EXTENDED DATASHEET

MCA527MICRO / MICRO+

DESCRIPTION

The MCA527micro is a very small ultra low power multichannel analyzer module designed fordirect integration into a detector housing. It is intended for use in NaI- and CdZnTe-detectors but it may be also usable 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 build an ultra compact spectrometer. The MCA527micro+ can operate with up to 16k channel resolution for HPGe detector purposes.

The module is powered by the USB port. In the idle mode it draws about 50mA, during ameasurement it needs typical not more than 80mA. Because of its ultra low power design it can be operated as USB low power device. In most cases the preamplifier and the high voltage power supply of the detector system will consume a significant additional amount of power. Therefore the MCA527micro is configured as USB high power device as default.

A large set of different interface and power supply lines makes it possible to develop additional functions, like GPS receivers, sensors or microcontrollers, around the module. Please contact us if you need support. Because the MCA527micro 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 MCA527micro. The basic functions will always work well but for complete device support only the latest software versions should be used.

Figure 1: MCA527micro / micro+ Block Diagram

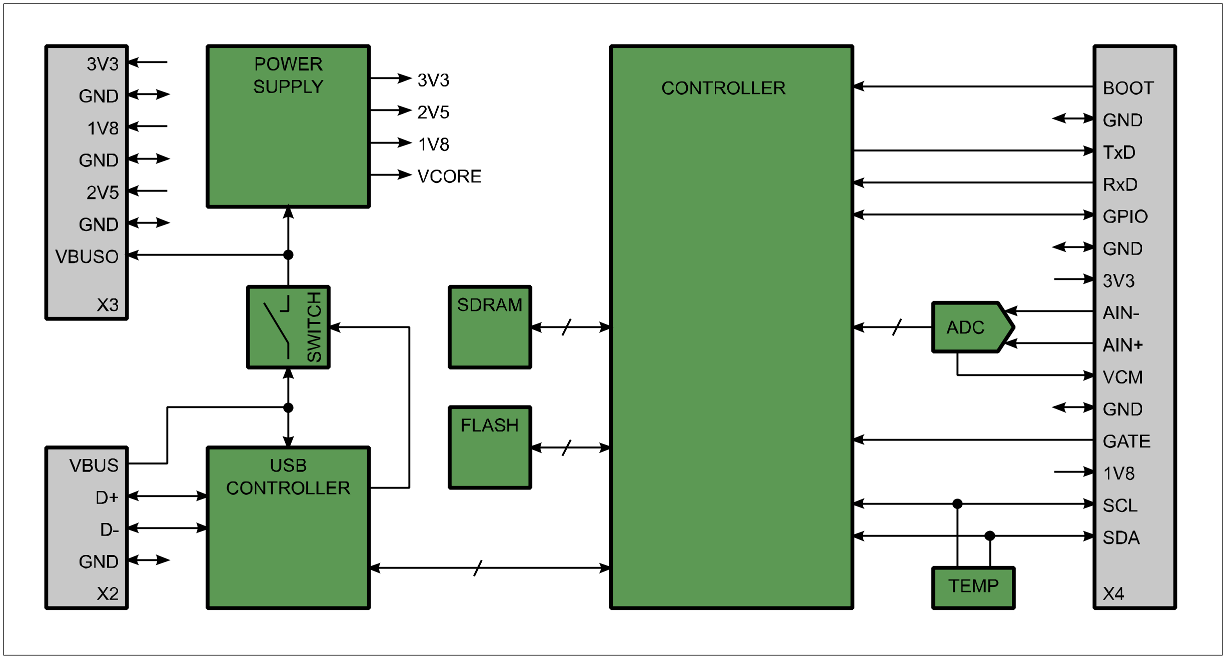


Table 1: Absolute Maximum Ratings

Parameter	Rating
USB Supply Voltage (V_{BUS})	-0.3V to +5.5V
Digital Input Voltage (BOOT, RxD, GPIO)	-0.3V to (V_{1V8} + 0.3V)
Digital Input Voltage GATE	-0.5V to +6.5V
Digital Input Voltage TWI (SDA, SCL)	-0.5V to +5.5V
Analog Input Voltage (AIN+, AIN-)	-0.3V to (V_{3V3} + 0.3V)
Operating Temperature Range	0°C to +50°C
Storage Temperature Range	–65°C to +125°C

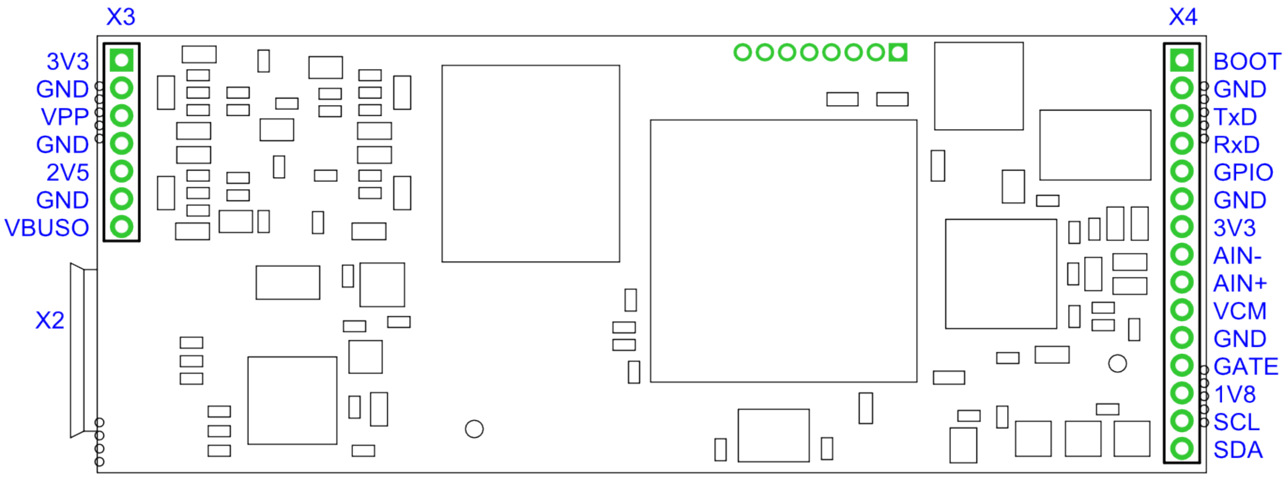


Figure 2: Connection Diagram (Top View)

Table 2: X2 Pin Out Description

Name	Pin	Type	Description
D+	2	I/O	**Positive Data Line:** USB data signal plus.
D-	5	I/O	**Negative Data Line:** USB data signal minus.
ID	4	I/O	**ID:** USB ID pin. This pin is floating (USB device).
VBUS	1	Supply	**Power Supply:** USB bus power supply, 5V nominal.
GND	5	Supply	**Ground:** USB ground supply pin.

Table 3: X3 Pin Out Description

Name	Pin	Type	Description
3V3	1	Supply	**3.3V Power Supply:** 3.3V output from the integrated power supply. The pin is internally connected to 3V3 from X4.
1V8	3	Supply	**1.8V Power Supply:** 1.8V output from the integrated power supply. The pin is internally connected to 1V8 from X4.
2V5	5	Supply	**2.5V Power Supply:** 2.5V output from the integrated power supply. **Important: We do not recommend to use this power supply because it may be removed in future versions. Please use 3V3 instead, if possible.**
VBUSO	7	Supply	**System Power Supply:** Output from the USB power switch. The whole system is powered by this supply voltage. When the device is connected to an USB hub which is able to operate it, the USB controller turns on this voltage. It is directly derived from the USB bus voltage (5V nominal).
GND	2, 4, 6	Supply	**Ground:** Ground supply pins.

Table 4: 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

GBS Elektronik GmbH
Bautzner Landstraße 22
01454 Großerkmannsdorf
Germany

Tel.: 0049 (0)351 21 70 07 - 0
Fax.: 0049 (0)351 21 70 07 - 21
E-Mail: kontakt@gbs-elektronik.de
Website: www.gbs-elektronik.de

Name	Pin	Type	Description
			gating. Otherwise this pin should be left floating. The input is pulled down with 5.1kΩ to ground.
SCL	14	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.
SDA	15	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.
3V3	7	Supply	**3.3V Power Supply:** 3.3V output from the integrated power 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 5: Electrical Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
V_{BUS}	USB Supply Voltage [1]		4.50		5.25	V
I_{BUSMAX}	Maximum USB Supply Current	4.5V < V_{BUS} < 5.25V	400		500	mA
I_{BUS_IDLE}	Supply Current Idle Mode	all outputs unloaded		50		mA
I_{BUS_MEAS}	Supply Current Measurement	all outputs unloaded, input count rate 50kcps		65	80	mA
V_{BUSO}	Output Voltage on VBUSO	any external load	4.3		V_{BUS}	V
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 [2]		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 [2]		0		150	mA
V_{2V5}	Output Voltage of 2.5V Regulator [3]	0mA < I_{2V5} < 90mA	2.38	2.50	2.63	V
I_{2V5}	Output Current of 2.5V Regulator [2], [3]		0		90	mA
Digital Inputs and Outputs						
V_{IH}	High Level Input Voltage [4], [5]		1.10			V
V_{IL}	Low Level Input Voltage [4], [5]				0.60	V
V_{IHTWI}	High Level Input Voltage		1.35			V

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
	TWI [7]					
V_{ILTWI}	Low Level Input Voltage TWI [7]				0.51	V
V_{OH}	High Level Output Voltage [6]	I_{OH} = –0.5mA	1.35			V
V_{OL}	Low Level Output Voltage [6]	I_{OL} = 2mA			0.40	V
I_{IH}	High Level Input Current [4]	V_{IN} = 3.6V			10	µA
I_{IL}	Low Level Input Current [4]	V_{IN} = 0V			10	µA
C_{IN}	Input Capacitance [4]	f_{IN} = 1 MHz, $T_{AMBIENT}$ = 25°C		5	8	pF
C_{INTWI}	Input Capacitance TWI [7]	f_{IN} = 1 MHz, $T_{AMBIENT}$ = 25°C			15	pF
V_{T+}	Positive-going Threshold Voltage [8]		0.70	1.02	1.20	V
V_{T-}	Negative-going Threshold Voltage [8]		0.30	0.53	0.72	V
V_H	Hysteresis Voltage [8]		0.30	0.48	0.62	V
R_{IGATE}	GATE Input resistance [8]			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] The USB-controller works with voltages down to 4.4V during initialisation.
[2] I_{BUSMAX} must not exceed its maximum value under all load conditions. This may limit the maximum output current available from any voltage regulator.
[3] It is not recommend to use this power supply because it may be removed in future versions.
[4] Parameter value applies to input pins RxD and GPIO (if configured as input).
[5] Parameter value applies to input pin BOOT.
[6] Parameter value applies to output pins TxD and GPIO (if configured as output).
[7] Parameter value applies to SCL and SDA.
[8] Parameter value applies to GATE input.

GBS Elektronik GmbH
Bautzner Landstraße 22
01454 Großerkmannsdorf
Germany

Tel.: 0049 (0)351 21 70 07 - 0
Fax.: 0049 (0)351 21 70 07 - 21
E-Mail: kontakt@gbs-elektronik.de
Website: www.gbs-elektronik.de

Power Supply

The MCA527micro is entirely powered from the USB host. It is configured as an USB high power function. Therefore it can be operated only on high power hosts or hubs.

At power-up only the USB controller draws about 15mA from the USB port and is initialized by the hub. When the hub or host is able to supply an USB high power function, the USB controller turns on the USB power switch. The voltage V_{BUSO} ramps up to slightly below V_{BUS} and the integrated power supply turns on V_{3V3}, V_{2V5}, V_{1V8} and V_{CORE} (in that order). When V_{CORE} is stable the reset is released and the controller starts the boot process.

Because the MCA527micro is an USB high power function, it cannot draw more than 500mA from the USB port. To ensure that the module never draws more then this, the USB power switch is current limited. The limit is set so that I_{BUSMAX} never exceeds 500mA.

Through its pin headers X3 and X4 the MCA527micro is able to supply external circuits with V_{BUSO}, V_{3V3}, V_{2V5} and V_{1V8}. The current rating for each voltage can be found in 5, Electrical Characteristics (expected V_{BUSO}). 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_{BUSMAX}. The USB power switch limits it to 400mA to 500mA. When the external circuit tries to overrun this limit, V_{BUSO} will drop until the under voltage lockout or the thermal shutdown turns off the USB power switch. The maximum current an external circuit may draw from V_{BUS} can be estimated as follows:

$$I_{BUSext} \approx I_{BUSMAX(min)} - I_{\mathrm{BUS\_MEAS(max)}} \approx 400\mathrm{mA} - 80\mathrm{mA} \approx 320\mathrm{mA}$$

This means that V_{BUSO} may be loaded with up to 320mA when V_{3V3}, V_{2V5} and V_{1V8} are unloaded. If current is drawn from any of this three voltage rails, it is difficult to calculate the resulting current for I_{BUS}. Therefore, the user must verify that I_{BUS} never exceeds $I_{BUSMAX(min)}$.

If capacitive loads are connected to V_{BUSO}, the modules input current is also limited to I_{BUSMAX} by the USB power switch. In this way no inrush current is seen on the USB bus and the requirements of the USB specification are met. However, as long as the capacitive load is not fully charged, the USB power switch works as a linear regulated current source and the chip temperature increases due to the resulting voltage drop. If the capacitive load is to large, the USB power switch will perform a thermal shutdown. Therefore the effective capacitive load of all external circuits should be held as small as possible. This concerns not only capacitors directly connected to V_{BUSO} but also capacitors behind voltage regulators.

Especially at power-up a large current may flow on the USB cable (up to I_{BUSMAX}). Therefore it is very important that only USB cables are used that fulfill the USB specification. Unfortunately there are a lot of weak cables with high DC resistance on the power lines available on the market. Using such a cable may result in undefined behavior of the MCA527micro like oscillation on start-up (power-up and reboot) or spontaneous reboots. We strongly recommend to use only well specified cables such as Molex 68784-0001. For more information please refer to technical note "Choosing USB Cable".

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.

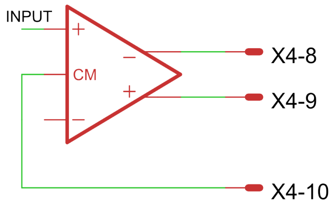


Figure 3: Differential ADC Driver

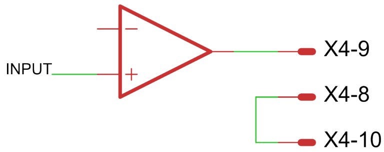
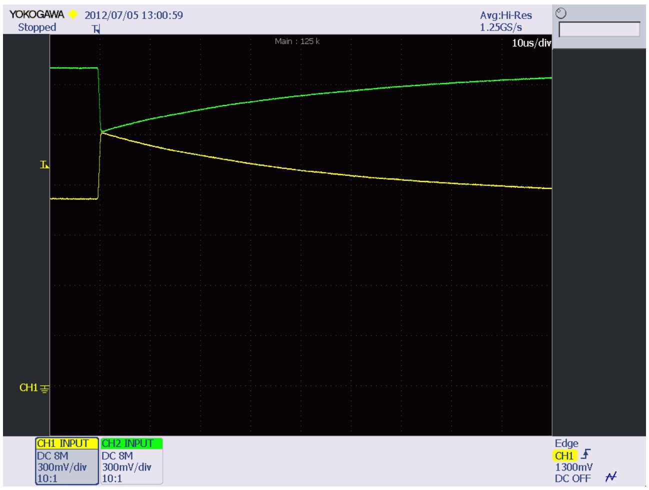
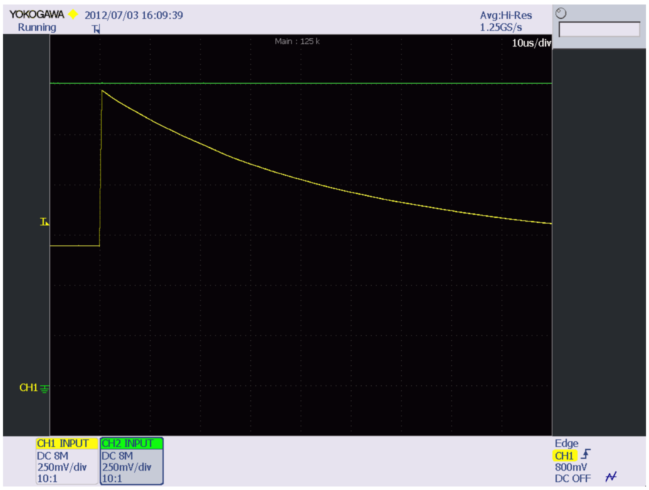


Figure 4: Single-Ended ADC Driver



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

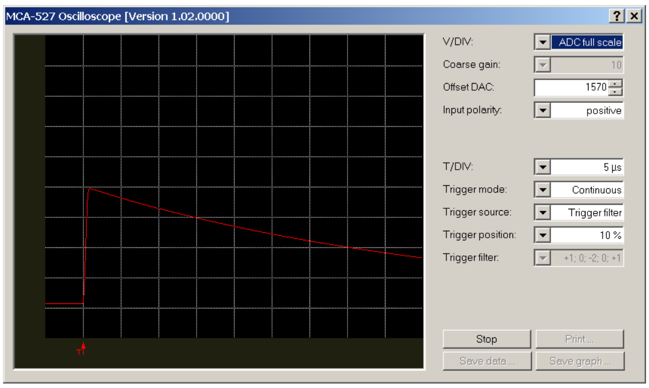


Figure 7: ADC Output for Figure 5 Signals

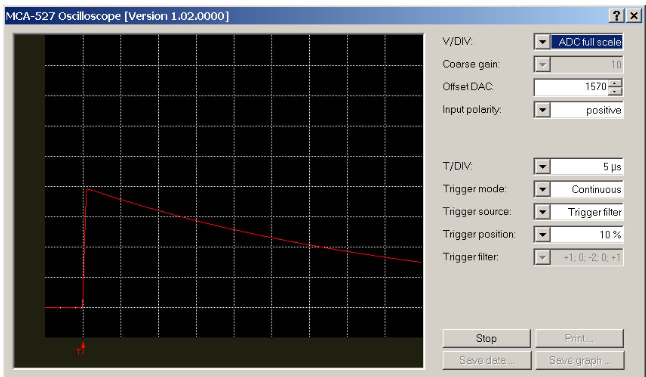


Figure 8: ADC Output for Figure 6 Signals

GBS Elektronik GmbH
Bautzner Landstraße 22
01454 Großerkmannsdorf
Germany

Tel.: 0049 (0)351 21 70 07 - 0
Fax.: 0049 (0)351 21 70 07 - 21
E-Mail: kontakt@gbs-elektronik.de
Website: www.gbs-elektronik.de

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.

Gate Input

Just like the MCA527, the MCA527micro 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 MCA527micro, 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.

Boot Input

During power-up the controller of the MCA527micro 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 MCA527micro 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.

Two-Wire Interface

For communication with external circuits a two-wire interface is available on X4. Both signals SDA and SCL 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.

UART Interface

In addition to the two-wire interface, the MCA527micro 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.

GBS Elektronik GmbH
Bautzner Landstraße 22
01454 Großerkmannsdorf
Germany

Tel.: 0049 (0)351 21 70 07 - 0
Fax.: 0049 (0)351 21 70 07 - 21
E-Mail: kontakt@gbs-elektronik.de
Website: www.gbs-elektronik.de

Table 6: Module Specification

Parameter	Value
Computer Interface	USB2.0 compliant, FullSpeed, Micro-B Receptacle
Power Supply	entirely powered from USB, USB high power function [1]
Number of Channels	128, 256, 512, 1024, 2048 [2]
Shaping Time	0.1µs to 4µs
Maximum Throughput	100,000cps
Special Features	- Integrated Temperature Sensor - various digital interfaces (TWI, UART, GPIO) - integrated digital Oszilloscope - MCS-mode - Gate-mode
Power Consumption (typical)	250mW / 350mW (Idle / Measurement)
Dimensions	50mm x 20mm x 5mm
Weight	5g

[1] Because of it's low power consumption the MCA527micro itself could work as an USB low power function, too. But in most situations more power is needed for additional circuits such as preamplifier and bias supply.
[2] Versions with 4096, 8192 and 16384 are available on request.

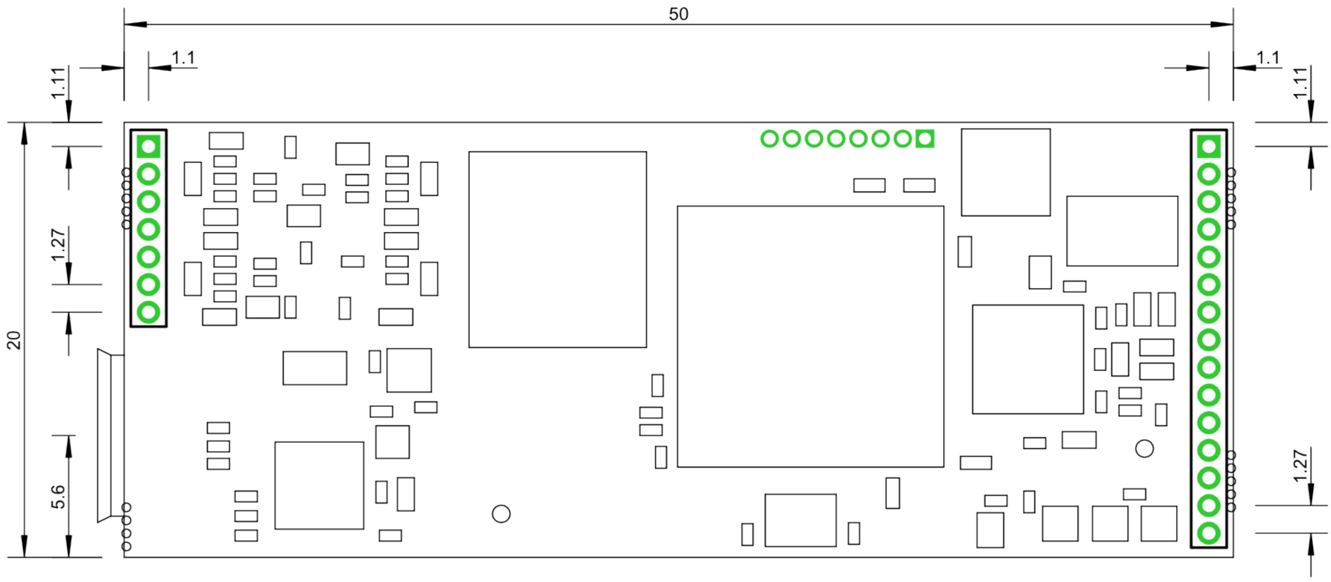


Figure 9: Outline Dimensions (Top View, all Dimensions are in Millimeters)

Preamplifier for Photomultiplier Tubes

A preamplifier for photomultiplier tubes is optionally available for the MCA527micro. It has a built-in bias supply which is software adjustable in the range of 0V to 1000V (both polarities are available), a charge sensitive preamplifier with two coarse gains and a monitor circuit for the supply voltage and the bias voltage.

Parameter	Value
Sensitivity @ CGain=10 Sensitivity @ CGain=50	~500pC Full Scale (Fine Gain = 1) ~100pC Full Scale (Fine Gain = 1)
Bias Supply	0V to 1000V or 0V to -1000V
Power Consumtion	tbd
Operating Temperature Range	0°C to 50°C
Size (L x W x H)	50mm x 35mm x 16mm (without DIL headers)
Weight	25g
Connectors	two DIL headers 1.27mm for MCA527micro, solder pads for input and bias supply

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GBS Elektronik GmbH
Bautzner Landstraße 22
01454 Großerkmannsdorf
Germany

Tel.: 0049 (0)351 21 70 07 - 0
Fax.: 0049 (0)351 21 70 07 - 21
E-Mail: kontakt@gbs-elektronik.de
Website: www.gbs-elektronik.de

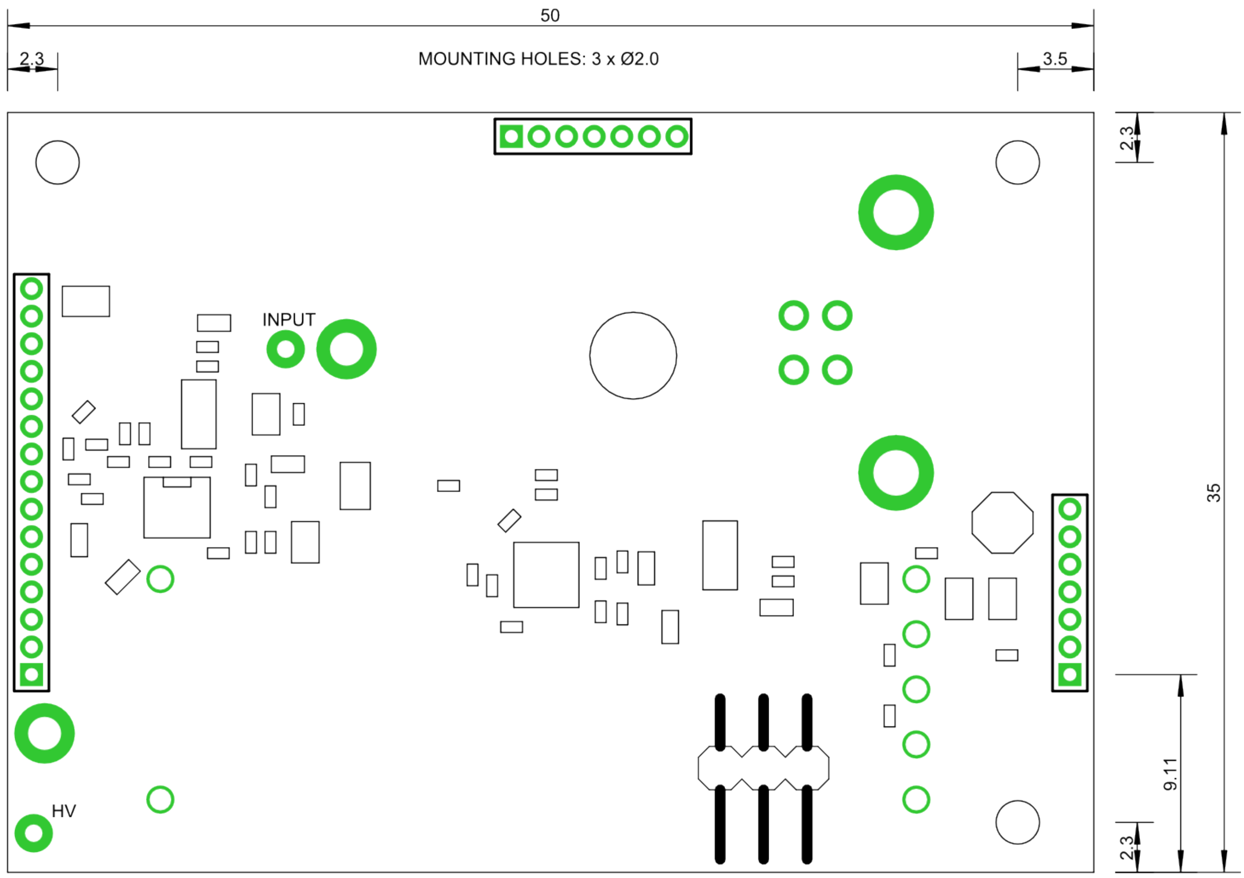

Figure 10: Outline Dimensions (Top View, all Dimensions are in Millimeters)

Table 7: Revision History

Revision	Section / Figure / Entry	Correction
1.0		Initial Version
1.1		Chapter “Preamplifier” added

GBS Elektronik GmbH
Bautzner Landstraße 22
01454 Großerkmannsdorf
Germany

Tel.: 0049 (0)351 21 70 07 - 0
Fax.: 0049 (0)351 21 70 07 - 21
E-Mail: kontakt@gbs-elektronik.de
Website: www.gbs-elektronik.de