Multichannel Metrology Getting Started Guide Beta version (4.00.00)

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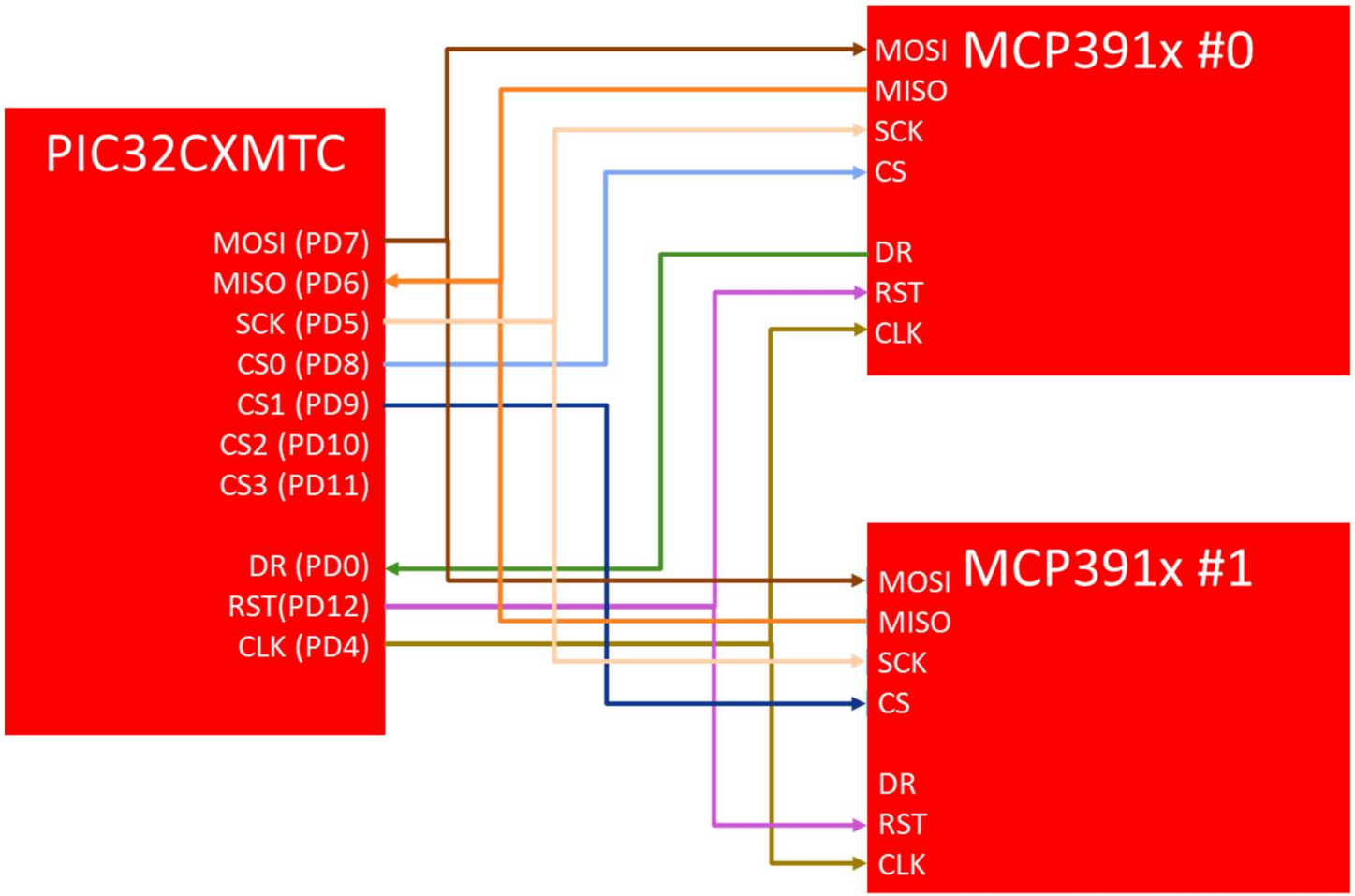
Deliverables

- **Main deliverable:**
  - “core1_metlib.bin”: Metrology library binary.
- **Firmware code:**
  - “thirdparty.metrology.demometer.pic32cxmtc_db”:
    - Demo meter application example code, based on the standard Demo Meter Application for the PIC32CXMTC Evaluation board.
    - It requires MCP3913/4 evaluation boards connected to the PIC32CXMTC-DB.
    - IDE: IAR 9.20.4.
- **Documentation:**
  - “PIC32CXMTC Multichannel Metrology Reference Guide”: Metrology library datasheet.
  - “Metrology Firmware 4.00.00 Test Report”: A report from our metrology lab demonstrating the outstanding performance of the Microchip metrology library and AFEs.
- **Tools:**
  - “METROLOGY_CONFIGURE_CALIBRATE_CALCULATE_v6.0_00-Jun-2024.xlsx”: Configuration and calibration tool.
- **Online resources:**
  - Please check the “Documentation” section in https://www.microchip.com/en-us/development-tool/ev58e84a, containing information about the standard metrology library release, which is the baseline of the multichannel metrology library

HARDWARE CONNECTIONS

HARDWARE CONNECTIONS

CONNECTION DIAGRAM



- The MCSPI peripheral on the PIC32CXMTC can manage up to four MCP391x devices; however, the current version of the metrology library is limited to a maximum of two MCP3913/4 devices.
- Please utilize the pin designations PDxx (PIC32CXMTC) as indicated in the accompanying diagram.
- The "CLK" and "SCK" signals operate at a frequency of 8.192MHz. Appropriate routing techniques should be taken to accommodate these high-frequency signals. Depending on the specific application, the use of a clock buffer or the inclusion of series resistors may be necessary to ensure signal integrity.
- Additionally, pull-up resistors are recommended for the "DR" and "RST" lines to maintain proper functionality.
- For further guidance and best practices, including the suggestion to incorporate series resistors (100 ohm) within the SPI lines, please consult the MCP391x datasheet.

HARDWARE CONNECTIONS

METROLOGY INPUT NETWORKS

- Kindly refer to the " PIC32CXMTC-DB HW User Guide," which offers guidance on the configuration of metrology input networks.
- For optimal performance in standard metrology applications, it is advisable to employ differential inputs for current channels. Single-ended inputs are typically sufficient for voltage channels.

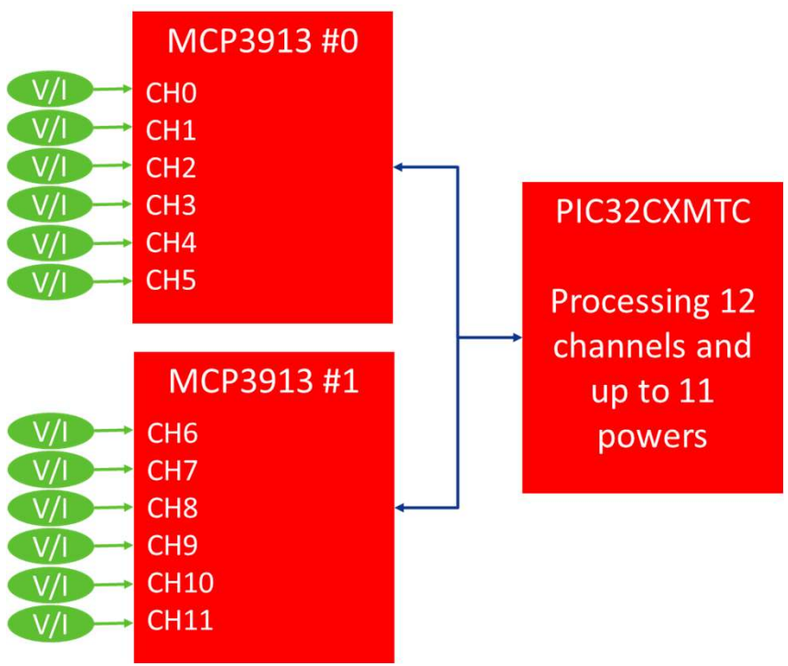
MULTICHANNEL METROLOGY LIBRARY BASIC CONCEPTS

BASIC CONCEPTS

- **The metrology library systematically acquires data from the signals connected to the MCP391x devices, designating each signal as a "channel" for the purpose of measuring electrical currents or voltages.**
- **A "power" is defined as a pair of one voltage and one current channel.**
- **The library's control registers offer users the capability to tailor the configuration of both channels and powers, ensuring an outstanding degree of adaptability. Standard configuration procedures include:**
  - Selection of the MCP391x devices connected to the PIC32CXMTC MCU.
  - Configuring each channel to function as either a voltage or current measurement channel.
  - Determining the specific voltage and current channels that constitute each power measurement.
- **The library calculates various metrological parameters for both individual channels (such as root mean square and peak values) and powers (such as active and reactive power measurements).**

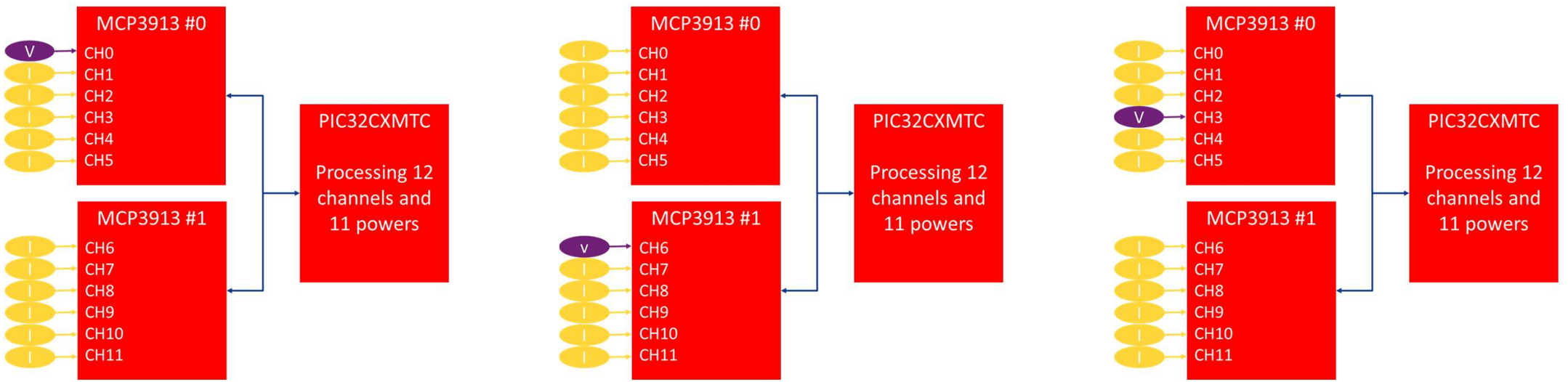
BASIC CONCEPTS

- **The present version of the metrology library allows to manage up to 2 MCP3913 or 2 MCP3914 devices.**
- **In the future, more MCP391x models will be supported, and the number of managed devices will increase up to 4 units.**
- **Analysis of the configuration alternatives available when utilizing 2 MCP3913 units:**
  - The system features a total of 12 channels, with 6 channels allocated to each MCP3913.
  - Channel indexes 0 through 5 correspond to the MCP3913 linked to the CS0 signal.
  - Channel indexes 6 through 11 correspond to the MCP3913 linked to the CS1 signal.
  - Each channel can be configured as voltage or current channel.
  - The configuration of channels and powers is highly adaptable, supporting all the possible combinations.



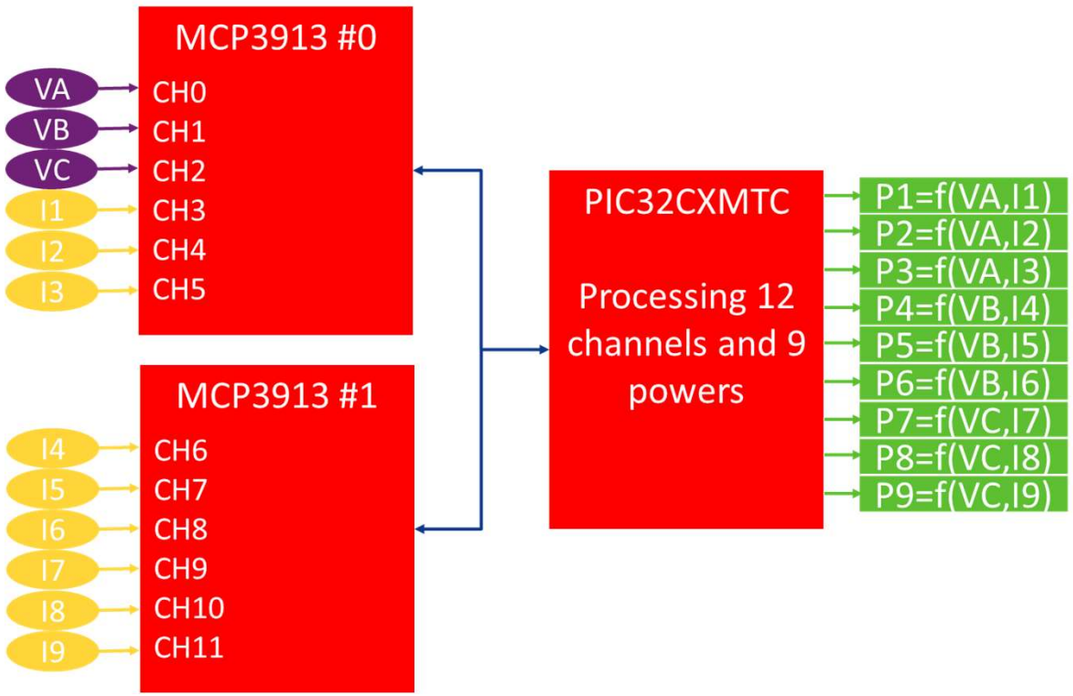
BASIC CONCEPTS

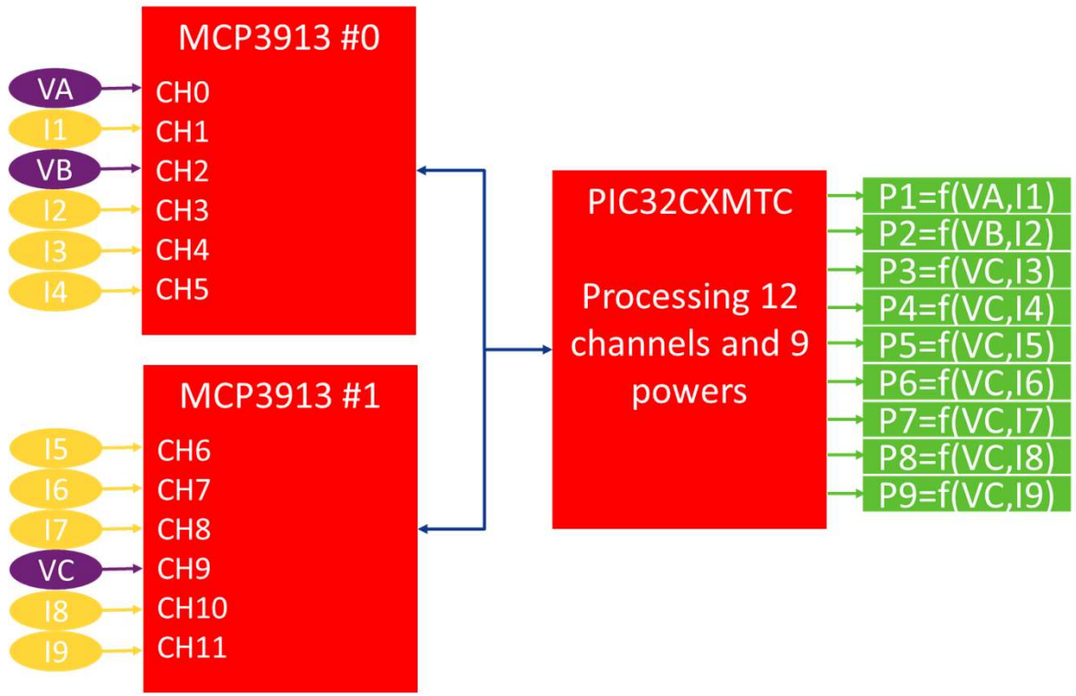
- **Below are some illustrative configurations utilizing two MCP3913 devices, exemplifying the library's versatility in accommodating various power monitoring setups:**
  - Case 1: Single-phase power strip:
    - Voltage channels: 1.
    - Current channels: 11.
    - Powers: 11.
    - Examples (please note that the channel assignment is totally flexible, allowing for sources to be connected to any chosen channel):



BASIC CONCEPTS

- **Below are some illustrative configurations utilizing two MCP3913 devices, exemplifying the library's versatility in accommodating various power monitoring setups:**
  - Case 2: Poly-phase Power Distribution Unit (PDU):
    - Voltage channels: 3 (VA, VB, VC).
    - Current channels: 9.
    - Powers 9.
    - Examples (the channel assignment to the MCP391x inputs is totally flexible, allowing for sources to be connected to any chosen channel. Additionally, the channel assignment to powers is also fully adaptable):





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CORE 0 APPLICATION CONSIDERATIONS

- **The metrology registers (control, status, accumulators and harmonics registers) are allocated within IRAM2 at a predetermined address. It is imperative that the application executing on Core 0 acknowledges this fixed address and allocates the necessary space for these registers.**
- **For your reference, please review the source code file "thirdparty.metrology.demometer.pic32cxmtcdb." This resource illustrates the proper method for defining the address (" MEM_REG_IN_ADDRESS ") and reserving the required space for the metrology registers.**
- **Additionally, please examine the example code provided, which demonstrates the initialization process for the metrology library. It also details the procedure for communicating with the library via IPC interrupts, enabling access to the metrology results.**
- **The Metrology Library version 4.0.00 necessitates the allocation of the following resources from Sub-system 0:**
  - IRAM2: 3584B
  - Flash: 16460B

MULTICHANNEL METROLOGY LIBRARY GETTING STARTED

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GETTING STARTED: SUMMARY

- **Initial Action Required:**
  - Kindly review the "Documentation" section at https://www.microchip.com/en-us/development-tool/ev58e84a, which provides details on the standard metrology library release. This serves as the foundation for the multichannel metrology library and includes comprehensive documentation that explains the procedures for utilizing Microchip's metrology solutions.

- **Multichannel metrology library initial steps:**
  - Step 1: Configuration
  - Step 2: Calibration
- **Tool: “METROLOGY_CONFIGURE_CALIBRATE_CALCULATE.xslx” excel file.**
- **Resources needed:**
  - A serial terminal connected to the PIC32CXMTC-DB is needed to send commands to the demo meter application example (“thirdparty.metrology.demometer.pic32cxmtc_db”).
  - When using a custom hardware and firmware solution, it is essential to establish a method for programming the metrology control registers.

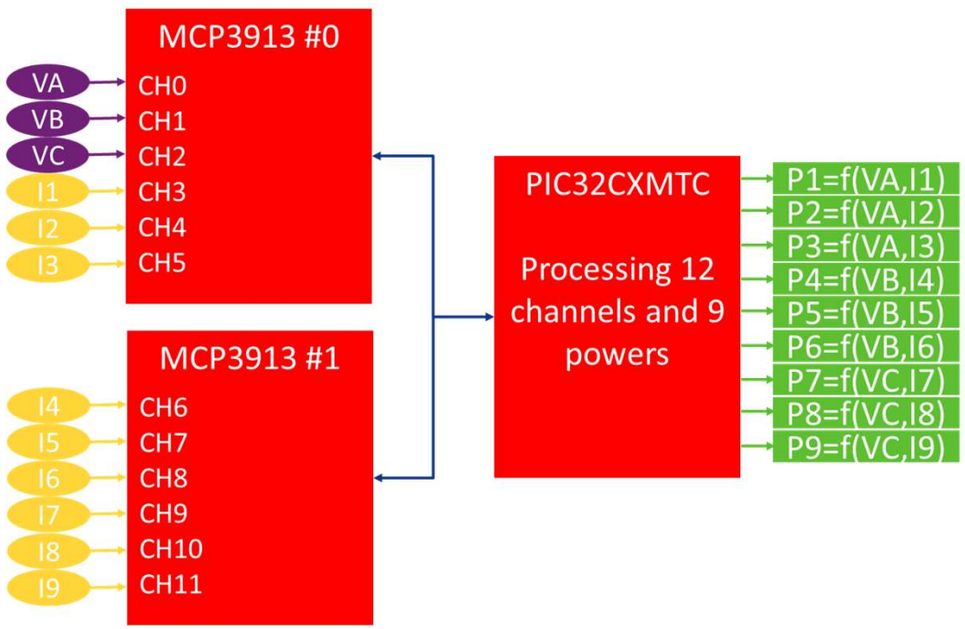
MUTICHANNEL CONFIGURATION

- The "CONFIGURATOR" tab within the "METROLOGY_CONFIGURE_CALIBRATE_CALCULATE.xslx" document provides a detailed, sequential guide for customizing the library to suit the specific requirements of a multichannel configuration.

CONFIGURATION TOOL

INSTRUCTIONS: WRITE IN THE YELLOW CELLS. THEN SEND THE RESULTS (GREEN CELLS) TO THE BOARD

- Below is an illustrative example demonstrating the configuration process corresponding to the following diagram:



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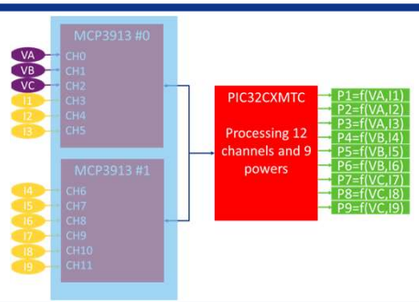
MUTICHANNEL CONFIGURATION

STEP 1: AFE SELECTION

SELECT THE AFE PART AND NUMBER. CHECK THE METROLOGY REFERENCE GUIDE FOR THE OPTIONS AVAILABLE IN THE VERSION BEING USED.

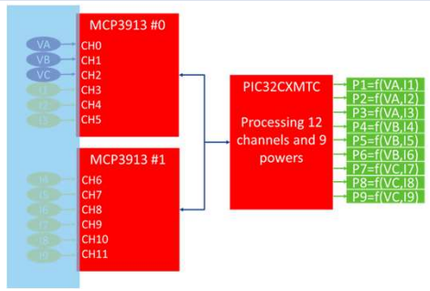
2 x MCP3913. 12 channels and up to 11 powers are allowed



STEP 2: CHANNEL CONFIGURATION

CONFIGURE EACH CHANNEL AS A VOLTAGE OR CURRENT SOURCE, BY SELECTING THE SENSOR TYPE I

CH ID	0	1	2	3	4	5	6	7	8	9	10	11
I/V SEL	V	V	V	I(CT)	I(CT)	I(CT)	I(CT)	I(CT)	I(CT)	I(CT)	I(CT)	I(CT)



STEP 3: POWER NUMBER

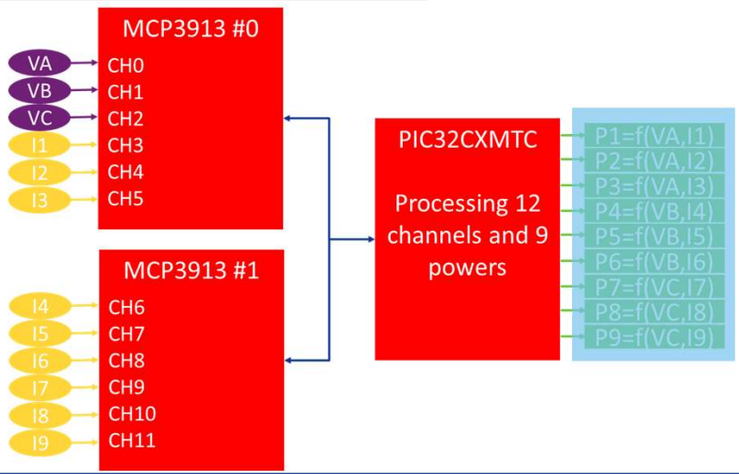
SELECT THE NUMBER OF POWERS TO BE COMPUTED. THE NUMBER CAN EXCEED THE MAXIMUM LIMIT ESTABLISHED BY THE AFE SELECTION (STEP 1)

9		Max. Power Number	11	Power number	9

STEP 4: POWER MATRIX

FOR EACH POWER, SELECT THE CHANNELS WITH THE CURRENT AND VOLTAGE INPUTS. BLUE LABEL SIGNALS THE L

PW ID	V CH	I CH	Meaning:
0	0	3	Power number 0 is obtained from voltage channel 0 and current channel 3
1	0	4	Power number 1 is obtained from voltage channel 0 and current channel 4
2	0	5	...
3	1	6	...
4	1	7	...
5	1	8	...
6	2	9	...
7	2	10	...
8	2	11	...



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MUTICHANNEL CONFIGURATION

- **Step 5 computes the “Voltage and Current Conversion Factor” registers, using as inputs the cells in yellow.**

STEP 5: ADC INPUT CHANNEL CONVERSION FACTOR

Resistor divider ratio	1651					VALUE(HEX)	0019CC00			
								USE THIS VALUE FOR THE CURRENT CHANNELS ("Y" or "N", SELECT JUST ONE)		
CT Ratio	1000	Burden resistor	1.62	PGA	1	VALUE(HEX)	0004D291	Y	0004D291	
Shunt resistor	100 uOhm	PGA	8			VALUE(HEX)	00138800	N		
Rogowski coil scale fac	500 uV/A at 60Hz	PGA	4			VALUE(HEX)	0007D000	N		

- **The excel sheet computes the values to be written in the involved control registers and generates the commands to be sent to the evaluation board.**

STEP 6: SEND THE GENERATED COMMANDS TO THE BOARD

SEND THE COMMANDS TO THE BOARD. WHEN USING A SERIAL TERMINAL, SIMPLY COPY AND PASTE EACH ROW

```
DCW[1](50000900)
DCM(4:4000300; 5:6010500; 6:8010701; 7:A020902; 8:B02)
DCW[21](0000003F)
DCW[22](00000000)
DCM(106:0019CC00; 107:0019CC00; 108:0019CC00; 109:0004D291; 110:0004D291; 111:0004D291; 112:0004D291; 113:0004D291; 114:0004D291; 115:0004D291; 116:0004D291; 117:0004D291)
DCS
```

MUTICHANNEL CONFIGURATION

- **In addition to the registers that are automatically computed by the Excel document, it is recommended to thoroughly review the remaining control registers, with particular attention to the following:**
  - Pulse control registers (number 25 to 27): Please ensure that any unused pulses are disabled and that the pulse width is correctly configured to support the maximum expected pulse rate, which depends on the applied power and the values of the pulse.
  - Pulse constant registers (number 32 to 34).
  - Pulse contribution registers (number 29 and 30).
  - MCP391x Control registers (number 209 to 216).

- **For further details, kindly refer to the "PIC32CXMTC Multichannel Metrology Reference Guide," as well as the MCP391x datasheets, which can be found on the Microchip website.**

MUTICHANNEL CALIBRATION

- A complete description of the calibration procedure is included in the “Microchip PIC32CXMTx Metrology User Guide”. This guide is tailored for conventional meters having a fixed number of channels and powers, and consequently without the multichannel advanced capabilities (flexible channel and power assignment, variable number of channels and powers). However, the principles outlined remain applicable to the calibration processes required for the multichannel metrology library.
- For guidance on calibrating the multichannel metrology library, please refer to the "CALIBRATION GUIDE" sheet within the "METROLOGYCONFIGURECALIBRATE_CALCULATE.xlsx" document. This guide offers a step-by-step approach to calibration, yet due to the extensive range of configurations and applications supported by the multichannel metrology library, it should be utilized as a foundational resource. The guide not only aids in understanding the calibration process by providing relevant formulas and calculations but also acts as a template to assist in devising a tailored calibration procedure for the specific configuration under development.
- The following slides will present an example of the application of this guide.

MUTICHANNEL CALIBRATION - EXAMPLE

- **First, configure the input sources and select the channels to be calibrated. This guide only consider a single value for the voltage magnitude and for the phase shift between voltage and current channels.**

STEP 1: CONFIGURE THE INPUT SOURCES AND SELECT THE CHANNELS TO BE CALIBRATED	
Type the values in the yellow cells:	
Test Current	30.000 A
Test Voltage	220.000 V
Meter Tester Freq	50.00 Hz
Meter Tester I-V Phase	60.00 deg
Meter Tester V-V Phase	120.00 deg

CH ID	V/I	MAGNITUDE (V/I)	CALIBRATE (Y/N)
0	V	220.000	Y
1	V	220.000	Y
2	V	220.000	Y
3	I(CT)	30.000	Y
4	I(CT)	30.000	Y
5	I(CT)	30.000	Y
6	I(CT)	30.000	N
7	I(CT)	30.000	N
8	I(CT)	30.000	N
9	I(CT)	30.000	N
10	I(CT)	30.000	N
11	I(CT)	30.000	N

MUTICHANNEL CALIBRATION - EXAMPLE

- **Set the default values (optional). Then activate the sources and allow sufficient time for stabilization before proceeding to read the measurements and the control registers from the evaluation board.**

STEP 2 (OPTIONAL): SET THE CALIBRATION CONSTANTS TO THE DEFAULT VALUES (UNITY GAIN AND ZERO PHASE ADJUSTMENTS)

This is an optional step, because the calibration parameters can be calculated using parameterts not having the default values

Using the metrology console, send the default calibration constants to the board. Please check the board documentation showing how to work with the terminal console

Send the commands to the board, copying from the green/purple cells and pasting to the terminal console

REGISTER SET	UNITY GAIN COMMAND / ZERO PHASE COMMAND
CAL_M_x	DCM(138:20000000; 139:20000000; 140:20000000; 141:20000000; 142:20000000; 143:20000000; 144:20000000; 145:20000000; 146:20000000; 147:20000000; 148:20000000; 149:20000000; 150:20000000; 151:20000000; 152:20000000; 153:20000000; 154:20000000; 155:20000000; 156:20000000; 157:20000000; 158:20000000; 159:20000000; 160:20000000; 161:20000000; 162:20000000; 163:20000000; 164:20000000; 165:20000000; 166:20000000; 167:20000000; 168:20000000; 169:20000000)
CAL_PH_x	DCM(170:0; 171:0; 172:0; 173:0; 174:0; 175:0; 176:0; 177:0; 178:0; 179:0; 180:0; 181:0; 182:0; 183:0; 184:0; 185:0; 186:0; 187:0; 188:0; 189:0; 190:0; 191:0; 192:0; 193:0; 194:0; 195:0; 196:0; 197:0; 198:0; 199:0 200:0; 201:0)

STEP 3: READ THE MEASUREMENTS AND THE METROLOGY REGISTERS FROM THE BOARD

Send to the board the commands in dark blue cells, and Copy and Paste ONLY THOSE EXACT LINES from the serial port interface results (soft blue).

PAR[I]
Present RMS values are :
CH00=215.114V CH01=215.121V CH02=215.170V CH03=30.600A
CH04=30.520A CH05=30.518A CH06=0.004A CH07=0.009V
CH08=0.000A CH09=0.000V CH10=0.000A CH11=0.000V

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MUTICHANNEL CALIBRATION - EXAMPLE

- **Excel computes the calibration parameters and generates the commands to be sent to the board. The sheet “CALCULATIONS MCP” parses the readings from the serial terminal and includes all the formulas to compute the calibration values.**

STEP 4: SEND THE COMPUTED CALIBRATION REGISTERS TO THE BOARD		
Using the metrology console, send the computed calibration constants to the board.		
Send the commands to the board, copying from the green/purple cells and pasting to the terminal console		
Use these commands to send the calibration registers as groups:		

REGISTER SET	GAIN COMMAND / PHASE COMMAND
CAL_M_x	DCM(138:20BA73D2; 139:20B77771; 140:20B56992; 141:1F5D9BA8; 142:1F73A467; 143:1F74DAC6)
CAL_PH_x	DCM(170:0; 171:0; 172:0; 173:FFF3AD39; 174:FFF22FC1; 175:FFF0A58D)

- **Finally, check the accuracy of the measurements. If the results are not as good as expected, check the input sources, check the configuration and come back to step 3.**

CUSTOMER SUPPORT:
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