpp	Factor	Offset		Span	Final Result	Mean 50	Std Dev	SNR [bit]
0	C0/Cref	08000013	none 💂	S	-27	25p	-15p	AO	10p	10p	10p	0	Inf
1	C1/Cref	0808B6B7	none 💂	s	-27	25p	-15p	AO	10p	10,1064p	10,1063p	234,5a	15,38
2	C2/Cref	088F5F56	none 💂	S	-27	25p	-15p	AO	10p	12,3361p	12,336p	225,2a	15,44
3	C3/Cref	08BA5E49	none 💂	s	-27	25p	-15p	AO	10p	12,275p	12,2748p	316,8a	14,95
4	C4/Cref	075FA4B4	none 💂	S	-27	25p	-15p	AO	10p	8,04252p	8,04221p	291,4a	15,07
5	C5/Cref	07688199	none 💂	S	-27	25p	-15p	AO	10p	8,15071p	8,15064p	257,6a	15,24
C	DT1/Def	00000000			25	1	0	40	1	0	0	0	Tof

Figure 32 Grounded single, no compensation

b) Floating single, no compensation

The influence of parasitic capacitances is the same and therefore the setting for Factor and Offset are the same.

#	Name	Results	Filter		fpp	Factor	Offset		Span	Final Result	Mean 50	Std Dev	SNR [bit]
0	C0/Cref	08000009	none	- S	-27	25p	-15p	AO	10p	10p	10p	0	Inf
1	C1/Cref	08B81EAB	none ,	- 5	-27	25p	-15p	AO	10p	12,2476p	12,2474p	273,1a	15,16
2	C2/Cref	076008D8	none .	- S	-27	25p	-15p	AO	10p	8,0473p	8,04729p	167,9a	15,86

Figure 33 Floating single, no compensation

c) Ground single, internal compensation

Now the chip sees only the port parasitic capacitance, not the internal one. This is in the order of 5 pF to 6 pF. Accordingly, the total base capacitance is 15 pF (Factor) with an offset of 5 pF.





#	Name	Results	Filter	fpp	Factor	Offset		Span	Final Result	Mean 50	Std Dev	SNR [bit]
0	CO/Cref	08000021	none 🖵 S	-27	15p	-5p	AO	10p	10p	10p	0	Inf
1	C1/Cref	080E6BCE	none 🖵 S	-27	15p	-5p	AO	10p	10,1056p	10,1059p	219,2a	15,48
2	C2/Cref	0946D492	none 🖵 S	-27	15p	-5p	AO	10p	12,3938p	12,3935p	283a	15,11
3	C3/Cref	093E1B82	none 🖵 S	-27	15p	-5p	AO	10p	12,3299p	12,3295p	353,1a	14,79
4	C4/Cref	06ECA6E1	none 🖵 S	-27	15p	-5p	AO	10p	7,98329p	7,98315p	274,7a	15,15
5	C5/Cref	06FBDDE2	none 🖵 S	-27	15p	-5p	AO	10p	8,09473p	8,09469p	214,2a	15,51

Figure 34 Ground single, internal compensation

d) Floating single, internal compensation

Again, the chip sees only the port parasitic capacitance. But due to the different port pattern the correction factors are slightly higher.

#	Name	Results	Filter		fpp	Factor	Offset		Span	Final Result	Mean 50	Std Dev	SNR [bit]
0	C0/Cref	080000C	none	🖵 S 🛊	-27	20p	-10p	AO	10p	10p	10p	1,632E-	52,44
1	C1/Cref	08E7E36C	none	🖵 S 🛊	-27	20p	-10p	AO	10p	12,2645p	12,2646p	301,6a	15,02
2	C2/Cref	0735B673	none	💌 S	-27	20p	-10p	AO	10p	8,02454p	8,02458p	252,1a	15,28
2	02/06	00000000			27	4	0	1.0	10-	0	0	0	T£

Figure 35 Floating single, internal compensation

Using floating in combination with an internal reference there is a deviation as we have internally only a single grounded capacitor. This is measured twice and the factor needs to be doubled.

e) Floating, both compensation

Now all parasitic capacitances are compensated. The initial base capacitance without offset can be used.

F	Name	Results	Filter	fpp	Factor	Offset		Span	Final Result	Mean 50	Std Dev	SNR [bit]
0	CO/Cref	0800001A	none 🖵 S	-27	10p	0	AO	10p	10p	10p	0	Inf
1	C1/Cref	09E81FB7	none 🗶 S	-27	10p	0	AO	10p	12,3834p	12,1831p	1,414p	2,822
2	C2/Cref	066773EF	none 🗶 S	-27	10p	0	AO	10p	8,00514p	6,40549p	3,703p	1,433
	02/06	00000000		1 17	4	^	100	10-	0	0	0	Tref

Figure 36 Floating, both compensation





3.3 Scaling PDM Output

Here we describe how to scale the PDM output when working with the standard firmware. Open the Memory window and select tab calibration:

Firmw	are	Calibration	Misc. Calibrati	ion	Comp	lete Mem	iory		
Calil	brati	on No	o. of Calibration	Values	5 8	÷ S	tart Addre	ss d 800	
#	Na	me	Value	fpp	s/u	Length	Address	Value (hex)	^
0	[pi0	_result0	900.00001m	27	u	4	800	07333335	
1	pi0	_result1	1.1	27	u	4	804	08CCCCCD	
2	pi0	_pulse0 (min)	1	0	u	2	808	0001	
3	pi0	_pulse1 (max)	1.022k	0	u	2	810	03FE	
4	pi1	_result0	699.99999m	25	u	4	812	01666666	
5	pi1	_result1	1.1	25	u	4	816	02333333	
6	pi1	_pulse0 (min)	1	0	u	2	820	0001	
7	pi1	_pulse1 (max)	1.022k	0	u	2	822	03FE	
									~

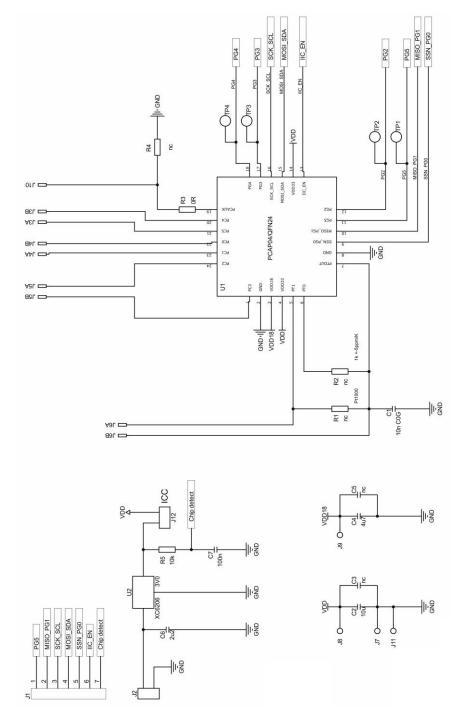
Figure 37 Scaling PDM Output

Set fpp to 27 and s/u to S for signed. Enter the capacitance ratios at minimum and maximum sensor signal. Set pix_pulse1 (max) to the value according to the set resolution of the PDM. This is 1023 at 10 bit and 65535 at 16 bit.

Press "Write" to write the data into the chip.



4 Schematics, Layers & BOM









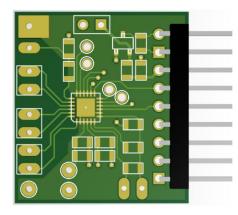


Figure 39: PCap04 LITE layout 2:1t

Table 2: Bill of materials for PCap04 LITE

Quantity	Designator	Value	Comment	Footprint
3	J3, J4, J5	10p	CHIP-CAPACITOR 0805	
1	C1	10n/C0G	CHIP-CAPACITOR 0805	
1	C7	100n	CHIP-CAPACITOR 0805	
1	C6	2u2	CHIP-CAPACITOR 0805	
1	C4	4u7	CHIP-CAPACITOR 0805	
1	C2	10u	CHIP-CAPACITOR 0805	
1	R3	0R	CHIP-RESISTOR 0805	
1	R5	10k	CHIP-RESISTOR 0805	
1	U1		PCap04 QFN24	
1	U2	3,0V	LDO XC6206 3,0V	

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5 RoHS Compliance & ScioSense Green Statement

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7 Revision information

Table 3: Revision history

Revision	Date	Comment	Page
1.0.2	2017	Latest version with old PICOPROG	All
2	May 2023	Release of second version for the kit which comes with PicoProg Lite	All
3	July 2023	Schematics J1 corrected, layout and board pictures updated	1, 2, 7, 8, 40

Note(s) and/or Footnote(s):

- 1. Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- 2. Correction of typographical errors is not explicitly mentioned.



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