EXTENDED DATASHEET

MCA527MICROE / MICROE+

DESCRIPTION

The MCA527microE is a very small ultra low power multichannel analyzer module designed for direct integration into a detector housing. It is intended for use in NaI- and CdZnTe-detectors but it is also suitable for other applications such as neutron counters or CsI detectors. In conjunction with a preamplifier and a high voltage power supply it is possible to realize an ultra compact spectrometer. The MCA527microE+ can operate with up to 16k channel resolution for HPGe detector purposes.
The module is powered by a single 5V power supply. In the idle mode it draws about 50mA, during a measurement it needs typical not more than 80mA. Because of its ultra low power design it is suitable for low power and battery powered operation.

Two basic interfaces are provided by the module for host communication, UART and RMII. The UART may be used for serial interfaces like USB, and RS232 while RMII enables 10/100 Ethernet communication. A large set of different interface and power supply lines makes it possible to attach additional functions, like GPS receivers, sensors or microcontrollers. Please contact us if you need support or a firmware extension.
Because the MCA527microE is derived from the MCA527, it is fully firmware compatible with it. All existing application programs and programming libraries for the MCA527 product family can be used to operate the MCA527microE. The basic functions will always work well but for complete device support only the latest software versions should be used. Please check our website at http://www.gbs-elektronik.de/en/downloads/ for newest software versions and documents.

Figure 1: MCA527microE /microE+ Block Diagram

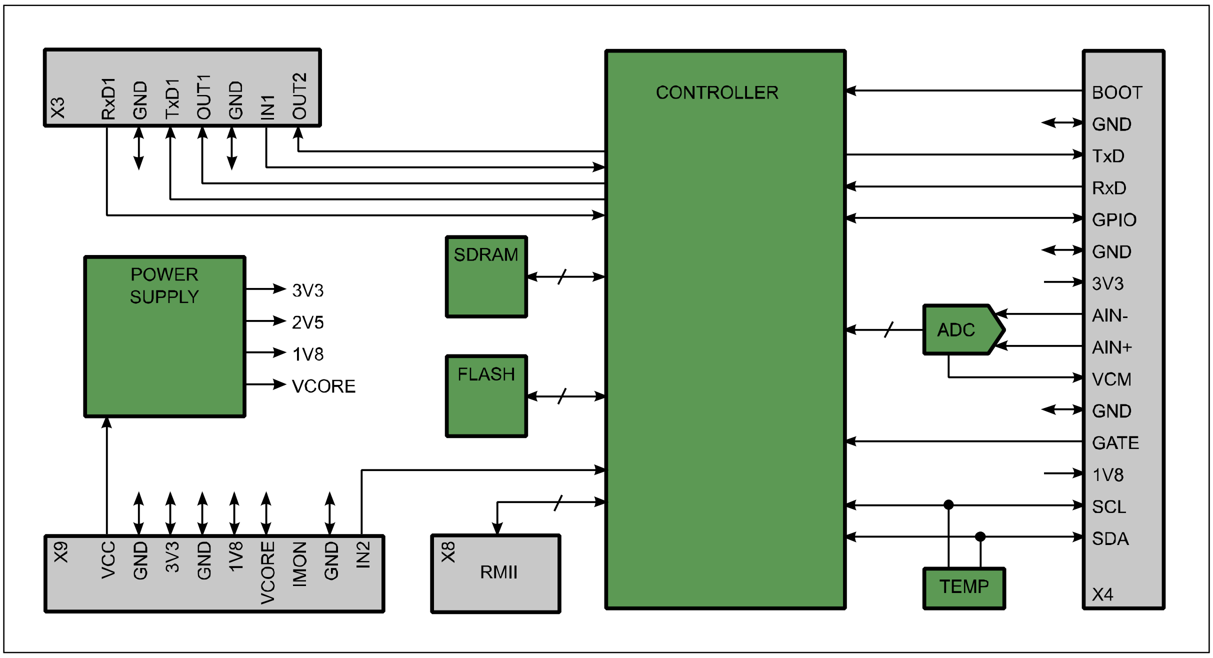

Table 1: Absolute Maximum Ratings

Parameter	Rating
Supply Voltage (V_{CC})	-0.3V to +5.5V
Digital Input Voltage (BOOT, RxD, RxD1, GPIO, IN1, IN2, RXD0, RXD1, RXER, CRSDV, MDIO)	-0.3V to (V_{1V8} +0.3V)
Digital Input Voltage GATE	-0.5V to +6.5V
Digital Input Voltage TWI (SDA, SDA_E, SCL, SCL_E)	-0.5V to +3.6V
Analog Input Voltage (AIN+, AIN-)	-0.3V to (V_{3V3} +0.3V)
Operating Temperature Range	0°C to +50°C
Storage Temperature Range	-40°C to +125°C

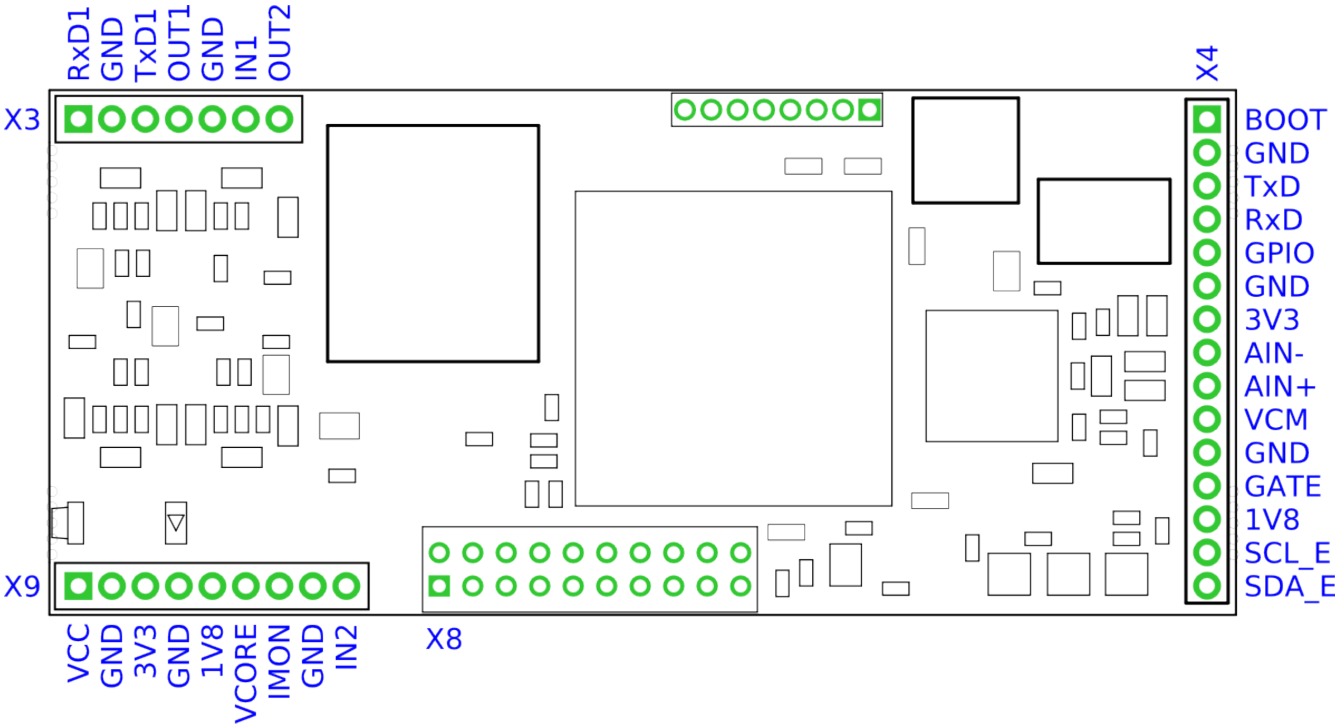

Figure 2: Connection Diagram (Top View)

Table 2: X9 Pin Out Description

Name	Pin	Type	Description
VCC	1	In	**Supply Voltage:** 5.0V power supply input.
IMON	7	I/O	**Input Current Monitor:** Not used by the MCA527microE module, leave it unconnected.
IN2	9	In	**Digital Input2:** Digital input for extension port functionality.
VCORE	6	Supply	**Core Power Supply:** 1.0V output from integrated power supply.

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Name	Pin	Type	Description
1V8	5	Supply	**1.8V Power Supply:** 1.8V output from the integrated power supply. The pin is internally connected to 1V8 from X4.
3V3	3	Supply	**3.3V Power Supply:** 3.3V output from the integrated power supply. The pin is internally connected to 3V3 from X4.
GND	2, 4, 8	Supply	**Ground:** Ground supply pins.

Table 3: X3 Pin Out Description

Name	Pin	Type	Description
RxD1	1	In	**UART Receiver:** The data input of the controller's host UART.
TxD1	3	Out	**UART Transmitter:** The data output of the controller's host UART.
OUT1	4	Out	**Digital Output1:** Digital output for extension port functionality.
IN1	6	In	**Digital Input1:** Digital input for extension port functionality.
OUT2	7	Out	**Digital Output2:** Digital output for extension port functionality.
GND	2, 5	Supply	**Ground:** Ground supply pins.

Table 4: X8 Pin Out Description

Name	Pin	Type	Description
TXD0	1	Out	**TXD0:** RMII - The MAC transmits data to the transceiver using this signal.
TXD1	2	Out	**TXD1:** RMII - The MAC transmits data to the transceiver using this signal.
TXEN	5	Out	**TXEN:** RMII - Indicates that valid transmission data is present on TXD[1:0].
RESET	6	Out	**RESET:** System reset output
CLK	8	Out	**CLK:** RMII - 50MHz clock output to the PHY
RXER	9	In	**RXER:** RMII - This signal indicates that an error was detected somewhere in the frame presently being transferred from the transceiver.
RXD1	10	In	**RXD1:** RMII - Bit 1 of the two data bits that are sent by the transceiver on the receive path.
CRSDV	13	In	**CRSDV:** RMII - This signal indicates that the receive medium is non-idle.
RXD0	14	In	**RXD0:** RMII - Bit 0 of the two data bits that are sent by the transceiver on the receive path.
MDC	15	Out	**MDC:** RMII serial management interface clock
MDIO	16	I/O	**MDIO:** RMII serial management interface data input/output

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Name	Pin	Type	Description
SDA	19	I/O	**Serial Data Line:** The data line of the system's two-wire interface (TWI). If not used, this pin should be left floating.
SCL	20	I/O	**Serial Clock Line:** The clock line of the system's two-wire interface (TWI). If not used, this pin should be left floating.
GND	3, 4, 7, 11, 12, 17, 18	Supply	**Ground:** Ground supply pins.

Table 5: X4 Pin Out Description

Name	Pin	Type	Description
BOOT	1	In	**Boot Mode Control:** This pin is internally pulled up to 1.8V with 10kΩ. For normal operation this pin must be tied to ground. If this pin is left floating or driven high during power-up, the controller boots into a special rescue mode for firmware programming.
TxD	3	Out	**UART Transmitter:** The data output of the controller's UART.
RxD	4	In	**UART Receiver:** The data input of the controller's UART.
GPIO	5	I/O	**General Purpose I/O:** Currently this pin has no function and should be left floating. It is reserved for future use.
AIN-	8	In	**Negative Differential Analog Input:** The output of the preamplifier must be connected to AIN+ and AIN-. The signal should swing ±0.5V around the common mode voltage V_{CM} (1.5V). In a single-ended configuration this pin should be driven at 1.5V.
AIN+	9	In	**Positive Differential Analog Input:** The output of the preamplifier must be connected to AIN+ and AIN-. The signal should swing ±0.5V around the common mode voltage V_{CM} (1.5V). In a single-ended configuration this pin should swing ±1.0V around AIN- (1.5V).
VCM	10	Out	**Common Mode Bias:** A 1.5V reference voltage is supplied to the preamplifier on this pin. It can be used to bias the preamplifier.
GATE	12	In	**Gate Signal:** If required, this Schmitt-trigger input can be used for gating. Otherwise this pin should be left floating. The input is pulled down with 5.1kΩ to ground.
SCL_E	14	I/O	**External Serial Clock Line:** The decoupled (33Ω, 12pF) clock line of the system's two-wire interface (TWI). If not used, this pin should be left floating.
SDA_E	15	I/O	**External Serial Data Line:** The decoupled (33Ω, 12pF) data line of the system's two-wire interface (TWI). If not used, this pin should be left floating.
3V3	7	Supply	**3.3V Power Supply:** 3.3V output from the integrated power

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Name	Pin	Type	Description
			supply. The pin is internally connected to 3V3 from X3.
1V8	13	Supply	**1.8V Power Supply:** 1.8V output from the integrated power supply. The pin is internally connected to 1V8 from X3.
GND	2, 6, 11	Supply	**Ground:** Ground supply pins.

Table 6: Electrical Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
V_{CC}	Supply Voltage		3.50		5.5	V
I_{CC}	Supply Current	$3.5V < V_{CC} < 5.5V$			500	mA
I_Q	Quiescent Current	$3.5V < V_{CC} < 5.5V$	50		100	mA
I_{Q_IDLE}	Supply Current Idle Mode	all outputs unloaded		50		mA
I_{Q_MEAS}	Supply Current Measurement	all outputs unloaded, input count rate 50kcps		65	80	mA
V_{3V3}	Output Voltage of 3.3V Regulator	$0mA < I_{3V3} < 250mA$	3.15	3.30	3.45	V
I_{3V3}	Output Current of 3.3V Regulator		0		250	mA
V_{1V8}	Output Voltage of 1.8V Regulator	$0mA < I_{1V8} < 150mA$	1.71	1.80	1.89	V
I_{1V8}	Output Current of 1.8V Regulator		0		150	mA
V_{CORE}	Output Voltage of Core Voltage Regulator	$0mA < I_{CORE} < 90mA$	0.95		1.05	V
I_{CORE}	Output Current of Core Voltage Regulator		0		90	mA
Digital Inputs and Outputs						
V_{IH}	High Level Input Voltage [1], [2]		1.10			V
V_{IL}	Low Level Input Voltage [1], [2]				0.60	V
V_{IHTWI}	High Level Input Voltage TWI [4]		1.35			V
V_{ILTWI}	Low Level Input Voltage TWI [4]				0.51	V
V_{OH}	High Level Output Voltage [3]	$I_{OH} = -0.5mA$	1.35			V
V_{OL}	Low Level Output Voltage [3]	$I_{OL} = 2mA$			0.40	V
I_{IH}	High Level Input Current [1]	$V_{IN} = 3.6V$			10	µA
I_{IL}	Low Level Input Current [1]	$V_{IN} = 0V$			10	µA

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
C_{IN}	Input Capacitance [1]	f_{IN} = 1 MHz, $T_{AMBIENT}$ = 25°C		5	8	pF
C_{INTWI}	Input Capacitance TWI [4]	f_{IN} = 1 MHz, $T_{AMBIENT}$ = 25°C			15	pF
V_{T+}	Positive-going Threshold Voltage [5]		0.70	1.02	1.20	V
V_{T-}	Negative-going Threshold Voltage [5]		0.30	0.53	0.72	V
V_H	Hysteresis Voltage [5]		0.30	0.48	0.62	V
R_{IGATE}	GATE Input resistance [5]			5.1		kΩ
Analog Inputs and Outputs						
V_{IN}	Analog Input Range (AIN+ – AIN–)			±1		V
V_{INCM}	Analog Input Common Mode Voltage	Differential Input Single Ended Input	1.0 0.5	1.5 1.5	1.9 2.0	V V
I_{IN}	Analog Input Leakage Current	0V < AIN+, AIN– < V_{3V3}	-1		1	µA
V_{CM}	Common Mode Bias	I_{OUT} = 0	1.475	1.500	1.525	V
Dynamic Characteristics						
f_{TWI}	TWI Bus Clock Frequency			100		kHz
BR	UART Baud Rate		110		3.0M	Baud
t_{GATEON}	Minimum GATE Pulse Width		500			ns

[1] Parameter value applies to all digital inputs and bidirectional pins, except BOOT, GATE, SCL, SCL_E, SDA, SDA_E
[2] Parameter value applies to input pin BOOT.
[3] Parameter value applies to all digital outputs and bidirectional pins
[4] Parameter value applies to SCL, SCL_E, SDA and SDA_E.
[5] Parameter value applies to GATE input.

Power Supply

When the supply voltage V_{CC} exceed it's minimum value, the integrated power supply starts working and turns on V_{3V3}, V_{1V8} and V_{CORE} (in that order). If V_{CORE} is stable for a few milliseconds, reset is released and the controller starts the boot process.

Through its pin headers X9 and X4 the MCA527microE is able to supply external circuits with V_{CORE}, V_{3V3} and V_{1V8}. The current rating for each voltage can be found in 6, Electrical Characteristics. However, these limits are only the maximum currents an external circuit may draw from each output rail assumed all other rails are unloaded. The real limiting factor is the module's maximum input current I_{CC}. This limit should never be exceeded under all operating conditions.

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Analog Frontend

The analog frontend consists of the two inputs AIN+ and AIN- and the reference output VCM. Both inputs are connected directly to the ADC which has a differential input stage. It is possible to drive the ADC with a differential or a single-ended amplifier. Referred to the ADC, SNR and DNL are the same for both versions but INL and harmonic distortion of the single-ended version are degraded. However, in most situations the single-ended driver should work well. Both versions must be configured that the signal's baseline is at 10% of full scale for positive input signals and at 90% of full scale for negative input signals.

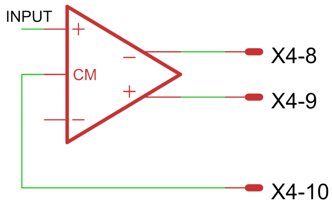


Figure 3: Differential ADC Driver

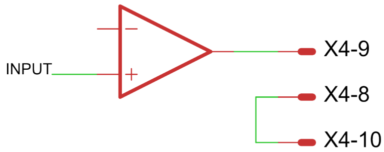
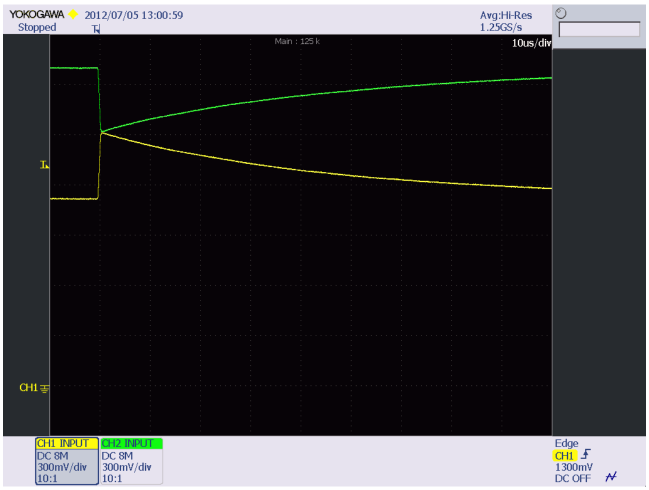
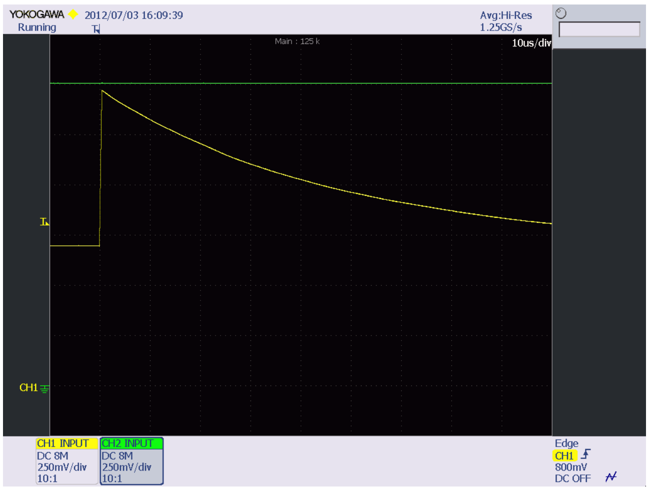


Figure 4: Single-Ended ADC Driver



Ch1 = X4-9
Ch2 = X4-8

Figure 5: Signals of Differential Driver



Ch1 = X4-9
Ch2 = X4-8

Figure 6: Signals of Single-Ended Driver

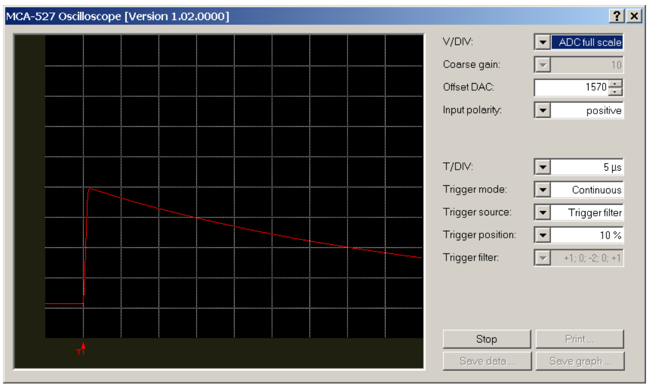


Figure 7: ADC Output for Figure 5 Signals

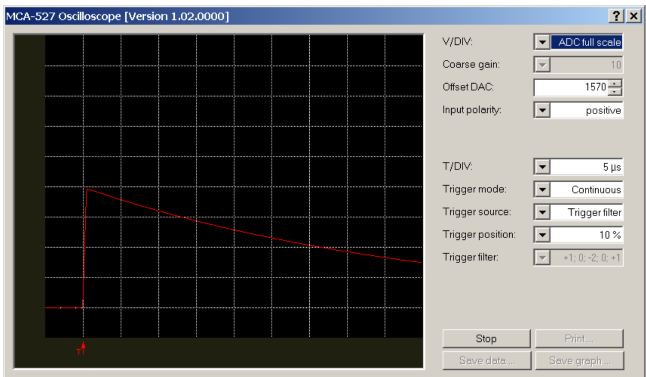


Figure 8: ADC Output for Figure 6 Signals

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Figure 3 shows a differential driver stage. The signals AIN+ and AIN- must swing around 1.5V (Figure 5). For that the reference voltage VCM may be used to bias the common mode input of the amplifier. When the previous stage has a single-ended output, the differential driver may be configured as single-ended to differential voltage converter.

A single-ended driver stage has two main advantages: It saves power and board space in most situations. Specially when a photomultiplier is used, only one operational amplifier is needed for pulse forming and ADC driving. Moreover, no additional noise is added to the signal by further operational amplifiers. In a single-ended configuration the signal AIN- should driven at 1.5V. For that the reference voltage VCM may be used. The signal AIN+ may swing between 0.5V (0% FS) and 2.5V (100% FS).

The ADC output of figures 5 and 6 produces a peak at about 95% of the spectrum's full scale when the fine gain is set to 1.

For best noise performance the bandwidth of the input signal must not be higher than 5MHz. It is recommended to use a low-pass filter directly before the ADC. The filter's corner frequency should set to 3.3MHz, higher values will only increase the noise. The higher the filter's attenuation for high frequencies, the lower the noise seen by the ADC.

Host Communication

The simplest way to establish host communication is to use the module's host UART. Currently four different baud rates are supported (38.4k, 115.2k, 307k, 3M), the baud rate is adjusted automatically. The interface may be used directly by a microcontroller using it's TTL signals or through an additional transceiver for various standard serial interfaces like USB, RS232 or RS485.

For 10/100 Ethernet communication the RMII standard interface is provided on connector X8. Different extension boards with Ethernet PHY are available from GBS-Elektronik for an off-the-shelf solution. We recommend to use this boards whenever possible. However, when no board fits to the requirements, customer specific solutions are possible. Please contact us for more information.

Boot Input

During power-up the controller of the MCA527microE checks the state of the BOOT pin. When it is driven low, the controller tries to start the standard firmware. After booting the state of this pin is meaningless. However, if for any reason the firmware does not start, it is posible to bring the controller in a special rescue mode where only firmware programming is possible. This is done by driving the BOOT pin high (or leaving it floating) during power-up. With the GBS Firmware Loader a new firmware may be loaded to the flash of the MCA527microE through the USB interface now.

This pin must be driven low for normal operation due to the internal pull-up resistor!

Because the pins status is only sampled one time at power-up, the pin may be also used as GPIO after booting. However, this feature is currently not implemented. Please contact us if you need an additional GPIO.

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Gate Input

Just like the MCA527, the MCA527microE is also provided with a gate input. It is accessible at the GATE pin of X4. All features for gated measurements of the MCA527 are available for the MCA527microE, too, as there are:

- turning gating on or off
- changing the gate signal polarity
- delay time adjustment
- discard or sort mode

In discard mode, the event associated with the gate trigger is rejected and dead time is generated, in sort mode, this event is counted in a second spectrum. Sort mode is an option if doing stabilization with a LED pulser on a NaI detector. Furthermore the gate input may be used to trigger a measurement.

Two-Wire Interface

For communication with external circuits a two-wire interface is available on X4 and X8. The signals SDA_E and SCL_E are decoupled from SDA and SCL by a series resistor of 33 Ω and a capacitor of 12pF to ground. Both signals SDA (SDA_E) and SCL (SCL_E) are pulled up with 2.2kΩ to V_{1V8}, therefore external pull-up resistors are only required, if the lines are loaded with large capacities. All addresses may be used for external devices, excepted addresses 0x92 and 0x94. Both addresses are reserved for temperature sensors of the type TMP102 or compatible, where 0x92 is the address of the internal temperature sensor and 0x94 is reserved for an optional external temperature sensor (maybe placed directly on the crystal).

Currently the firmware supports only the two temperature sensors but firmware extensions for other devices, like microcontrollers or ADCs, are possible. Please contact us if your application requires extended functionality.

Extension Port Signals

Like the MCA527 the MCA527microE provides two digital outputs and two digital inputs for extension port functionality. The signals IN1, IN2, OUT1 and OUT2 are available on X3 and X9. They can be used for counting, PWM output or simple GPIO functionality.

Table 7: Extension Port Signals

Signal	Functionality
IN1	- general purpose input - slow software counter
IN2	- general purpose input - fast hardware counter
OUT1	- general purpose output
OUT2	- general purpose output - fast hardware PWM output for signal generation

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Extension Port UART Interface

In addition to the two-wire interface, the MCA527microE provides a UART interface on X4, too. The two lines TxD and RxD are referred to V_{1V8}. The UART can be operated with various baud rates in the range of 110Baud to 3MBaud.

Currently two modes of UART operation are supported by the firmware, GPS receiver mode and transparent mode. In GPS receiver mode the controller records the data from an attached GPS receiver and the application software may evaluate this data. In transparent mode the controller passes the data received from the application program through the UART to the external device and vice versa. This mode is only available for programmers. Please refer to communication functions

- MMCA_SET_EXTENSION_PORT,
- MMCA_SET_EXTENSION_RS232,
- MMCA_WRITE_TO_EXTENSION,
- MMCA_READ_FROM_EXTENSION and
- MMCA_READ_FROM_EXTENSION_EX

of the Mca32com.dll library.

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Module Specification

Table 8: Module Specification

Parameter	Value
Host Interface	- UART for serial communication, up to 3MBaud (38.4k, 115.2k, 307k, 3M) - 10/100 RMII interface for Ethernet communication
Power Supply	3.6V … 5.5V, 80mA typical
Number of Channels	128, 256, 512, 1024, 2048 [1]
Shaping Time	0.1µs to 4µs
Maximum Throughput	100,000cps
Special Features	- Integrated Temperature Sensor - various digital interfaces (TWI, UART, GPIO) - integrated digital Oscilloscope - MCS-mode - Gate-mode
Power Consumption (typical)	250mW / 350mW (Idle / Measurement)
Dimensions	45mm x 20mm x 5mm
Weight	5g

[1] Versions with 4096, 8192 and 16384 are available on request.

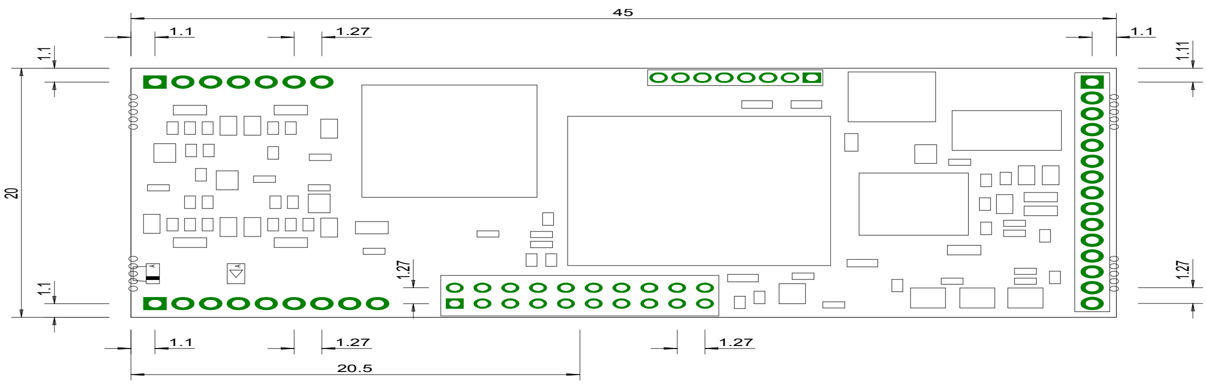

Figure 9: Outline Dimensions (Top View, all Dimensions are in Millimeters)

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Table 9: Revision History

Revision	Section / Figure / Entry	Correction
1.0		Initial Version

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