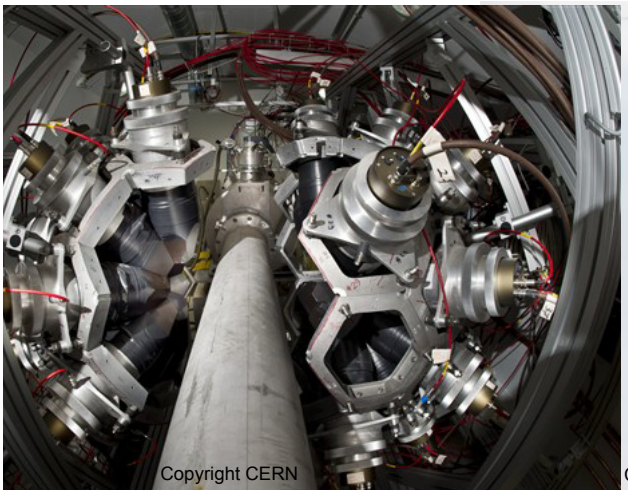
ADQ412 Datasheet

ADQ412 is a software-selectable 2 or 4 channel flexible member of the ADQ V6 Digitizer family. The ADQ412 has an outstanding combination of high bandwidth and dynamic range, which enables demanding measurements such as RF/IF sampling of very wide band signals and accurate capture of fast pulses.


Copyright CERN


Copyright SAAB

SWEDEN | Signal Processing Devices Sweden AB | Teknikringen 6, SE-583 30 Linköping | Phone: +46 (0) 13 4650600 | Fax: +46 (0) 13 991 3044
SWITZERLAND | Signal Processing Devices | 275, Route de Saint-Julien, CH-1258 Perly, Geneva | Phone: +41 78 845 5657
US | Signal Processing Devices Inc. | 2603 Camino Ramon, Suite 200, San Ramon CA 94583 | Phone: +1 415 533 1341

www.spdevices.com

ADQ412 Datasheet

Features

- Up to 4 analog channels
- Up to 4 GSPS per channel sampling rate
- 12 bits resolution
- AC-coupling for high dynamic range
- Optional bias for unipolar pulse capture
- Up to 2 GHz analog bandwidth
- Internal and external clock reference
- Clock reference output
- External trigger input and output
- Multi record >1 MHz PRF
- Time stamp
- 700 Msamples data memory
- Data interface
  USB 3.0 / cPCIe / PXIe / PCIe / MTCA
- FPGA open for custom applications

ADQ412 Development Kit

- FPGA open for custom applications
- Real-time signal processing

Applications

- RADAR
- LIDAR
- Wireless communication
- Optical transmission
- High-speed data recording
- Test and measurement
- Ultrasonic ranging
- Pulse capture

Advantages

- Host PC interface options for optimized systems partitioning.
- Sampling rate options for building family of products and streamlined maintenance. This optimizes cost of ownership.
- Real-time custom processing solutions for advanced systems.
- SP Devices' design service is always available for fast integration to reduce TTM.

Introduction

The ADQ412 is a flexible member in the ADQ V6 Digitizer family. It can be configured either as 2 or 4 analog input channels through a software control. There are several sample rate options; 2, 3.6 or 4 GSPS per channel in 2-channel mode and 1, 1.8 or 2 GSPS per channel in 4-channel mode. The vertical resolution is 12 bits. The analog input bandwidth is up to 2 GHz and a total of 700 Msamples data memory. The ADQ412 is optimized for dynamic performance over a wide bandwidth, which makes it ideal for broadband applications such as IF/RF sampling and high-speed data recording.

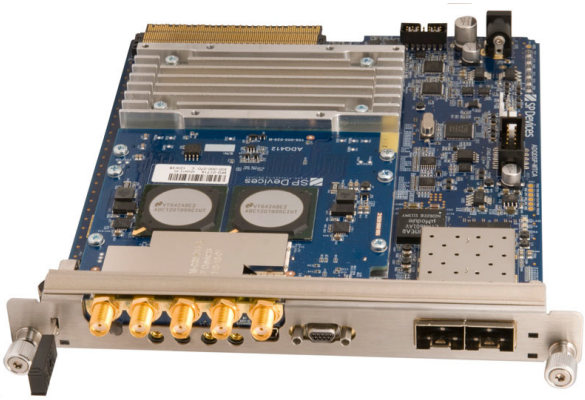
The ADQ412 offers an easy-to-use API that allows for easy integration into any application. The software development kit (SDK) is included with the digitizer.

The ADQ412 digitizer is available in several form factors to meet different systems integrations requirements; USB3.0 for stand alone operation, cPCIe / PXIe / Micro-TCA.4 for modular instruments, and PCIe for integration in a PC.

ADQ412 Development Kit

The ADQ412 is equipped with an powerful Xilinx V6 LX240T FPGA which is partly available for customized real-time applications. SP Devices' ADQ412 Development Kit is an optional FPGA programming tool that enables custom real-time signal processing of streaming data.

The ADQ412 Development Kit is purchased separately. More details about this product can be found in the datasheet for the ADQ Development Kit.



1 Technical data[1]

Table 1:

KEY PARAMETERS OVERVIEW	
Vertical resolution	12
Analog channels	2 / 4
Signal range	800 mV_{pp}
Bias setting	Factory installed
Sample rate	Up to 4 GSPS, see below
Impedance AC	50 Ω
Analog bandwidth AC	6 kHz–2 GHz
Channel-to-channel skew	60 ps
Cross talk	–80 dBc

Table 2:

SAMPLE RATE OPTIONS OPTION	–1G	–3G	–4G	
4-CHANNEL MODE				
Number of channels	4	4	4	
Sampling rate	1	1.8	2	GSPS
Analog bandwidth	2	2	2	GHz
SFDR @149MHz	63	63	63	dBc
SNR @149MHz	57	57	55	dB
2-CHANNEL MODE				
Number of channels	2	2	2	
Sampling rate	2	3.6	4	GSPS
Analog bandwidth	1.3	1.3	1.3	GHz
SFDR @149MHz	60	60	63	dBc
SNR @149MHz	55	55	55	dB

Table 3:

GPIO		
Number of GPIO	5	
Output impedance pin #5	33	Ω
Output impedance Pin #1–4	100	Ω
Output (low – high)	0.1 – 3.2	V
Input impedance	10	kΩ
Input (low – high)	1 – 2.3	V
Connector	Micro DSUB 9 way	

Table 4:

EXTERNAL CLOCK SOURCE		
Frequency 4 channels mode	FS	MHz
Frequency 2 channels mode	FS/2	MHz
Signal level (min – max)	0 – 10	dBm
	0.64 – 2	Vpp
Impedance AC	50	Ω
Duty cycle	50%	
Connector	SMA	

Table 5:

CLOCK REFERENCE INPUT		
Internal clock reference		
Frequency	10	MHz
Accuracy	± 5 ± 0.5/y	ppm
External clock reference		
Frequency (min – max)	1 – 250	MHz
Signal level (min – max)	0.8 – 3.3	V_{PP}
Impedance AC	50	Ω
Duty cycle	50% ± 5%	
Connector –USB, –PCIe, –PXIE	MCX	
Connector –MTCA	MMCX	
PXIe clock reference[1]		
PXIe clock	100	MHz
PXIe sync[2]	10	MHz

1. Available on PXIe form factor only
2. Jitter reduced by PXIe clock in digitizer

Table 6:

CLOCK REFERENCE OUTPUT		
Frequency	Set by clock reference	
Signal level	3.3	V_{PP}
Impedance AC	50	Ω
Duty cycle	50% ± 5%	
Connector –USB, –PCIe, –PXIE	MCX	
Connector –MTCA	MMCX	

Table 7:

EXTERNAL TRIGGER INPUT		
Input impedance DC	50	Ω
Input range (min – max)	–0.4 to 2.4	V
Threshold rising/falling edge	500	mV
Sensitivity	200	mV
Jitter	25	ps
Resolution	1/FS	s
Connector –USB, –PCIe, –PXIE	MCX	
Connector –MTCA	MMCX	

Table 8:

TRIGGER OUTPUT		
Output impedance	30	Ω
Output (low – high)	0.1 – 3.2	V
Connector –USB, –PCIe, –PXIE	MCX	
Connector –MTCA	MMCX	

1. All values are typical unless otherwise noted.

Table 9:

POWER SUPPLY		
Supply Voltage	12	V
Power	43	W
Connector –USB	External power supply[1]	
Connector –PCIe	6-pin ATX power	
Connector –PXIE	from slot	
Connector –MTCA	from slot	

1. Use only power supply included with the ADQ412.

2 Absolute maximum ratings

Exposure to conditions exceeding these ratings may reduce lifetime or permanently damage the device.

The ADQ412 has a built-in fan to cool the device. The built in temperature surveillance unit will protect the ADQ412 from overheating by temporarily shutting down parts of the device in such a situation.

The SMA connectors have an expected life time of 500 operations. For frequent connecting and disconnecting of cables, connector savers are recommended.

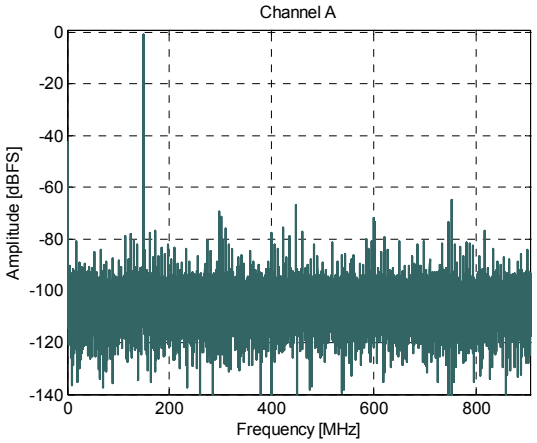
Table 10:

ABSOLUTE MAXIMUM RATINGS	MIN	MAX
Supply voltage (to GND)	–0.4 V	14 V
Trigger input (to GND)	–3 V	3.7 V
GPIO input (to GND)[1]	–1 V	4.6 V
Clock ref (AC)		3.3 V_{PP}
Ambient temperature (operation)	0 °C	45 °C
Analog inputs		
AC > 1kHz		5 V_{pp}
DC	–2.5 V	2.5 V

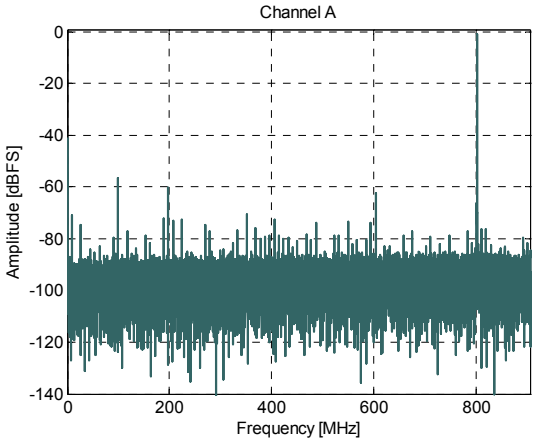
1. A voltage on a GPIO input higher than 3.3 V may change the output voltage on GPIOs which are set to outputs. This may damage external equipment.

3 Dynamic performance

3.1 Noise and distortion



SFDR	63	dB
SNR	57	dB
ENOB	8.7	bits



SFDR	55	dB
SNR	51	dB
ENOB	7.8	bits

Figure 1: FFT of 149 MHz and 801 MHz input signal at 1.8 GSPS.

4 Functional overview

4.1 Block diagram

The digitizer includes an analog front-end with signal conditioning and A/D conversions and a digital back-end for data flow control, triggering, and host communication.

4.2 Analog front-end

The ADQ412 can operate in a 4-channel mode where each ADC is connected to one analog input channel, **Figure 2**. In the 2-channel mode, two ADCs operate on the same analog input in an interleaved mode, **Figure 3**. This doubles the sampling rate. The interleaving is enabled by ADX, see **Section 4.3**. Switching between 2- and 4-channel mode is done in software.

The analog front-end contains AC-coupling and an optional DC-bias. The bias is set in factory and enables unipolar pulse capture, **Section 4.4**.

4.3 Interleaving ADX

The high data rate in 2-channel mode is enabled by SP Devices' proprietary technology for interleaving of ADCs: ADX.

4.4 Biased AC-coupled front-end

For unipolar signals, a biased front-end is available. It places the zero level at a pre-biased level and the entire input signal range can therefor be used to measure the pulses.

A positive bias (for negative pulses) is available at 90% of the signal range.

Order code: –PB

A negative bias (for positive pulses) is available at 10% of the signal range.

Order code: –NB

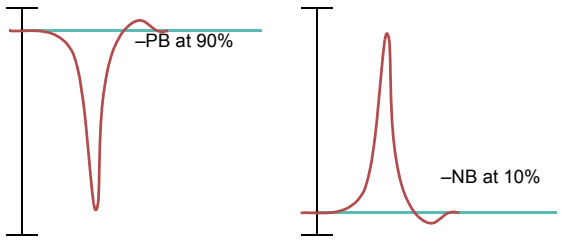


Figure 4: Bias option.

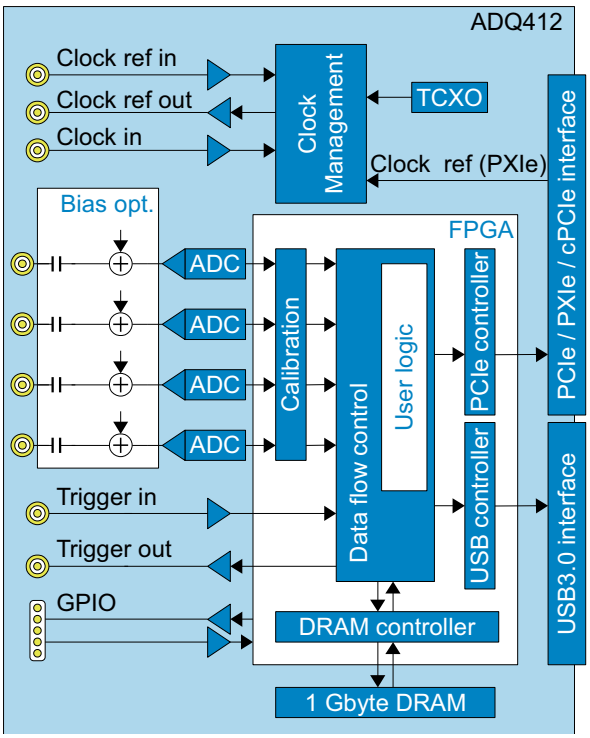


Figure 2: Block diagram 4-channel mode.

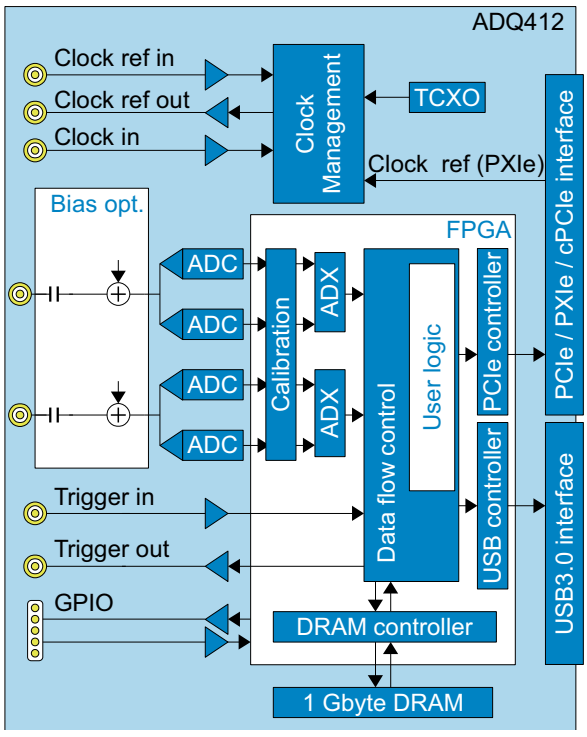


Figure 3: Block diagram 2-channel mode.

4.5 Data recording

There are several methods for data recording to serve different use cases;

- Multi-record recording in on-board DRAM for very long records.
- Triggered streaming for fast data transfer and long measurement time.
- Individual level trigger for multi-channel pulse capture
- Continuous multi-record via on-board DRAM for acquisition of long records during long measurement time.[1]
- Continuous streaming of data to the host PC for real time analysis of data[2]

To support data recording, there is on board DRAM of 1 GBytes. The interface to the host PC enables up to 3.2 GBytes/s over a Gen2 x8 PCIe interface.

4.6 Signal processing

There is support for real-time signal processing on the digitizer;

- Real-time waveform averaging.
- Level trigger for event detection.
- Gain and offset calibration.
- Custom real-time signal processing can be implemented using the ADQ412 Development Kit.

4.7 Trigger

There are several trigger modes;

- External for synchronization.
- Level trigger for data driven acquisition.
- Software for user's control.
- Internal for automatic sequencing.

There is also a trigger output for triggering external equipment. The trigger timing is controlled by pre-trigger buffer and trigger delay parameter settings.

4.8 Clock

There are several modes for clocking the digitizer

- Internal clock for stand alone operation
- External clock for synchronization
- External clock reference for synchronization

There is also a clock reference output for clocking external equipment.

4.9 GPIO

There are 5 GPIOs for real-time communication with external equipment. The GPIOs are controlled from software, but can also be accessed from the ADQ412 Development Kit for integration in a real-time control system.

GPIO pin #2 may also be used for time stamp synchronization signal. See **Section 10.5**.

The connector is Micro DSUB plug 9 way. A suitable socket with lead is for example MOLEX 83421-9044.

#	Function
1	GPIO
2	GPIO
3	GPIO
4	GPIO
5	GPIO
6	GND
7	GND
8	GND
9	GND

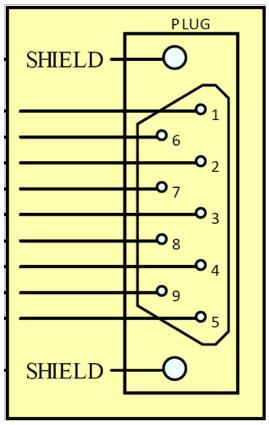


Figure 5: GPIO connector.

5 Software tools

5.1 Operating systems

The software package includes drivers for the main operating systems.

Table 11:

OPERATING SYSTEM	
Windows 7	32 bit and 64 bit
Windows 8 / 8.1	32 bit and 64 bit
Windows 10	When available
Linux[1]	Kernel 2 and 3, 32 and 64 bits

1. Contact SP Devices sales representative for information about distributions.

5.2 ADCaptureLab

The ADQ412 is supplied with the ADCaptureLab software that provides quick and easy control of

1. Option. Contact an SP Devices' sales representative for more details.
2. This mode requires sample skip or ADQ412 Development Kit for data rate reduction.

the digitizer. The tool also offers both time domain and frequency domain analysis, see **Figure 6**. Data can be saved in different file formats for off-line analysis. With ADCaptureLab, the ADQ412 operate as a desktop oscilloscope.

Please note that ADCaptureLab is available for Windows only.

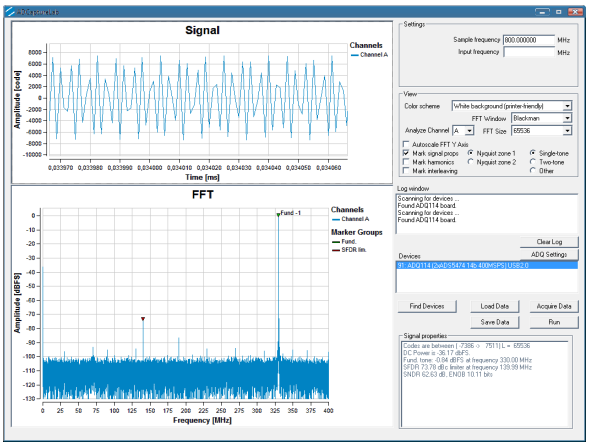


Figure 6: ADCaptureLab (Typical)

5.3 Software development kit (SDK)

The ADQ412 digitizer is easily integrated into the application by using the software development kit. The SDK is included with the ADQ412.

The SDK includes programming examples and reference projects for C/C++ and MATLAB. The ADQAPI users guide in detail describes all functions. Many examples and application notes simplify the integration process.

Using the SDK enables rapid custom processing of large amounts of data and real-time control of the digitizer.

Table 12:

APPLICATION SOFTWARE	
ADCaptureLab[1]	Acquisition and analysis
MATLAB[1]	API, examples
C/C++	API, examples
,Net (C#, Visual basic)	API, examples
Python	Limited example scripts
LabView[2]	Limited support

1. Windows only
2. Contact SP Devices sales representative for guidance.

6 Sample rate options

The ADQ412 is available with several sample rates options. The option determines the maximum sample rate. See **Section 1** for technical data.

The order code for option 1/2 GSPS[1] per channel is

Order code: –1G

The order code for option 1.8/3.6 GSPS per channel is

Order code: –3G

The order code for option 2/4 GSPS per channel is

Order code: –4G

1. The notation denotes sample rate for different modes of operation. For example, 1/2 GSPS means 1 GSPS per channel in 4-channel mode and 2 GSPS per channel in 2-channel mode.

7 Digital interface options

The ADQ V6 digitizer family supports various number of interfaces. The digital interface is used for control and data transfer between the host and the digitizer.

7.1 Firmware upgrade interface

Regardless of the selected data interface, there is always an additional USB interface for firmware upgrade. This connection is not related to the data and control interface.

7.2 USB interface

With the SuperSpeed USB interface, the digitizer is easily connected to any computer.

Table 13:

USB INTERFACE		
Standard	USB 3.0	
Data rate sustained	200	MB/s
Box size	53 x 106 x 166	mm3

(a) Front panel

(b) Rear panel

Figure 7: ADQ412 with USB3.0 interface.

Order code: –USB

7.3 cPCIe / PXIe interface

The ADQ412 is available with cPCIe / PXIe interface.

Table 14:

cPCIe / PXIe INTERFACE		
Bus width	8	lanes
Bus peak capacity	16	Gbit/s
Sustained data rate, 8 lanes[1]	3.2	GByte/s
PXIe card size	3U 2 slot 8TE	

1. This is depending performance of the system including the controller, chassis and application software.

Figure 8: cPCIe / PXIe card.

Order code: –PXIE

7.4 PCIe interface

The ADQ412 is available with PCIe Gen2 x8 interface.

Table 15:

PCIe INTERFACE		
Bus width	8	lanes
Sustained data rate, 8 lanes[1]	3.2	GByte/s
Bus width mechanical[2]	16	lanes
Board height	2	slots
Board length	188	mm

1. This is depending performance of the system including the PC and application software.
2. The wide contact is required to support the weight of the board.

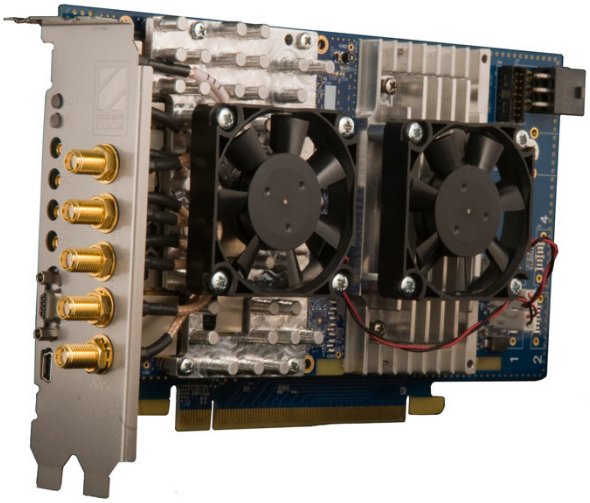


Figure 9: Typical PCIe card.

Order code: –PCIe

7.5 Micro-TCA interface

The ADQ V6 Digitizer family is available with digital back-end and interfaces for MTCA.4.

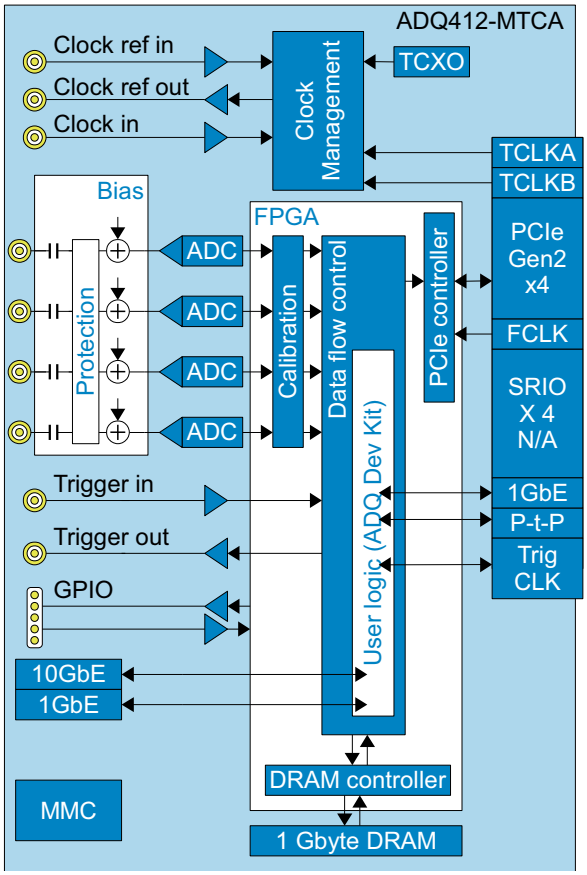


Figure 10: Block diagram of MTCA.4 option.

Table 16:

MICRO-TCA BOARD SIZE	
Board width	Double width
Board height	Mid-size

Some of the pins in the backplane connector are used for the standard digitizer functions. Some are available for custom design using the ADQ412 Development Kit for custom implementations.

Table 17:

MICRO-TCA INTERFACE		
Signal	Port	Status
1GbE	0	ADQ412 Dev Kit
PCIe	4-7	Standard
Point-to-point	12-15	ADQ412 Dev Kit
Trigger, Data, Clocks	17-20	ADQ412 Dev Kit
TCLKA	Clk 1	Standard
TCLKB	Clk 2	Standard
FCLKA	Clk 3	Standard

Table 18:

FRONT PANEL ADDITIONAL INTERFACE		
Signal	Connector	Status
1 GbE	SFP	ADQ412 Dev Kit
10 GbE	SFP+	ADQ412 Dev Kit

LED Red (Error)
LED Green (Operating OK)
10 GbE SFP+
1 GbE SFP
GPIO Micro D 9-w plug
Ext Clock SMA
Channel A SMA
Channel B SMA
Channel C SMA
Channel D SMA
USB 2.0 Mini-B
Trig out MMCX
Trig in MMCX
Clk ref out MMCX
Clk ref in MMCX
LED Yellow (Ready)
LED Red/Green (Power/Status)
LED Blue (hot swap)
Handle

Figure 11: Front panel of ADQ412–MTCA.

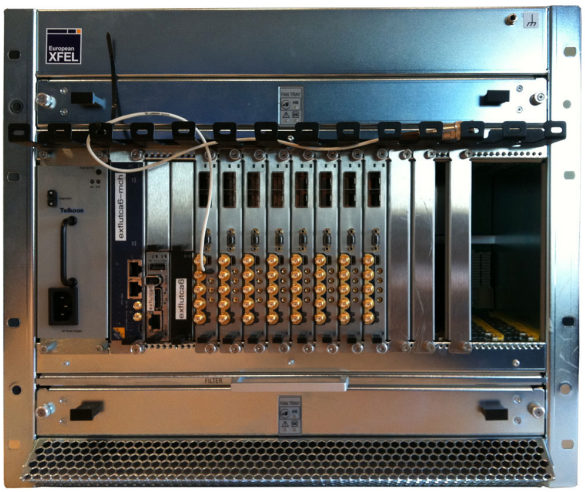


Figure 12: 32 channels ADQ412–MTCA in chassis.

Order code: –MTCA

Ordering information

Table 19:

ORDERING INFORMATION	
Order code	ADQ412
AVAILABLE OPTIONS	
Micro-TCA interface	–MTCA
cPCIe / PXIe interface	–PXIE
PCIe interface	–PCIe
USB3.0 interface	–USB
Sampling rate 1/2 GSPS	–1G
Sampling rate 1.8/3.6 GSPS	–3G
Sampling rate 2/4 GSPS	–4G
Positive bias	–PB
Negative bias	–NB
RELATED PRODUCTS	
ADQ412 Development Kit	

Important Information

Teledyne Signal Processing Devices Sweden AB (Teledyne SP Devices) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to Teledyne SP Devices' general terms and conditions supplied at the time of order acknowledgment.

Teledyne SP Devices warrants that each product will be free of defects in materials and workmanship, and conform to specifications set forth in published data sheets, for a period of one (1) year. The warranty commences on the date the product is shipped by Teledyne SP Devices. Teledyne SP Devices' sole liability and responsibility under this warranty is to repair or replace any product which is returned to it by Buyer and which Teledyne SP Devices determines does not conform to the warranty. Product returned to Teledyne SP Devices for warranty service will be shipped to Teledyne SP Devices at Buyer's expense and will be returned to Buyer at Teledyne SP Devices' expense. Teledyne SP Devices will have no obligation under this warranty for any products which (i) has been improperly installed; (ii) has been used other than as recommended in Teledyne SP Devices' installation or operation instructions or specifications; or (iii) has been repaired, altered or modified by entities other than Teledyne SP Devices. The warranty of replacement products shall terminate with the warranty of the product. Buyer shall not return any products for any reason without the prior written authorization of Teledyne SP Devices.

In no event shall Teledyne SP Devices be liable for any damages arising out of or related to this document or the information contained in it.

TELEDYNE SP DEVICES' EXPRESS WARRANTY TO BUYER CONSTITUTES TELEDYNE SP DEVICES' SOLE LIABILITY AND THE BUYER'S SOLE REMEDY WITH RESPECT TO THE PRODUCTS AND IS IN LIEU OF ALL OTHER WARRANTIES, LIABILITIES AND REMEDIES. EXCEPT AS THUS PROVIDED, TELEDYNE SP DEVICES DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT.

TELEDYNE SP DEVICES DOES NOT INDEMNIFY, NOR HOLD THE BUYER HARMLESS, AGAINST ANY LIABILITIES, LOSSES, DAMAGES AND EXPENSES (INCLUDING ATTORNEY'S FEES) RELATING TO ANY CLAIMS WHATSOEVER. IN NO EVENT SHALL TELEDYNE SP DEVICES BE LIABLE FOR SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING LOST PROFIT, LOST DATA AND THE LIKE, DUE TO ANY CAUSE WHATSOEVER. NO SUIT OR ACTION SHALL BE BROUGHT AGAINST TELEDYNE SP DEVICES MORE THAN ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS ACCRUED. IN NO EVENT SHALL THE ACCRUED TOTAL LIABILITY OF TELEDYNE SP DEVICES FROM ANY LAWSUIT, CLAIM, WARRANTY OR INDEMNITY EXCEED THE AGGREGATE SUM PAID TO SP BY BUYER UNDER THE ORDER THAT GIVES RISE TO SUCH LAWSUIT, CLAIM, WARRANTY OR INDEMNITY.

Worldwide Sales and Technical Support

www.spdevices.com

Teledyne SP Devices Corporate Headquarters

Teknikringen 6
SE-583 30 Linköping
Sweden

Phone: +46 (0)13 465 0600
Fax: +46 (0)13 991 3044
Email: info@spdevices.com

Copyright © 2017 Teledyne Signal Processing Devices Sweden AB. All rights reserved, including those to reproduce this publication or parts thereof in any form without permission in writing from Teledyne SP Devices.