

PCap04

Programming Board

PCAP04-EVA-KIT

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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 module, 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 Plug-in module	Based on PCapØ4 in QFN24 package
3	PicoProg V3.0	Programmer
4	Battery	
5	Wall power supply unit	9 V
6	High density DSUB15 cable	Connecting Evaluation board to programmer
7	USB cable	Connects PicoProg V3.0 to PC

The evaluation kit offers user friendly configurations for evaluating 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.

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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 it is described how to quickly set up 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:

- Make sure software is installed correctly 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 module 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 eval kit motherboard should be on.



Figure 2: Connected PCAP04-EVA-KIT

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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:

	acam PCap04		The second second	_		-	-				-		X	
F	File Memory Tools Interface Help													
	Setup CDC Frontend CDC RDC PDM/PWM DSP/GPIO Misc Expert													
	Select Device member of the ams group													
			[PCan04	a	-						Open Gra	ph	
			l	1 capos										
		Configuratio	ons ready	to use v	with	Evalua	tion Sys	ster	n		Sta	art Measur	ement	
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	Stand	ard		Humid	dity				Pres	sure		Vrite Comr	lete	
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	- Pure capacita	nce ratios	- Humi	dity in rh	% at	RES0	- Pres	sur	e in %	at RESO		ower on R	eset	
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	compensation	mode	- Floa	ating sin	gle		- Flo	atir	ng sing	gle				
			- Inte	rnal refe	erenc	e	- Int	erna	al refe	rence				
			- Interr	and refe	eratu erenc	ure :e	- Inte	rna or a	i temp nd refe	erature erence				
			- PDM F	PULSE0 rh	1%		- PDN	1 PU	LSE0 p	ressure in %				
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	Combined Error													
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#	Name	Results	Filter	erify Inte	erfac fpp	Factor	Offset		Span	Final Result	Co PI Mean	ombined E		
#	Name	Results 0	V Filter	erify Inte	erfac fpp 0	e Factor	Offset 0	AO	Span 0	Final Result	Co PI Mean	ombined E		
# 0 1	Name FR0 FR1	Results 0	Filter none [none [verify Inte	erfac fpp 0	Factor	Offset 0 0.	AO	Span 0 0	Final Result 0 0	Co PI Mean 100 0	ombined E Std Dev 0	rror O	
# 0 1 2	Name FR0 FR1 FR2	Results 0 0	Filter none [none [v s	fpp 0 0	Factor	Offset 0 0. 0	A0 A0	Span 0 0	Final Result 0 0	Co Pl Mean \$100 0 0	Std Dev	Internet SINR [bit]	
# 0 1 2 3	Name FR0 FR1 FR2 FR3 FR3	Results 0 0 0 0	Filter none [none] none [none]	verify Inte	fpp 0 0 0	e Factor 1 1 1 1 1	Offset 0 0. 0 0	A0 A0 A0	Span 0 0 0 0	Final Result 0 0 0 0	Cc PI Mean ∯100 0 0 0 0	Std Dev 0 0 0	rror O	
# 0 1 2 3 4	Name FR0 FR1 FR2 FR3 FR4 FD5	Results 0 0 0 0 0 0	Filter none i none i none i none i none i none i	v s v s v s v s v s v s v s v s v s v s	fpp 0 0 0 0 0	e Factor 1 1 1 1 1 1 1	Offset 0 0. 0 0 0 0	A0 A0 A0 A0	Span 0 0 0 0 0 0	Final Result 0 0 0 0 0	Cc PI Mean ∯100 0 0 0 0 0 0 0 0 0 0 0 0	Std Dev 0 0 0 0 0	rror O	
# 0 1 2 3 4 5 6	 Name FR0 FR1 FR2 FR3 FR4 FR5 FR6 	Results 0 0 0 0 0 0 0 0	Filter none [] none [] none []]]]]]]]]]]]]]]]]]	ferify Interest of the second	erfac fpp 0 0 0 0 0 0 0	e Factor 1 1 1 1 1 1 1 1 1 1 1	Offset 0 0. 0 0 0 0 0 0 0 0		Span 0 0 0 0 0 0 0 0	Final Result 0 0 0 0 0 0 0 0 0	Cc PI Mean‡100 0 0 0 0 0 0 0 0 0 0 0 0	Dombined E Std Dev 0 0 0 0 0 0 0 0	rror CAP	

Figure 3: Setup page

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

(
	Software Version: 1.2 PicoProg Firmware Version: 2.0.5 Memory read/write: OK
	OK

Figure 4: Verify Message

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The PCap04 plug-in module 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:

	acam PCap04												X
F	ile Memory T	ools Interfa	ce Help										
	Setup CDC From	tend CDC	RDC	PDM/I	PWM	DSP/0	SPIO N	Aisc	Exp	ert	3		Ш
	Cap	pacitance to	Digital	Conver	sion I	ronter	nd					member of t	he ams group
	Capacitance Measurement Scheme Cap. Port Select Stray Compensation								Open Gra	ph			
	Floating Sin	gie 💌	1	000		•	D	oth		▼ 3	Sta	irt Measur	ement
	0 1 2 3 4 5 Write Config												
				Port Err	or						V	Vrite Comp	olete
						_					P	ower On R	eset
	Discharge Res	istance Port	03 Disc	harge Re	esista	nce Port	:45 Ch	arg	e Resi	stance		Init Res	et
	90k	• 1	90k			▼ 1	10	Jk		▼ 0			
	C Reference Se	elect Ir	ternal Ca	p.									
	external	9	, pF										
												Rui	nbit 🔵
											Co	ombined E	rror 🔵
													~
											PI		CAP
#	Name	Results	Filter		fpp	Factor	Offset		Span	Final Result	Mean 150	Std Dev	SNR [bit]
To	C0/Cref	0	none	– S	-27	10p	0	AO	10p	0	0	0	0
1	C1/Cref	0	none	– S	-27	10p	0	AO	10p	0	0	0	0
2	C2/Cref	0	none	🖵 S	-27	10p	0	AO	10p	0	0	0	0
3	C3/Cref	0	none	🖵 S	-27	10p	0	AO	10p	0	0	0	0
4	C4/Cref	0	none	🖵 S	-24	10p	0	AO	10p	0	0	0	0
5	C5/Cref	0	none	▼ 5	-24	10p	0	AO	10p	0	0	0	0
6	PT1/Ref	0	none	▼ 5 ;	-25	1	0	AO	1	0	0	0	0
7	Alu/Ref	0	Median 5	▼ 5	-25	1	0	AO	1	0	0	0	0

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:

	acam PCap04		-		_		24				-		X
Fil	e Memory T	ools Interfa	ce Help										
S	etup CDC From	ntend CDC	RDC	PDM/F	ww	DSP/C	SPIO N	lisc	Exp	ert		Ee	300
	Cap	oacitance to	Digital C	onvers	sion F	ronter	nd					member of t	he ams group
	Capacitance Measurement Scheme Cap. Port Select Stray Compensation Open Graph												
	Floating Sin	gle 🔻	1	000	• • •	•	В	oth		▼ 3	Sto	p Measur	ement
				012	34	5							
				999								Write Con	fig
				Port Erro	or						V	/rite Comp	olete
											P	ower On R	eset
	Discharge Res	istance Port	03 Discl	harge Re	esista	nce Port	45 Ch	arg	e Resis	stance		Init Rese	et
	90k	▼ 1	90k		[• 1	10	Dk		▼ 0			
	C Reference Se	elect Ir	nternal Ca	p.									
	external 💌	9	pF										
												D	nhit 🦳
												Nu	
											Co	ombined E	rror 🔵
													JAP
#	Name	Results	Filter		fpp	Factor	Offset		Span	Final Result	Mean 50	Std Dev	SNR [bit]
0	C0/Cref	08000011	none	- S	-27	10p	0	AO	10p	10p	10p	0	Inf
1	C1/Cref	080AD6D5	none	- 5	-27	10p	0	AO	10p	10.0529p	10.0531p	140.2a	16.12
2	C2/Cref	07E66A02	none	- 5	-27	10p	0	AO	10p	9.87507p	9.87533p	146.9a	16.05
3	C3/Cref	00000000	none	- S	-27	10p	0	AO	10p	0	0	0	Inf
4	C4/Cref	00000000	none		-24	10p	0	AO	10p	0	0	0	Inf
5	CS/Cref	100000000	none		-24	10p	0	AO	10p	0	0000	0	1.04
7	PII/RET	16666666	none Mediar E		-25	1	0	AO	1	10	900m	300 5-	1 357
/	Alu/Kel	TULLULUL	weulans	ĽĽ.	-25	1	U	AO	1	Mcco.coe	007.0290	590.5M	1.557

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 module. Following is a picture of the Mother board with the plug-in module.



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

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

3.2 Hardware Architecture

Board block diagram; board layout; jumper, pin, connector, LED, display explanations

3.3 Key Elements

3.3.1 Capacitance Measurement



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

For the purpose of evaluating the capacitance measurement using PCapØ4, the plug-in module 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.

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 module, 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 PCapØ4 data sheet on how to select the value of the internal discharge resistor.

3.3.2 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 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
В	Port PT0 for external temperature sensor	
С	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 module. The module 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.

3.3.3 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 module, 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

3.3.4 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

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.

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

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"</pcap04v1></pcap04v0>
Read Device Version from Chip	Reads the device version from chip
Standard	Opens the <i><selected device="">_</selected></i> standard.prj project file with configuration and standard firmware.

Humidity	Opens the <i><selected device="">_</selected></i> humidity.prj project file with configuration and linearization firmware.
Pressure	Opens the <i><selected device="">_</selected></i> 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.'
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4.2.1.2 CDC Frontend Page

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	e Memory	Tools Inte	rface H	lelp										1251
S	etup CDC Fro	ontend C	DC RD	C PE	DM/P	WM	DSP/G	SPIO I	Misc	Exp	pert	_ =		3 11
	Ca	apacitance	to Digit	al Con	vers	ion I	ronten	d					member of t	the ams grou
														-
	Capacitance M	Measureme	nt Schem	e Cap	o. Por	t Sele	ect	St	ray (Compe	nsation		Open Gra	iph
	Grounded S	Single	• 0	0	00	0	ി	1	nterr	nal	• 1	Sta	art Measur	ement
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	Discharge Re	sistance Pr	ort 0 3 D	ischarg	e Re	sista	nce Port	45 0	are	e Resie	stance		ower on n	.c.set
	ook		1	ischung Mil	, e ne	51510		4	ol.	e nesi.			Init Res	et
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#	C Reference S	Results	9 🛓	PF		fpp	Factor	Offset		Span	Final Result	C PI Mean∯50	Ru ombined E	nbit) irror) CAF
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ŧ)	C Reference S external	Results	Interna 9 4/2 Filter none none	Cap. pF		fpp -27 -27 -27	Factor 10p 10p 10p	Offset 0 0 0	AO AO	Span 10p 10p 10p	Final Result 0 0	C PI Mean ‡ [50 0 0 0	Ru ombined E Std Dev 0 0 0	nbit irror CAF SNR (bit 0 0 0
# 0 1 3	C Reference S external	Results 0 0 0 0 0	Filter none none none	Cap. pF	S S S S	fpp -27 -27 -27 -27	Factor 10p 10p 10p 10p	Offset 0 0 0 0 0	40 40 40	Span 10p 10p 10p 10p	Final Result 0 0 0 0	C Mean∯[50 0 0 0 0	Rui ombined E Std Dev 0 0 0 0	nbit trror CAF SNR (bit 0 0 0 0
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t 1 1	C Reference S external	Results 0 0 0 0 0 0 0 0 0 0	Filter none none none none none	Cap. pF	ALPAID	fpp -27 -27 -27 -27 -27 -24 -24	Factor 10p 10p 10p 10p 10p 10p	Offset 0 0 0 0 0 0 0 0 0 0		Span 10p 10p 10p 10p 10p 10p	Final Result 0 0 0 0 0 0 0	C PI Mean∯50 0 0 0 0 0 0 0 0 0	Rui ombined E Std Dev 0 0 0 0 0 0 0	nbit rror CAF SNR (bit 0 0 0 0 0 0 0 0 0 0 0 0 0
# 0 1 2 3 4 5 5	C Reference S external	Results 0 0 0 0 0 0 0 0 0 0 0 0 0	Filter none none none none none none	Cap. pF	S S S S S S S S S S S S S S S S S S S	fpp -27 -27 -27 -27 -24 -24 -25	Factor 10p 10p 10p 10p 10p 10p 10p	Offset 0 0 0 0 0 0 0 0 0 0 0 0		Span 10p 10p 10p 10p 10p 10p 10p	Final Result Ø Ø Ø Ø Ø Ø Ø Ø	C PI Mean∯[50 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Rui ombined E Std Dev 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	nbit rror CAF SNR (bit 0 0 0 0 0 0 0 0 0 0 0 0 0

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 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)

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 $1 \rightarrow No$ 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 module, 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 module, the pins DSP_IN0 and DSP_IN1 are part of the

4.2.1.5 PDM / PWM Page

File	e Memory Toc	ols Interfa	re Help									
S	etup CDC Front	end CDC	RDC	PDM/P	WM D	SP/GPIO	Misc	Exp	pert	_ =		IM
	Pulse Interface 0			Pul	se Interfa	ce 1				_	member of t	the arms group
	Clock Sele	ct.			Clo	k Select					Open Gra	ph
	off)		off			0		St	art Measur	ement
	Resolution	n			Res	olution		-			Write Cor	nfig
	10 bits	•			10	oits	-	0			Write Com	olete
	Pulse Inte	rface Selec	t		Pul	se Interfa	ice Sele	ect			Power On R	eset
	PDM	•			PD	И		1			Init Res	et
	Toggle I	Enable			T	oggle En	able			142		
	Pulse Sele	ect			Pul	e Select						
	C1/Cref				Alu	/Ref	-	7				
										P	Ru: Combined E	nbit) irror) CAF
#	Name F	Results	Filter		fpp Fac	tor Offs	et	Span	Final Result	(PI Mean∯50	Rui Combined E	nbit) irror) CAF
#	Name F C0/Cref 6	Results	Filter		fpp Fac -27 10;	tor Offs	et AO	Span 10p	Final Result	Mean∯[50 Ø	Ru Combined E	nbit rror CAF SNR (bit 0
# 0 1	Name F CO/Cref G C1/Cref G	Results	Filter none none		fpp Fav -27 10g -27 10g	tor Offs	et AO	Span 10p 10p	Final Result 0 0	Mean∯[50 0 0	Ru Combined E Std Dev 0 0	nbit) irror) CAF SNR [bit 0 0
# 0 1 2	Name F C0/Cref 6 C1/Cref 6 C2/Cref 6	Results 0 0	Filter none none		fpp Fac -27 10μ -27 10μ -27 10μ	tor Offs 0 0 0	et AO AO	Span 10p 10p 10p	Final Result 0 0	Mean∯ <u>50</u> 0 0	Ru Combined E Std Dev 0 0	nbit) irror) CAF SNR (bit 0 0
# 0 1 2 3	Name F CO/Cref 6 C1/Cref 6 C2/Cref 6 C3/Cref 6	Results	Filter none none none		fpp Fac -27 10; -27 10; -27 10; -27 10; -27 10;	tor Offs 0 0 0 0 0 0	et AO AO AO	Span 10p 10p 10p	Final Result 0 0 0	Mean∯ <u>50</u> 0 0 0 0	Rui Combined E Std Dev 0 0 0	nbit irror CAF SNR (bit 0 0 0
# 0 1 2 3 4	Name F CO/Cref 6 C1/Cref 6 C2/Cref 6 C3/Cref 6 C4/Cref 6	Results	Filter none none none none		fpp Fac -27 100 -27 100 -27 100 -27 100 -27 100 -21 00	tor Offs 0 0 0 0 0 0 0 0	et AO AO AO AO	Span 10p 10p 10p 10p	Final Result 0 0 0 0	(PI Mean‡50 0 0 0 0	Rui Combined E Std Dev 0 0 0 0	nbit
# 0 1 2 3 4 5	Name F C0/Cref 6 C1/Cref 6 C2/Cref 6 C3/Cref 6 C4/Cref 6 C5/Cref 6	Results 0 0 0 0 0 0	Filter none none none none none		fpp Fac -27 10; -27 10; -27 10; -27 10; -24 10; -24 10;	tor Offs 0 0 0 0 0 0 0 0 0 0 0 0	et AO AO AO AO AO	Span 10p 10p 10p 10p	Final Result 0 0 0 0 0	Mean‡50 0 0 0 0 0	Rui Combined E Std Dev 0 0 0 0 0 0	nbit

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 = $(100 \text{ kHz} / 1024) \sim 100 \text{ Hz}.$



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

	acam PCap04												
Fi	le Memory T	ools Inter	face Help										
S	etup CDC Fro	ontend CE	DC RDC PE	DM/P	wм	DSP/G	iPIO I	Misc	Exp	pert	73	member of f	the ams group
	DSP												100
												Open Gra	iph
	Fast	• 1		OSP_F	F_IN		DS	P_M	OFLO_E	EN	St	art Measur	ement
	DSP_STAR	T_EN		INI	IN3		ENO	EN1				Write Cor	nfig
	0000	ſ										Write Com	olete
			C	OSP_S	TART	ONPIN						Power On R	leset
	코코꼬콜	1										Init Res	et
	PG_DIR_IN	PG_PU	5 5 5 6	P	GOxPC Puls G1xPC Puls	32 se0 > PG 33 se1 > PG	2 3		■ PG4 ▼ PG5	_INTN_EN _INTN_EN		Ru Combined E	
#	Name	Results	Filter		fpp	Factor	Offset		Span	Final Result	Mean 50	Std Dev	SNR [bit]
0	C0/Cref	0	none 💌	s A	-27	10p	0	AO	10p	0	0	0	0
1	C1/Cref	0	none 💌	s	-27	10p	0	AO	10p	0	0	0	0
2	C2/Cref	0	none 💌	5	-27	10p	0	AO	10p	0	0	0	0
3	C3/Cref	0	none 💌	S	-27	10p	0	AO	10p	0	0	0	0
4	C4/Cref	0	none 💌	s	-24	10p	0	AO	10p	0	0	0	0
5	C5/Cref	0	none 💌	s	-24	10p	0	AO	10p	0	0	0	0
6	PT1/Ref	0	none 💌	5	-25	1	0	AO	1	0	0	0	0
7	Alu/Ref	0	Median 5 💂	S	-25	1	0	AO	1	0	0	0	0

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

acam PCap)4 (Tools Inter	face Heln										
Setup CDC	Frontend C		PDM/P	WM	DSP/G	SPIO N	Aisc	Exp	pert	٦	member of f	the ams grou
LF Clock				HEC	lock						Open Cr	
OLE CTU		IF FTUNE			OX_RUN	1				<u></u>	Open Gra	ipn
50kHz	• 1 7				Off			•	0	Sta	a <mark>rt M</mark> easur	ement
					ox_D	IS			OX_STOP		Write Cor	nfig
					OX_A	UTOSTOP	DI	s 🕅	OX DIV4	V	Vrite Com	olete
								20 D-	1999-1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1 1997 -	F	ower On F	eset
											Init Res	et
C_G_OP_ perman	RUN ent 💌	□ c_G_0	P_EXT			C_G_OF	_vu	0		PI	Ru ombined E	nbit) irror)
Name	Results	Filter		fpp	Factor	Offset		Span	Final Result	Mean \$ 50	Std Dev	SNR [bi
CO/Cref	0	none [- S -	-27	10p	0	AO	10p	0	0	0	0
C1/Cref	0	none [- 5	-27	10p	0	AO	10p	0	0	0	0
C2/Cref	0	none [- 5	-27	10p	0	AO	10p	0	0	0	0
C3/Cref	0	none [👻 S 🛔	-27	10p	0	AO	10p	0	0	0	0
C4/Cref	0	none	▼ 5 ‡	-24	10p	0	AO	10p	0	0	0	0
C5/Cref	0	none	▼ 5 €	-24	10p	0	AO	10p	0	0	0	0
	0	none	_ < +	-25	1	0	AO	1	0	0	0	
PT1/Ref	U	I done		1			10.01	3	12		-	0

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. (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).

4.2.1.8 Expert Page

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

4.2.2 Front Panel Menus

4.2.2.1 File Menu

File	Memory	Tools	Interface
0	pe <mark>n</mark> Project	Ctrl+0	bc
Sa	ave Project	Ctrl+S	
In	nport		•
Ð	port		
C	lose	Ctrl+W	tion

Figure 18 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

4.2.2.2 Memory Menu

File	Memory	Tools	Interface	Help	
Sctu	Firmwa Calibra Read C	are ition Config fro	om NVRAM	Ctrl+M	i/PV

Figure 19 Memory Menu

Figure 1-10: 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.

4.2.2.3 Tools Menu

File Me	emory	Tools	Interface He	elp	
Setup	CDC I	Run	Measurement	Ctrl+R	WN
		Grap	bh	Ctrl+G	Г
		Regi	isters	Ctrl+F	De
		Line	arize	Ctrl+L	4a
		Asse	mbler	Ctrl+A	w

Figure 20 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

4.2.2.4 Interface Menu



Figure 21 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

4.2.2.5 Help Menu

File M	emory Tools I	nterface	Help			
Setup	CDC Frontend	CDC	He Ch	lp Contents eck Errors	; F1	SP
			Ab	out	F12	

Figure 22 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.

4.2.3 Special Windows

4.2.3.1 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.

Firmware	Calibratio	n	Mi	sc. C	alib	orati	on	C	omp	lete	Me	mor	v					0
		Wri	te D	ata		PCa	p04_	sta	nda	rd_v	XX.h	ex						
Oper	File	24	05	AO	01	20	55	42	5C	48	B 1	07	92	02	20	13	02	
		20	93	02	B2	02	78	20	54	B 3	06	91	00	7 F	20	86	20	
Reloa	dFile	54	B6	03	72	62	20	54	B7	00	00	42	5C	A1	00	49	BO	
1997 - 19		00	49	40	AB	5D	92	10	90	02	7F	20	86	66	67	76	77	
Remove	'FF' at End	66	7A	CF	CD	E6	43	F1	44	29	EO	7A	DC	E7	41	32	AA	=
		01	99	FD	7B	01	7A	CF	EB	E6	43	F1	44	29	EO	7A	C1	
		E7	41	32	6A	DE	44	7A	CF	EA	E6	43	F1	44	29	EO	6A	
		DF	44	7A	C4	E7	41	32	AB	05	7A	C1	E1	43	EO	3A	7A	1
Address	Length	CO	E1	43	EO	3A	02	7A	CF	E6	E6	43	F1	44	29	EO	7A	
Address	Lengui	EF	44	02	20	9D	84	01	21	2E	21	74	20	37	C8	7A	E7	
90	d 1024	43	49	11	6A	D4	44	7A	C1	D8	E6	43	E9	44	10	43	13	
S 53	25 Sa	AB	63	6A	DE	41	AB	OB	46	46	46	7A	DF	FF	FF	FF	FF	
Write		E3	41	32	10	44	E9	13	6A	D4	13	41	AA	DF	7A	C5	E1	
		43	49	EO	34	7A	CF	E3	E6	43	F1	44	29	EO	DB	CO	27	
De		E5	6A	DF	43	7A	C8	E7	41	30	AB	03	86	01	92	37	7A	
ĸe	au	C6	E7	41	7A	FA	E7	43	EA	44	7A	C1	E1	E6	43	E9	44	70.0
		Rea	d D	ata											Da	ta e	qual	
		24	05	AO	01	20	55	42	5C	48	B1	07	92	02	20	13	02	
		20	93	02	B2	02	78	20	54	B3	06	91	00	7F	20	86	20	(T)
		54	B6	03	72	62	20	54	B7	00	00	42	5C	A1	00	49	BO	E
		00	49	40	AB	5D	92	10	90	02	7F	20	86	66	67	76	77	
		66	7A	CF	CD	E6	43	F1	44	29	EO	7A	DC	E7	41	32	AA	1
Firmware V	/ersion	01	99	FD	7B	01	7A	CF	EB	E6	43	F1	44	29	EO	7A	C1	
Deadure C	1	E7	41	32	6A	DE	44	7A	CF	EA	E6	43	F1	44	29	EO	6A	
Product G	roup	DF	44	7A	C4	E7	41	32	AB	05	7A	C1	E1	43	EO	3A	7A	
		CO	E1	43	EO	3A	02	7A	CF	E6	E6	43	F1	44	29	EO	7A	
Program T	vne	EF	44	02	20	9D	84	01	21	2E	21	74	20	37	C8	7A	E7	
riogranti	The	43	49	11	6A	D4	44	7A	C1	D8	E6	43	E9	44	10	43	13	
		AB	63	6A	DE	41	AB	OB	46	46	46	7A	DF	FF	FF	FF	FF	
Version		E3	41	32	10	44	E9	13	6A	D4	13	41	AA	DF	7A	C5	E1	
a		43	49	EO	34	7A	CF	E3	E6	43	F1	44	29	EO	DB	CO	27	
0		E5	6A	DF	43	7A	C8	E7	41	30	AB	03	86	01	92	37	7A	

Figure 23 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
	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.

4.2.3.2 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.

Firmw	are	Calibration	Misc. Calibrati	ion	Comp	lete Mem	ory		(
Cali	brati	on No	o. of Calibration	Values	5 8	St.	tart Addres	ss d 800	
#	Na	me	Value	fpp	s/u	Length	Address	Value (hex)	
0	pi0	_result0	900,00001m	25	u	4	800	01CCCCCD	
1	pi0	_result1	1,1	25	u	4	804	02333333	
2	pi0	_pulse0 (min)	1	0	u	2	808	0001	
3	piC	_pulse1 (max)	1,022k	0	u	2	810	03FE	
4	pi1	_result0	900m	27	u	4	812	07333333	
5	pi1	_result1	1,1	27	u	4	816	08CCCCCD	
6	pi1	_pulse0 (min)	1	0	u	2	820	0001	
7	pi1	_pulse1 (max)	1,022k	0	u	2	822	Ø3FE	
		r							-

Figure 24 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.

4.2.3.3 Misc. Calibration Window

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

	re	Calibration	Misc	. Calibr	ation	Con	npl	ete Me	mory
isce	llar	neous Calibrati	ion Bits	at Add	dress d	956].	d 959	
#	Na	me	1	#	Name	2	2043		
0	4		0	16					0
1	5		0	17					0
2	į.		0	18	0				0
3	0		0	19	l.				0
4			0	20					0
5	i)		0	21	1				O
6	Q.		0	22					0
7			0	23	l.				0
8			0	24					0
9			0	25	1				O
10	į.		0	26					0
11	Q		0	27					0
12			0	28					0
13	1		0	29					0
14	<u> </u>		0	30					0
15	<u>.</u>		0	31					0
							×	000000	000
								Write	
								Read	

Figure 25 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.

Irmware	Ci	alibra	ation	N	Aisc.	Calib	oratio	n	Com	plete	Mer	nory					(
V	Vrite	Mem	nory														
0	24	05	AØ	01	20	55	42	5C	48	B1	07	92	02	20	13	02	
16	20	93	02	B2	02	78	20	54	B 3	06	91	00	7F	20	86	20	
32	54	B6	03	72	62	20	54	B7	00	00	42	5C	A1	00	49	BØ	
48	00	49	40	AB	5D	92	1C	90	02	7F	20	86	66	67	76	77	1
64	66	7A	CF	CD	E6	43	F1	44	29	EØ	7A	DC	E7	41	32	AA	
80	01	99	FD	7B	01	7 A	CF	EB	E6	43	F1	44	29	EØ	7A	C1	
96	E7	41	32	6A	DE	44	7A	CF	EA	E6	43	F1	44	29	EØ	6A	1
112	DF	44	7A	C4	E7	41	32	AB	05	7A	C1	E1	43	EØ	ЗA	7A	-
						-	- 2			Stor	e	- 2		3	trase	2	- 2
F	lead	Mem	ory			-				Stor	e			Da	ta ec	e Jual	0
F 0	ead	Mem 05	ory A0	01	20	55	42	5C	48	B1	07	92	02	Da 20	ta ec	ual 02	
0 16	24	Mem 05 93	AØ	01 B2	20 02	55	42	5C	48 83	B1 06	07 91	92 00	02 7F	Da 20 20	ta ec	e ual 02 20	
0 16 32	24 20 54	Mem 05 93 B6	ory A0 02 03	01 B2 72	20 02 62	55 78 20	42 20 54	5C 54 B7	48 83 00	B1 06 00	07 91 42	92 00 5C	02 7F A1	Da 20 20 00	ta ec 13 86 49	e ual 02 20 B0	
0 16 32 48	24 20 54 00	Mem 05 93 86 49	A0 02 03 40	01 B2 72 AB	20 02 62 5D	55 78 20 92	42 20 54 1C	5C 54 87 90	48 B3 00 02	B1 06 00 7F	07 91 42 20	92 00 5C 86	02 7F A1 66	Da 20 20 00 67	ta ec 13 86 49 76	e uual 02 20 80 77	
0 16 32 48 64	24 20 54 00 66	Mem 93 86 49 7A	0ry A0 02 03 40 CF	01 82 72 AB CD	20 02 62 5D E6	55 78 20 92 43	42 20 54 1C F1	5C 54 87 90 44	48 83 00 02 29	B1 06 00 7F E0	07 91 42 20 7A	92 00 5C 86 DC	02 7F A1 66 E7	Da 20 20 00 67 41	ta ec 13 86 49 76 32	02 20 80 77 AA	
0 16 32 48 64 80	24 20 54 00 66 01	Mem 93 86 49 7A 99	A0 02 03 40 CF FD	01 B2 72 AB CD 78	20 02 62 5D E6 01	55 78 20 92 43 7A	42 20 54 1C F1 CF	5C 54 87 90 44 EB	48 B3 00 02 29 E6	B1 06 00 7F E0 43	07 91 42 20 7A F1	92 00 5C 86 DC 44	02 7F A1 66 E7 29	Da 20 20 67 41 E0	ta ec 13 86 49 76 32 7A	e ual 02 20 80 77 AA C1	
0 16 32 48 64 80 96	24 20 54 00 66 01 E7	Mem 93 86 49 7A 99 41	A0 02 03 40 CF FD 32	01 B2 72 AB CD 7B 6A	20 02 62 5D E6 01 DE	55 78 20 92 43 7A 44	42 20 54 1C F1 CF 7A	5C 54 87 90 44 EB CF	48 83 00 02 29 E6 EA	B1 06 00 7F E0 43 E6	e 07 91 42 20 7A F1 43	92 00 5C 86 DC 44 F1	02 7F A1 66 E7 29 44	Da 20 20 67 41 E0 29	ta ec 13 86 49 76 32 7A E0	 02 20 80 77 AA C1 6A 	

Figure 26 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.



4.2.3.4 Graph Window

Figure 27 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.

4.2.3.5 Registers Window

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.

Results

x 08000014

× 08066338

× 080F08C4 × 081D6C44

× 00000000 × 00000000

× 00000000

× 01D120B8

Read Results

COMB_ERR ERR_OVFL

MUP_ERROR RDC ERR

SENSE_TESTO

8 8 8 8 8 8 8

Results

X

Write Registers Re	sults	Write Registers
	Register	
Register 3, 2, 1, 0	× 1058001D	Res 0 <310>
Register 7, 6, 5, 4	× 200F0010	Res 1 <310>
Register 11, 10, 9, 8	× 0007D000	Res 2 <310>
Register 15, 14, 13, 12	× 03FF0800	Res 3 <310>
Register 19, 18, 17, 16	× 00002400	Res 4 <310>
Register 23, 22, 21, 20	× 30500100	Res 5 <310>
egister 27, 26, 25, 24	× 04520434	Res 6 <310>
egister 31, 30, 29, 28	× 0882005A	Res 7 <310>
egister 35, 34, 33, 32	× 00470008	
egister 39, 38, 37, 36	× 71002800	C 1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-
egister 43, <mark>4</mark> 2, 41, 40	× 00080000	Statusreg
Register 47, <mark>4</mark> 6, 45, 44	× 01000000	Port Error
Register 51, 50, 49, 48	× 00000000	Runbit
		CDC active
		TENDFLAG
		Autoboot busy
		TESTMODE
		COO RES_FLAC

Figure 28 Write Registers and Results

4.2.4 Linearize

4.2.4.1 **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 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 29 Sensor Characterization

4.2.4.2 Temperature Sensor Characterization

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 1-18) 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.



Figure 30 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).

4.2.4.3 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	s for Linear	ization-Polynomial			Load from File	Save to File
Sensor Characterization	tion Temp. Sensor Characterization		One/Two Point Calibration	Pulse	Expert		
Note: For lot Capa CCP: CCP: CCP: CCP: CCP: CCP: CCP: TCP TCP TCP TCP TCP TCP CCP: CCP:	For most accura calibration with Z_Result t 0,000000 2 0,000000 2 0,000000 ire ci_at_CCP from lect Ratio /Cref • berature Set Point Temp. (*C) 1 0,000000 2 0,000000 ire r_at_TCP from lect Ratio	te calibration i n only one or tr off • Temp. [*C] 0,000000 0,000000 PCap Acquire CCP2 s off • PCap	ndividual sensor calibration wo calibration points pleas c_hex_i 04000 r_hex_i 000000 04000	at_CCP 000 000 000 000	tiance and tem is sheet. x_at_CCP 0 1 1	perature) is recommende x_hex_at_CCP 0000000 04000000 y_hex_at_CCP 00000000 02000000	≥d.
	/Cref 💌 🚺	Acquire TCP2					

Figure 31 One/Two Point Calibration

4.2.4.4 Pulse

calculating the	Coefficients for Linear	ization-Polynomia		-	Load from File	Save to File
ensor Characterization	Temp. Sensor Characterization	One/Two Point Calibratio	n Pulse	Expert		
Pulse Interface 0						
Acquire Results fro	m PCap	Contribution				
Input of Result		Coefficients	0000000			
C0/Cref 💌	Acquire Result 1	pi0_result1 0,00000	00000000			
Input of Pulse		pi0_result 0,00000	000000000			
PT1/Ref	Acquire Result 2	pi0_pulse1_0.00000	00000000			
		pic_paner streets				
Acquire Results fro	m PCap					
Acquire Results fro	m PCap	Coefficients				
Acquire Results fro	M PCap	Coefficients	00000000			
Acquire Results fro Input of Result C1/Cref v Input of Pulse	Acquire Result 1	Coefficients pil_result0 0,00000 pil_result1 0,00000 pil_result2 0,00000	00000000			
Acquire Results fro Input of Result C1/Cref Input of Pulse	M PCap Acquire Result 1 Acquire Result 2	Coefficients pil_result0 0,00000 pil_result1 0,00000 pil_pulse0 0,00000 pil_pulse1 0,00000	00000000			
Acquire Results fro Input of Result C1/Cref • Input of Pulse Alu/Ref •	M PCap Acquire Result 1 Acquire Result 2	Coefficients pil_result0 0,00000 pil_result1 0,00000 pil_pulse0 0,00000 pil_pulse1 0,00000	00000000 00000000 00000000 00000000			
Acquire Results fro Input of Result C1/Cref v Input of Pulse Alu/Ref v	m PCap Acquire Result 1 Acquire Result 2	Coefficients pil_result0 0,00000 pil_result1 0,00000 pil_pulse0 0,00000 pil_pulse1 0,00000	00000000 00000000 00000000 00000000			
Acquire Results fro Input of Result C1/Cref v Input of Pulse Alu/Ref v	m PCap Acquire Result 1 Acquire Result 2	Coefficients pil_result0 0,00000 pil_result1 0,00000 pil_pulse0 0,00000 pil_pulse1 0,00000	00000000 00000000 00000000 00000000			
Acquire Results fro Input of Result C1/Cref v Input of Pulse Alu/Ref v	m PCap Acquire Result 1 Acquire Result 2	Coefficients pi1_result0 0,00000 pi1_result1 0,00000 pi1_pulse0 0,00000 pi1_pulse1 0,00000	00000000 00000000 00000000 00000000			
Acquire Results fro Input of Result C1/Cref v Input of Pulse Alu/Ref v	m PCap Acquire Result 1 Acquire Result 2	Coefficients pi1_result0 0,00000 pi1_result1 0,00000 pi1_pulse0 0,00000 pi1_pulse1 0,00000	00000000 00000000 00000000 00000000			
Acquire Results fro Input of Result C1/Cref v Input of Pulse Alu/Ref v	M PCap Acquire Result 1 Acquire Result 2	Coefficients pi1_result0 0,00000 pi1_result1 0,00000 pi1_pulse0 0,00000 pi1_pulse1 0,00000	00000000 00000000 00000000 00000000			
Acquire Results fro Input of Result C1/Cref Input of Pulse Alu/Ref I	m PCap Acquire Result 1 Acquire Result 2	Coefficients pi1_result0 0,00000 pi1_result1 0,00000 pi1_pulse0 0,00000 pi1_pulse1 0,00000	00000000 00000000 00000000 00000000			
Acquire Results fro Input of Result C1/Cref v Input of Pulse Alu/Ref v	m PCap Acquire Result 1 Acquire Result 2	Coefficients pi1_result0 0,00000 pi1_result1 0,00000 pi1_pulse0 0,00000 pi1_pulse1 0,00000	000000000000000000000000000000000000000			

Figure 32 Pulse

4.2.4.5 Expert

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 33 Expert

4.2.5 Assembler



Figure 34 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.

5 Schematics, Layers and BOM







Figure 36: PCa04 AD module schematics



Figure 37: PCa04 AD module layout



Item	Qty	Reference	Part Name	Description
2	1	C2		C805, 10u
3	1	C4		C805, 4u7
5	1	U1		PCAP04/QFN24
6	3	R1 R2 R3	R805, nc	
4	2	C3 C5	C805, nc	
1	1	C1	C805, nc	CHIP-CAPACITOR

Bill of Materials for PCap04 plug-in module

6 Ordering & Contact Information

Ordering Code	Description
PCAP04-EVA-KIT	PCap04 Eval Kit Programming Board

Buy our products or get free samples online at:

www.ams.com/ICdirect

Technical Support is available at:

www.ams.com/Technical-Support

Provide feedback about this document at:

www.ams.com/Document-Feedback

For further information and requests, e-mail us at:

ams_sales@ams.com

For sales offices, distributors and representatives, please visit:

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Headquarters

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Revision Information 8

Changes from previous version to current revision 1-00 (2016-Jun-09)

Page

Initial version 1-00

Note: Page numbers for the previous version may differ from page numbers in the current revision.

Correction of typographical errors is not explicitly mentioned.