USER MANUAL

CWCT & BCM-CW-E

CW Current Transformer

Beam Current Monitor for

CW beams and Macropulses

Rev 2.0

www.bergoz.com

bergoz INSTRUMENTATION

More than 40 years of experience recognized in the world of particle accelerators

Record of updates

Version	Date	Updates performed
1.0	04/2018	First release
1.1	12/2019	Modification of the cover page and creation of the distributors' page
1.2	01/2020	Additions and corrections in the section USB communication
1.3	01/2020	Corrections concerning BCM-CW-E and firmware revisions
1.4	10/2020	Update of CWCT Test Kit 1, GUI and General Specifications; plus minor corrections
1.5.	03/2021	Improved description of USB communication
2.0	07/2024	Manual template update, LC option added

DISTRIBUTORS

U.S.A.

GMW Associates
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sales@gmw.com

Japan

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www.h-repic.co.jp
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info@geebeeinternational.com

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sales@conveyi.com

South Korea

Seyoung Co., Ltd
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apark@seyoungsys.com

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INITIAL INSPECTION

It is recommended that the shipment be inspected immediately upon delivery. If it is damaged in any way, contact Bergoz Instrumentation or your local distributor. The content of the shipment should be compared to the items listed on the invoice. Any discrepancy should be notified to Bergoz Instrumentation or its local distributor immediately. Unless promptly notified, Bergoz Instrumentation will not be responsible for such discrepancies.

WARRANTY

Bergoz Instrumentation warrants its beam current monitors to operate within specifications under normal use for a period of 12 months from the date of shipment. Spares, repairs and replacement parts are warranted for 90 days. In exercising this warranty, Bergoz Instrumentation will repair, or at its option, replace any product returned to Bergoz Instrumentation or its local distributor within the warranty period, provided that the warrantor's examination discloses that the product is defective due to workmanship or materials and that the defect has not been caused by misuse, disassembly, neglect, use of faulty part, accident or abnormal conditions, repair made by the customer, or operations. Damages caused by ionizing radiations are specifically excluded from the warranty. Bergoz Instrumentation and its local distributors shall not be responsible for any consequential, incidental or special damages.

ASSISTANCE

Assistance in installation, use or calibration of Bergoz Instrumentation beam current monitors is available from Bergoz Instrumentation, 01630 Saint Genis Pouilly, France. It is recommended to send a detailed description of the problem by email to info@bergoz.com.

SERVICE PROCEDURE

Products requiring maintenance should be returned to Bergoz Instrumentation or its local distributor: The purchaser/customer must ask for a RMA (Return Material Authorization) number to Bergoz Instrumentation or its local distributor before return of goods. Bergoz Instrumentation will repair or replace any product under warranty at no charge.

For products in need of repair after the warranty period, Bergoz Instrumentation will assess the technical issue and send a quote to the purchaser/customer. The purchaser/customer must provide a purchase order before repairs can be initiated. Bergoz Instrumentation can issue fixed price quotations for most repairs.

RETURN PROCEDURE

All products returned for repair should include a detailed description of the defect or failure as well as name, phone number and email of a contact person to allow further inquiry. Contact Bergoz Instrumentation or your local distributor to determine where to return the product. Returns must be notified by email prior to shipment.

The shipment of a product under warranty or out of warranty back to the factory is paid by the user/customer, including the customs fees. The return of this repaired product under warranty back to the customer is paid by Bergoz Instrumentation.

Return of product out of warranty should be made prepaid or will be invoiced. Bergoz Instrumentation will not accept freight-collect shipments. Shipments should be made via UPS, FedEx or DHL. Within Europe, the transportation services offered by the national Post Offices can be used. The delivery charges or customs clearance charges arising from the use of other carriers will be charged to the customer.

SAFETY INSTRUCTIONS

This instrument is operated from the mains power supply. For safe operation, it must be grounded by way of the grounding conductor in the power cord. Use only the fuse specified. Do not remove cover panels while the instrument is powered. Do not operate the instrument without the cover panels properly installed.

Chassis originally shipped to U.S. or Canada feature AC mains power entry modules where the Phase is fused and the Neutral unfused, as is the rule.

Chassis to other destinations but U.S. and Canada feature AC mains power entry modules where both Phase and Neutral are fused.

When a chassis with unfused Neutral shall be used outside the U.S. and Canada, fuse configuration must be modified so that both Phase and Neutral will be fused:
The Power entry module must be opened, the Phase fuse must be removed, the fuse holder must be flipped; its reverse side presents two slots where two new fuses must be inserted, one in each slot. The fuses rating must be same as the Phase fuse that was removed.

The Toroid sensor contains materials such as cobalt and iron. Those materials may become radioactive when exposed to high energy particle beams. Follow applicable radiation-safety procedures when the Toroid sensor must be handled.

CWCT & BCM-CW-E SET

This manual applies to BCM-CW-E revisions 222.1 with firmware 1.4 and above.
It does NOT apply to earlier BCM-CW-E revisions or earlier firmware versions.
It does not apply to either BCM-IHR-E, BCM-CA-E or BCM-RF-E.

The CWCT & BCM-CW-E set includes:

- CWCT Current Transformer
- BCM-CW-E electronics module
- BCM-RFC/xx 19" RF-shielded chassis for BCM-E modules of all versions with power supply
- BCM-C-xxx CWCT to BCM-RFC chassis interconnect coaxial cable with PEX dielectric and SMA connectors with PTFE dielectric
- Option: BCM-RHC-xxx CWCT to BCM-RFC chassis interconnect coaxial cable with PEX dielectric and SMA connectors with PEEK dielectric.
- Option: BCM-C400-xxx or BCM-C600-xxx CWCT to BCM-RFC chassis interconnect cable for long distances. When provided, each end needs to be connected to a one-meter interconnect cable BCM-C-xxx or BCM-RHC-xxx.

In-flange CWCT and BCM-CW-E

BCM-RFC/xx RF shielded chassis is compatible with BCM-CW-E, BCM-IHR-E and BCM-RF-E. BCM-CW-E, BCM-IHR-E and BCM-RF-E electronics modules can be mixed in the same BCM-RFC/xx chassis.

Power supply must however be dimensioned according to power consumption. Please contact Bergoz Instrumentation before adding more BCM modules into a chassis.

GENERAL DESCRIPTION

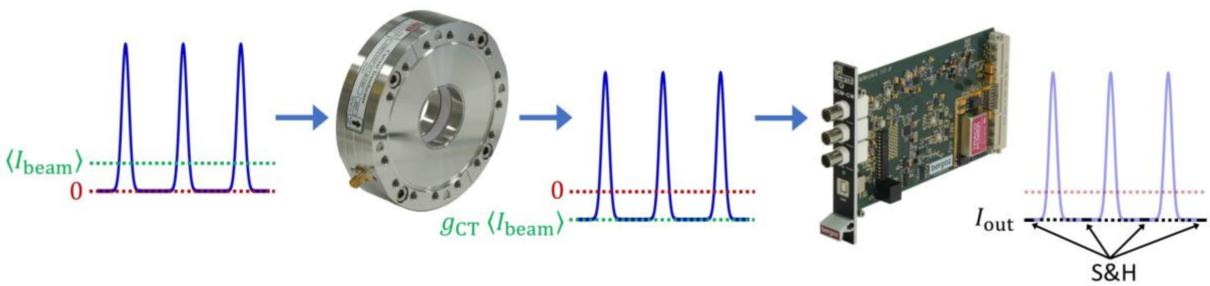
Working Principle

CWCT current sensor and BCM-CW-E electronics are designed to measure average currents of CW beams and macropulses.

The CWCT is a current transformer with strict limits on lower and upper cut-off frequencies, tailored to the beam properties. Its lower cut-off assures that droop between bunches is negligible, yet high enough to allow full differentiation of its output signal as quickly as possible. Its upper cut-off is high enough to allow its output signal to return to baseline level after each particle bunch.

The BCM-CW-E is the electronics module processing the CWCT output signal. It provides an output voltage proportional to the beam average current.

The BCM-CW-E contains a fast sample-and-hold circuit which measures the CWCT output signal in between two consecutive pulses. This baseline signal is proportional to the average beam current passing through the CWCT aperture. Additional filters remove high and low frequency noise. A low-noise input amplifier can be used to increase sensitivity.



The BCM-CW-E electronics module includes:

- Gain control of the RF signal input amplifier stage: 0dB, +20dB, +40dB, and RF Signal input disconnect. This function can be controlled by either logic levels (see rear panel DB9 description) or via USB.
- Timing adjustment of baseline measurement: Timing adjustment is necessary to sample the baseline at the right time. A programmable delay line is available onboard, allowing a timing delay up to 10ns in 10ps steps. This delay line can be controlled via USB only. When USB control is not available, the timing adjustment must be performed by delaying the “Trigger in” signal.

The BCM-CW-E embeds a PIC microcontroller that can be used for BCM-CW-E configuration and digital data read-out. Please note that the digital data read-out is not calibrated. It should not be used for high precision measurements.
The communication is done via specific commands send over a USB connection, e.g. as used by the BCM-CW-E graphical user interface (GUI). Details on the GUI and USB communication are described later in this manual.

The BCM-CW-E microcontroller is factory-loaded with calibration constants corresponding to its associated CWCT. The calibration constants can also be found in the Calibration Report provided with the CWCT and BCM-CW-E.

WARNING: PIC configuration
At the time of delivery, BCM-CW-E is in the "Ex-factory" configuration.
Do not change those settings until you are familiar with the BCM-CW system.

Low Current Option

For currents below 50 µA, the Low-Current option is available. A front-end amplifier is mounted on the CWCT sensor to amplify the signal before its transportation to the BCM-CW-E.

With this option it is possible to measure currents with a resolution down to 8 nA rms.

This option can be installed only when the CWCT surroundings are with low radiations level.

In-flange CWCT models

In-flange models are current transformers whose cores are embedded in a pair of flanges. Flanges are Conflat with usual inner diameters. These current transformers are UHV compatible at least to 1e-9 mbar. Soap or alcohol cleaning before installation is however recommended. To reach pressure down to 1e-11 mbar, adequate pumping and cleaning, e.g. plasma, are required.

CWCT temperature should never exceed 100°C (212°F) at any time during bake out or operation unless the CWCT is made from a selection of higher temperature alloys and materials:

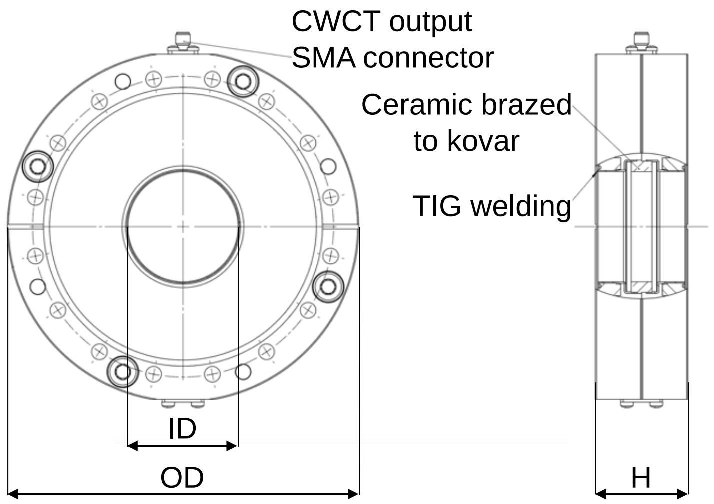
- Option BK150C allows bake out up to 150°C (300°F)
- Option BK185C allows bake out up to 185°C (365°F)
- Option BK200C allows bake out up to 200°C (392°F)

CWCT wall current break ("gap") is a ceramic ring (Al2O3 99.7%) brazed onto two Kovar transition sleeves.
Standard models are made from AISI 304 steel, AISI 316LN is available on option.

CWCT part numbers follow below syntax:

CWCT	
-CFx"-	x" is the CF flanges OD [inch]
-xx.x-	xx.x is the sensor ID [mm]
-xx-	xx is the sensor axial length [mm]
-UHV-	UHV: Sensor UHV compatible with brazed ceramic wall current break As delivered, down to 1e-9 mbar After adequate cleaning, down to 1e-11 mbar
Example: CWCT-CF6"-60.4-40-UHV	
Options for In-flange CWCT	
-LC-	Increased resolution to measure lower currents, ≤ 8 nA rms
-ARBxx-	In-flange CWCT sensor with special arbitrary aperture
-316LN-	In-flange CWCT sensor in AISI316LN instead of AISI304
-BK150C-	In-flange CWCT sensor bakeable up to 150°C (300°F)
-BK185C-	In-flange CWCT sensor bakeable up to 185°C (365°F)
-BK200C-	In-flange CWCT sensor bakeable up to 200°C (392°F)
-H	Radiation-tolerant sensor option, all components R.I.>6

MECHANICAL DIMENSIONS AND DRAWINGS



In-flange CWCT sensor order code	Flange OD (inch)	Pipe OD (inch)	Mating flange	CWCT ID (mm)	CWCT H (mm)
CWCT-CF3"3/8-22.2-40-UHV-xx	3.375”	1"	DN/NW50CF	22.2	
CWCT-CF4"1/2-34.9-40-UHV-xx	4.5”	1.5"	DN/NW63CF	34.9	
CWCT-CF4"1/2-38.0-40-UHV-xx	4.5”	40 mm	DN/NW63CF	38.0	
CWCT-CF6"-47.7-40-UHV-xx	6”	2"	DN/NW100CF	47.7	
CWCT-CF6"-60.4-40-UHV-xx	6”	2.5"	DN/NW100CF	60.4	
CWCT-CF6"3/4-96.0-40-UHV-xx or CWCT-CF8"-96.0-40-UHV-xx	6.75” 8”	4"	DN/NW130CF DN160/NW150CF	96.0	
CWCT-CF10"-147.6-40-UHV-xx	10”	6"	DN/NW200CF	147.6	
CWCT-CF12"-198.4-40-UHV-xx	12”	8"	DN/NW250CF	198.4	
CWCT-CFXX"-XXX-XX-UHV-xx					40.0

Drawings

Drawings in .pdf can be found on our website:
www.bergoz.com :: CWCT & BCM-CW-E :: Downloads :: Technical drawings
Dimensions missing on the website can be obtained by contacting info@bergoz.com

BCM Chassis

The BCM-RFC/xx chassis is based on a 19” Schroff rackable RF chassis.

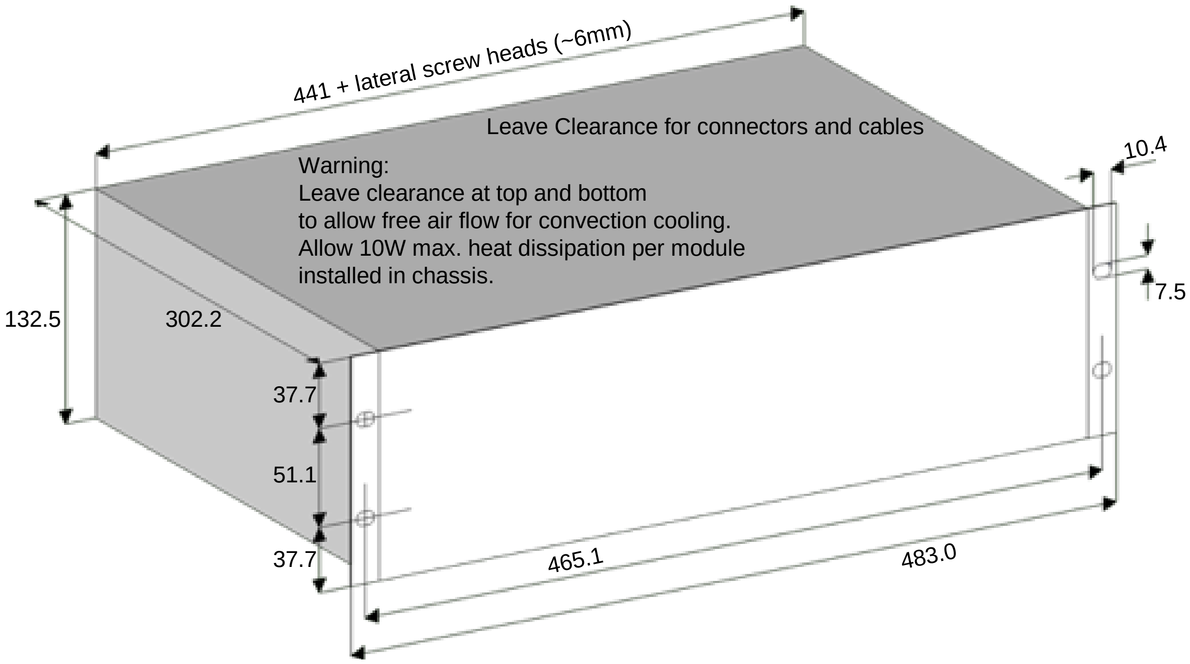
Bin dimensions: 3U x 84F

Schroff reference: Europac Lab HF/RF #20845-283

The BCM-RFC/xx can be wired with up to 6 BCM-E stations, xx being the number of wired stations (e.g. one BCM-CW-E module per station).

Unwired stations are masked with RF-shielded blank panels.

BCM-RFC/xx outer dimensions:



BCM-CW-E front panel description

Signal View:
CWCT Signal, after input amplification (50 Ω readout).

Output View:
Baseline output voltage proportional to the average input current (1 MΩ readout). This signal follows beam current fluctuations within 1µs, permitting fast detection of beam loss.

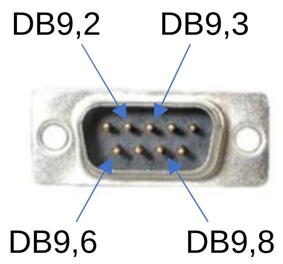
Timing View:
Clock signal (50 Ω readout). Used to visualize timing of baseline measurement (positive edge zero crossing)[1].

Power ON LED

USB connector type B:
Data readout and remote control.

[1] To ensure a perfect coincidence between Signal View and Timing View, you should use coaxial cables of equal length and equal characteristics. Otherwise, a phase adjustment may be needed on your oscilloscope, to correct for cable- or oscilloscope-induced timing errors.

BCM-RFC rear panel description



Remote control:
Pin DB9,6: Input TTL Gain Control A (internal Pull up to 5V) (see Hardware Gain Control Input table below)

Pin DB9,2: Input TTL Gain Control B (internal Pull up to 5V) (see Hardware Gain Control Input table below)

Pin DB9,8: Output Signal – 10 kHz bandwidth
Output voltage proportional to the average beam current (1 MΩ readout).

Pin DB9,3: Output Signal – 100 Hz bandwidth
Output voltage proportional to the average beam current (1 MΩ readout).

Pins DB9,1; DB9,4; DB9,5; DB9,7; DB9,9: connected to GND

BCM Input:
BCM-CW-E input signal from the CWCT.

BCM Output:
Full bandwidth output voltage proportional to the average beam current (50 Ω readout). This signal follows beam current fluctuations within 1µs, permitting fast detection of beam loss.

Trigger in:
Clock signal synchronized to Beam RF (50 Ω terminated)
See General Specifications chapter on page 29 for clock signal properties

Hardware Gain Control Input (DB9)		
DB9,6	**DB9,2**	**Input Gain**
OPEN (High)	OPEN (High)	ISOLATED
GROUNDED (Low)	OPEN (High)	Gain: 0dB
OPEN (High)	GROUNDED (Low)	Gain: 20dB
GROUNDED (Low)	GROUNDED (Low)	Gain: 40dB

MEASURED RANGES

Standard CWCT and BCM-CW-E

CWCT and BCM-CW-E typical performances and measurement ranges are shown below:

BCM-CW-E output		BCM output	Remote control DB9, 8	Remote control DB9, 3
0dB GAIN	Max	100 mA		
	Resolution	1 mA rms	500 µA rms	100 µA rms
20dB GAIN	Max	20 mA		
	Resolution	100 µA rms	50 µA rms	10 µA rms
40dB GAIN	Max	2 mA		
	Resolution	10 µA rms	5 µA rms	1 µA rms

LC-CWCT and BCM-CW-E

With the Low-Current option, CWCT and BCM-CW-E show following typical performances and measurement ranges:

BCM-CW-E output		BCM output	Remote control DB9, 8	Remote control DB9, 3
0dB GAIN	Max	50 µA		
	Resolution	5 µA rms	500 nA rms	100 nA rms
20dB GAIN	Max	20 µA		
	Resolution	2.5 µA rms	250 nA rms	50 nA rms
40dB GAIN	Max	2 µA		
	Resolution	250 nA rms	25 nA rms	8 nA rms

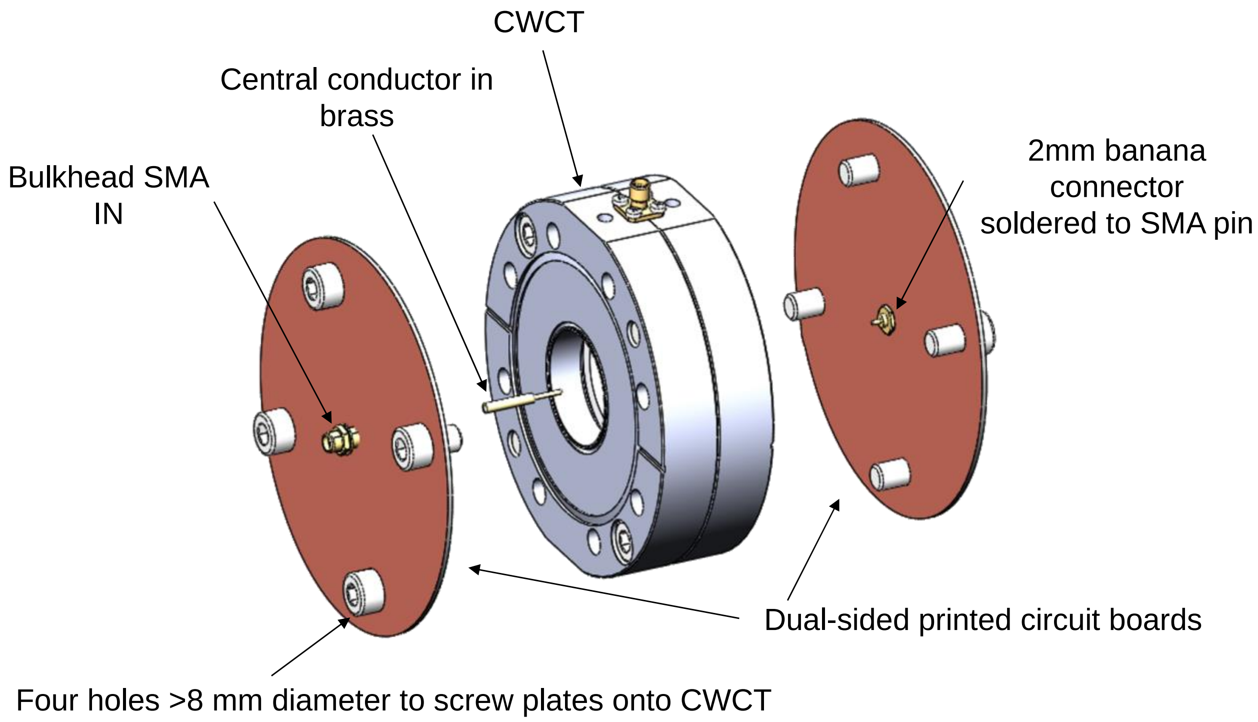
QUICK CHECK

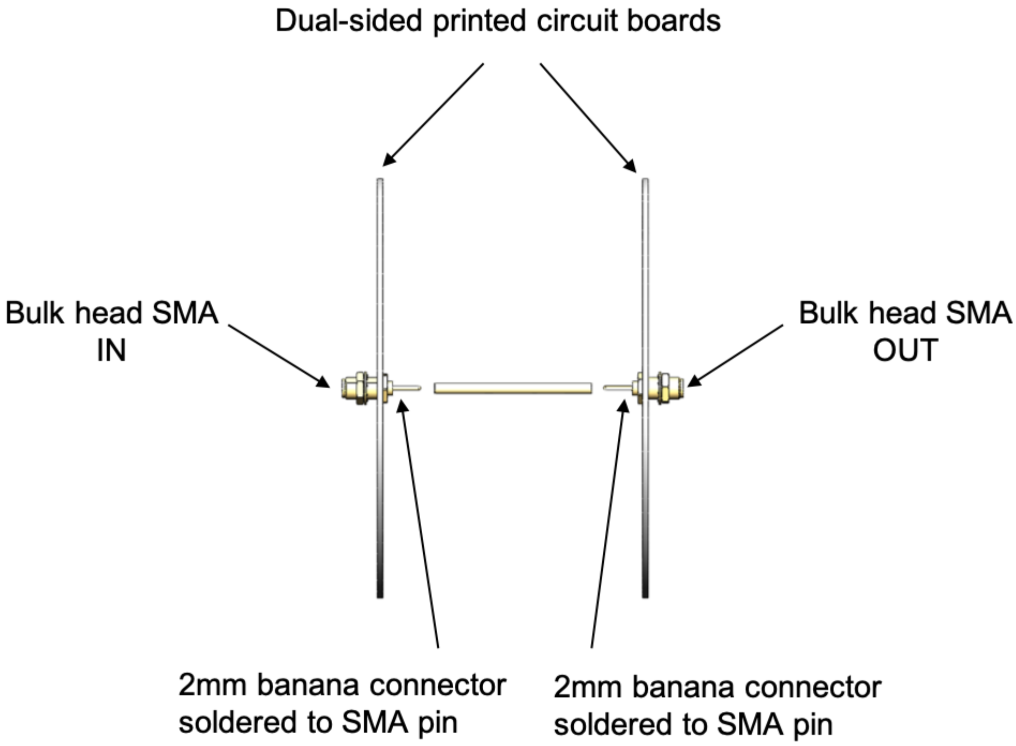
Before installation in the accelerator, different bench tests can be performed to get familiar with the CWCT and the BCM-CW-E. The input signal can be provided by an RF signal generator, square wave generator or CW pulse generator, as described below in the quick check setup.

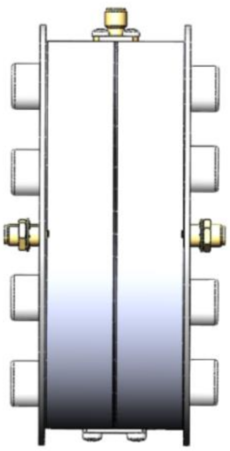
Current Transformer Test Fixture

A test fixture is required to transmit the signal through the CWCT aperture. This test fixture and the CWCT flanges form a coaxial transmission line. Like this, impedance mismatch remains at acceptable levels and the input signal is maintained. It is not recommended to pass a simple wire through the CWCT aperture.

CWCT test fixture:




Dual-sided printed circuit boards
Bulk head SMA
IN
Bulk head SMA
OUT
2mm banana connector
soldered to SMA pin
2mm banana connector
soldered to SMA pin



BCM-CW-E + CWCT Current Measurement Example Setup

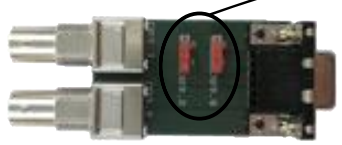
What is needed:

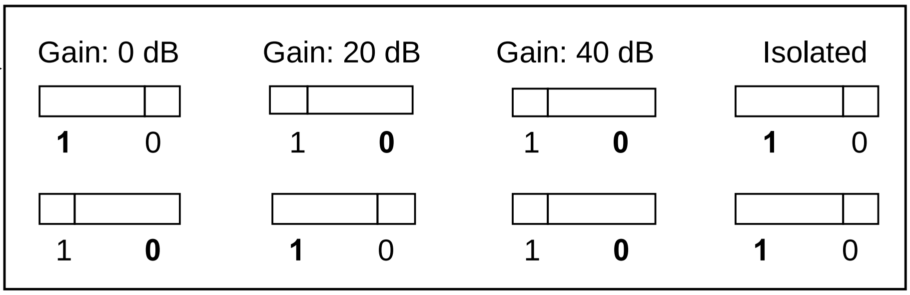
- CWCT
- Current Transformer test fixture (see description page 13)
- BCM-CW-E electronics module
- BCM-RFC/xx chassis
- RF Pulse generator, 15MHz minimum, with a 50% Duty cycle trigger output or a second output channel, preferably capable of operating at the nominal CWCT/BCM-CW-E frequency.
- Programmable delay line allowing delay adjustment up to 60ns in 50ps steps preferably
- A single four-channel oscilloscope or two dual-channel oscilloscopes with 500 MHz bandwidth or higher
- SMA 50 Ω load
- Short (1–2 m) 50 Ω coaxial cables
- SMA/BNC adapters.

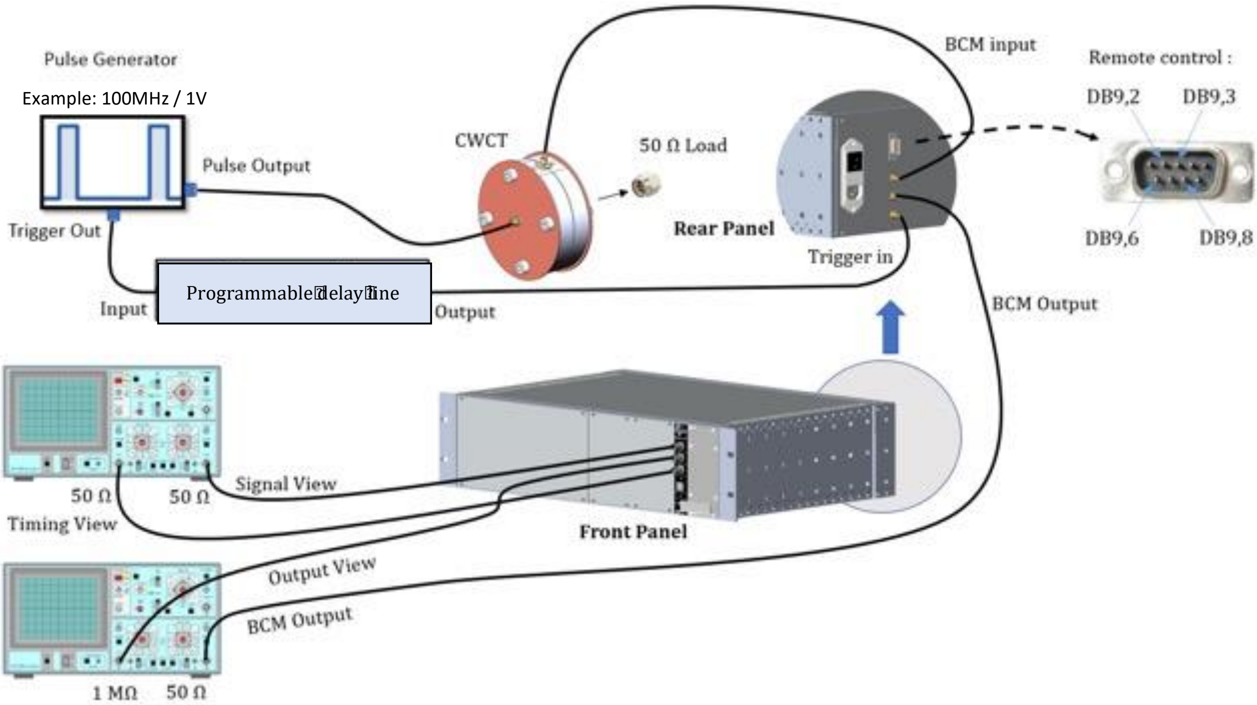
Setup

Default State
Ex-factory default state: Gain Control thru "Remote control" DB9.

CWCT Test Kit 1





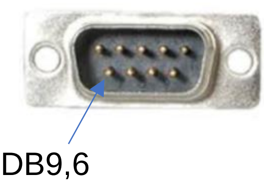


BCM-CW-E which have been controlled by USB may be left in a state other than Ex-factory default state. For example, control via DB9 may be disabled

1) At time of shipment, the AC mains voltage is set according to the country of destination. A label on the power supply unit shows the AC voltage it is set up to. Check that it corresponds to your AC mains voltage. If located out of North America, Turn OFF the chassis power switch and connect the AC mains to the chassis.
2) Adjust the Pulse Generator to the CWCT & BCM-CE-E nominal frequency: e.g. 100MHz / 1Vp-p / duty cycle: 20% to 50%
3) CWCT must be mounted in the test fixture.
4) Connect the Pulse generator output to the CWCT test fixture SMA input.
5) Connect CWCT test fixture SMA output to a 50Ω Load.
6) Connect CWCT output SMA to the “BCM input” SMA located on the chassis rear panel.
7) Connect Trigger Output from Pulse generator to the Programmable delay line.
8) If Trigger signal from Programmable Delay Line exceeds 200mVp-p, insert attenuators until signal is in the range 20mVp-p … 200mVp-p
9) Connect Output from Programmable delay line to “Trigger Input” located on the chassis rear panel.
10) Connect “Output View” located on front panel to a 1 MΩ oscilloscope channel.
11) Connect “BCM Output” SMA located on the chassis rear panel to an 50Ω oscilloscope channel.
12) Connect “Signal View” BNC located on front panel to a 50 Ω oscilloscope channel.
13) Connect “Timing View” BNC located on front panel to a 50 Ω oscilloscope channel.
14) Turn ON the BCM-RFC/xx chassis power switch.
15) Select an appropriate input gain using DB9 remote control pins (DB9,6 & DB9,2)

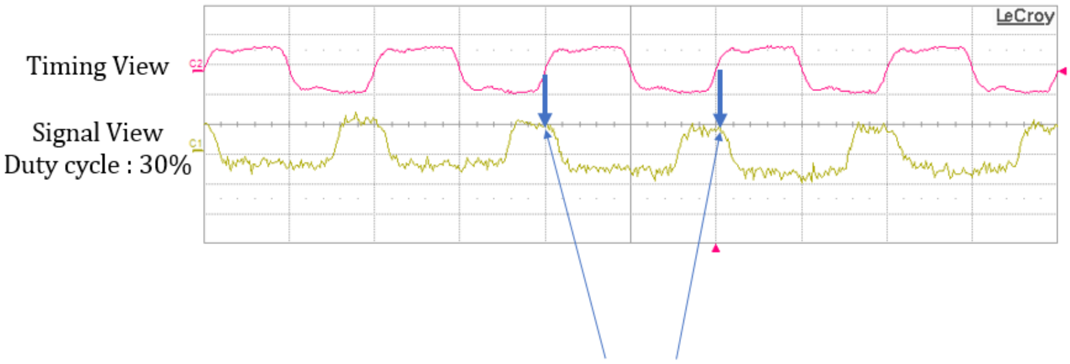
Hardware Gain Control Input (DB9)		
DB9,6	**DB9,2**	**Input Gain**
OPEN (High)	OPEN (High)	ISOLATED
GROUNDED (Low)	OPEN (High)	Gain: 0dB
OPEN (High)	GROUNDED (Low)	Gain: 20dB
GROUNDED (Low)	GROUNDED (Low)	Gain: 40dB

e.g. to select a Gain =40dB DB9,2 should be left open (unconnected) and DB9,6 should be connected to ground, for example by connecting to a DB9 ground pin. Available DB9 Ground Pins are: DB9,1 DB9,4 DB9,5 DB9,7 DB9,9

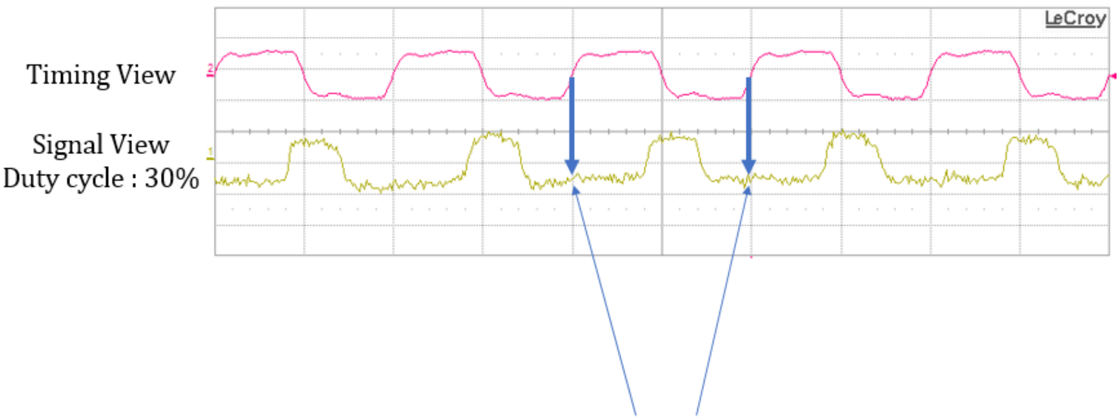


16) Turn ON the Pulse Generator

Visualize “Timing View”, “Signal View”, “BCM Output”, and “Output View”.
Adjust the delay line to get a good baseline measurement.



Wrong Baseline Sampling time

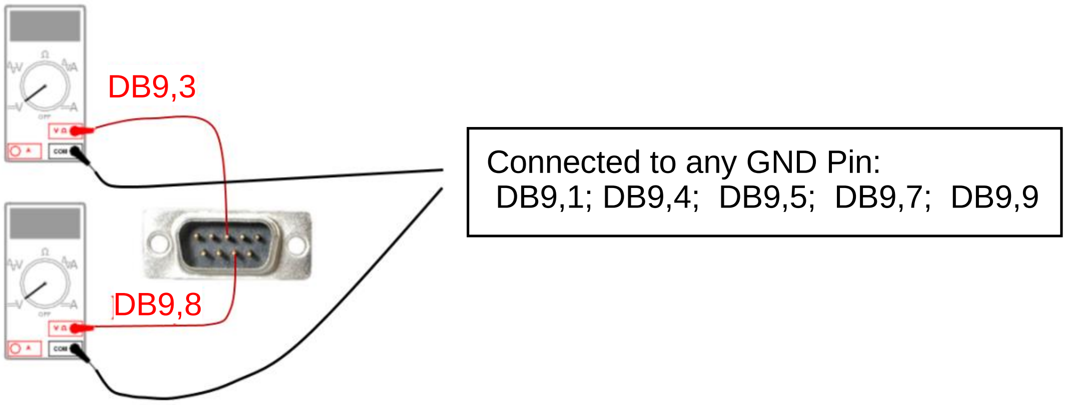


Good Baseline Sampling time

In case “Signal View” is not well visible, select a higher gain.

The measured voltage is available on the following output ports:

"BCM Output" located on chassis Rear Panel: full bandwidth
"Output View" located on BCM-CW-E Front Panel: full bandwidth
"DB9,8": located on chassis Rear Panel: 10 kHz bandwidth
"DB9,3": located on chassis Rear Panel: 100 Hz bandwidth



All output voltages are proportional to the average current passing the CWCT aperture.

The transfer functions to get the current from the output voltages are indicated in the calibration report.

The transfer functions depend on BCM output port and input gain setting.

GRAPHICAL USER INTERFACE

Bergoz Instrumentation provides a GUI to communicate with the BCM-CW-E via USB. It allows to control the BCM-CW-E settings and to acquire the BCM-CW-E output signal.
This software was developed with LabVIEW 2014. It is provided as a Microsoft Windows compatible executable file. The LabVIEW .vi file can be obtained upon request to info@bergoz.com.

Operating systems supported:
Any Microsoft Windows version that can run LabVIEW 2014 or the corresponding run time environment and the NI-VISA driver package, e.g. Windows XP, Vista, 7, 8, 10, 11.

To use other operating systems, please ask for the LabVIEW .vi file

The installer package of the BCM-CW system GUI contains the LabVIEW run time environment and the VISA drivers. They can also be obtained from the National Instruments web site.

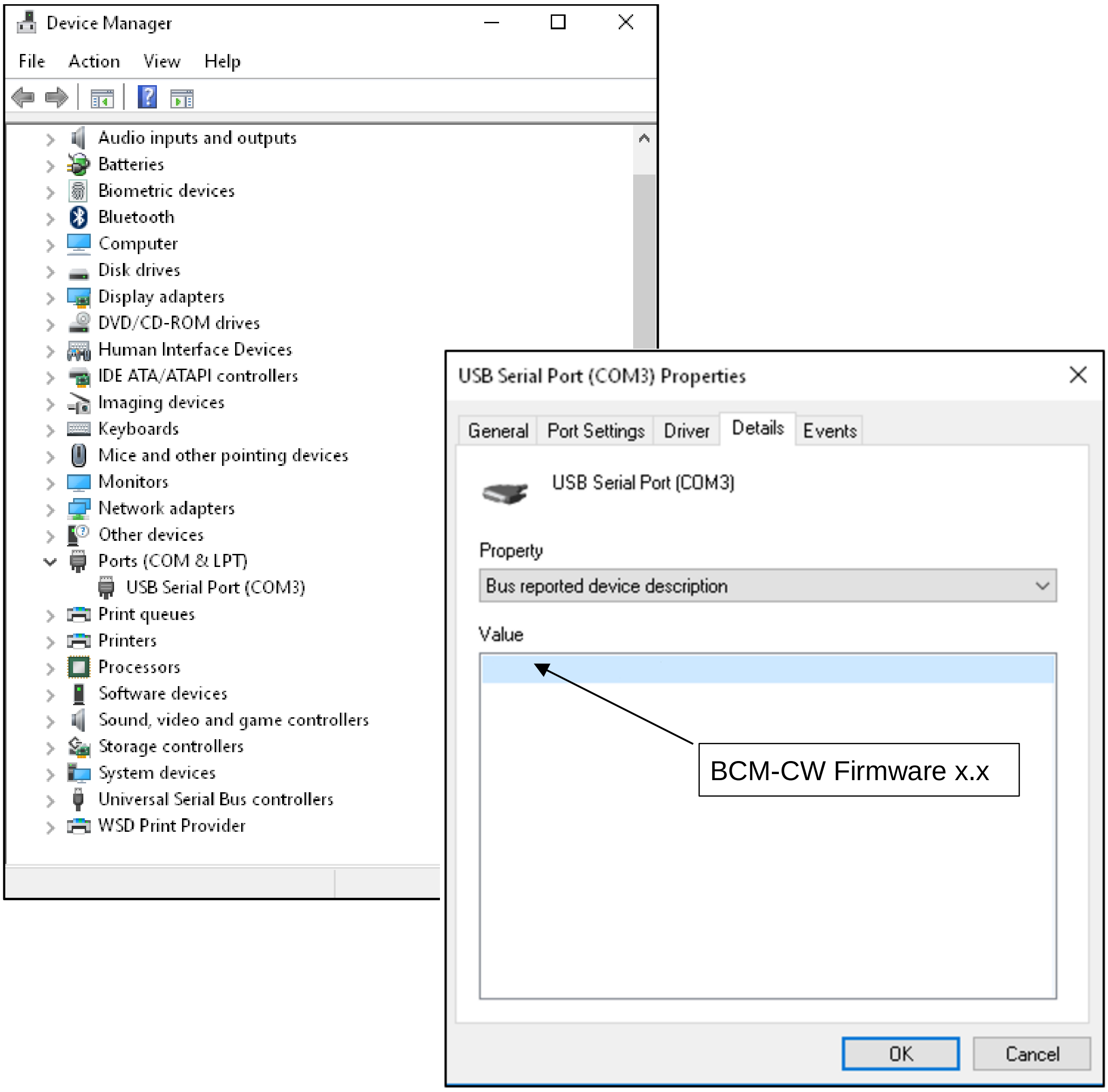
The Microchip USB CDC serial driver might be required on Windows systems to communicate with the BCM-CW-E. This driver is part of the Microchip Libraries for Applications (USB package of Legacy MLA). It is also provided with the BCM-CW-E or can be obtained from Bergoz Instrumentation upon request to info@bergoz.com.

Installation

1) At time of delivery, a USB stick is attached to the last page of the printed manual accompanying the CWCT / BCM-CW-E. Open the folder containing the BCM-CW GUI Installer.
2) Run the Setup executable file and proceed with the installation.
3) The BCM-CW GUI application (.exe) is installed at the location specified during installation. If necessary, also the LabVIEW 2014 run-time environment and the NI VISA drivers are installed.
4) The Microchip USB CDC serial driver is provided on the USB stick in a compressed ZIP archive. Un-compress this archive. A folder will be created containing the files necessary for driver installation.
5) Right-click on the file "mchpcdc.inf" and choose "Install".

BCM-CW-E communication

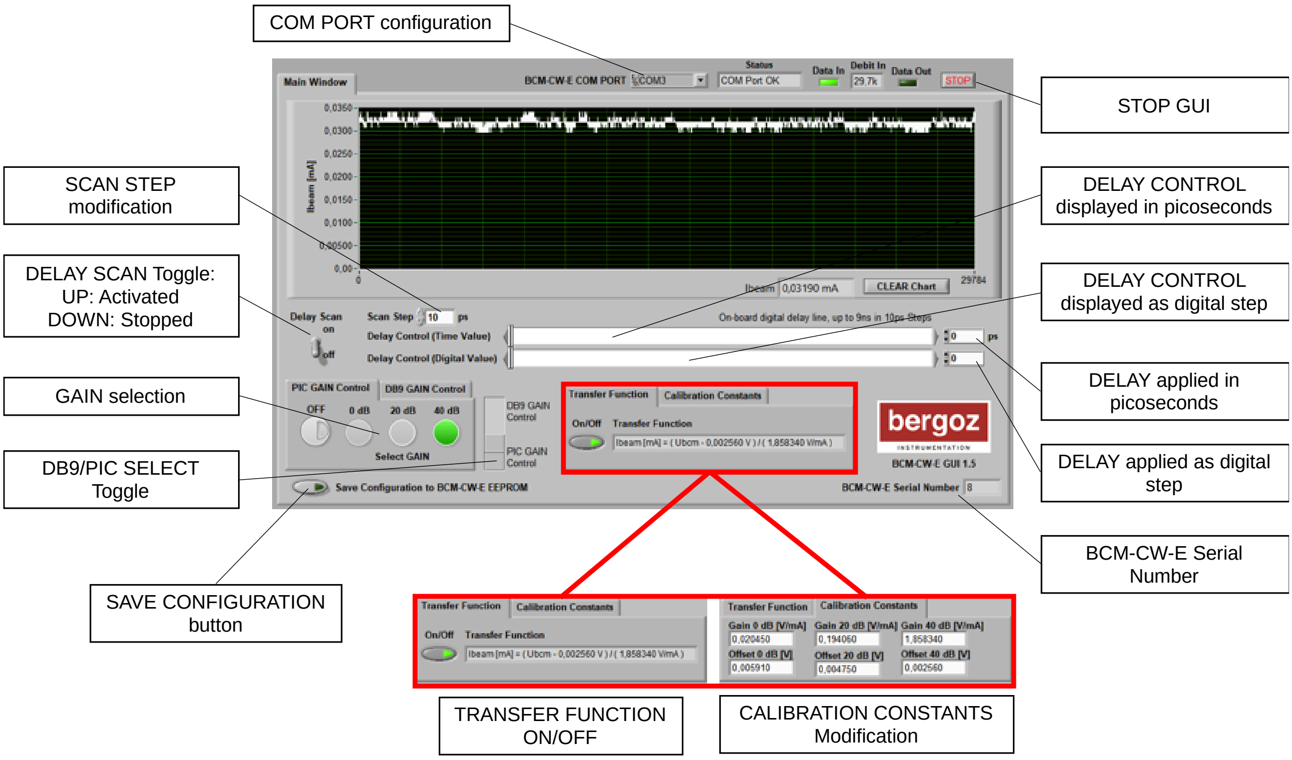
1) Connect the USB cable from the BCM-CW-E front panel USB port to the PC.
2) Windows automatically recognizes the device and loads the USB CDC serial driver.
3) In the device manager, look for the serial COM port number associated to the BCM-CW-E.



4) Open the GUI and enter the COM port in the GUI field called "BCM-CW-E COM PORT".
5) Run the GUI; communication with BCM-CW-E starts.

GUI user's guide

The graph is displaying the BCM-CW-E output voltage as measured by the on-board PIC microcontroller (uncalibrated).



PIC GAIN Control Tab:

- This window is active if DB9 / PIC SELECT toggle is set to "PIC GAIN Control".
- Three BCM input amplification gains can be selected:
  - 0dB
  - 20dB
  - 40dB
  - OFF: BCM input isolated

DB9 GAIN Control Tab:

- This window is active if DB9 / PIC SELECT toggle is set to "DB9 GAIN Control".
- This window shows the gain selected by hardware (DB9).

COM Port configuration:

- Address of the virtual COM port used by the BCM-CW-E for communication.

Delay Control:

- Used to set up the correct timing of the clock signal relative to the beam signal. Can be set as temporal value (in picoseconds) or as digital value (delay step number).

Delay Scan:

- Toggle on/off the automatic clock delay scan.

Scan Step:

- Temporal step of the automatic delay scan.

Transfer Function Tab:

- Toggle on/off the conversion of measured voltage values to average beam current.

Calibration Constants Tab:

- Calibration constants required to convert measured voltage to average beam current. Ex-factory set to the calibration constants for the 100Hz output (see calibration report).

Save Configuration to BCM-CW-E:

- Stores the current BCM-CW-E settings in the BCM-CW-E microcontroller EEPROM. The settings saved to the EEPROM will be restored when the BCM-CW-E is switched on.

BCM-CW-E FIRMWARE

The BCM-CW-E embeds a PIC18F2458 microcontroller from Microchip Technology Inc. This microcontroller includes a 12bit ADC and allows USB communication.

The BCM-CW-E firmware is written in C using the MPLAB 8.9 IDE and the MPLAB C18 compiler, both available from the Microchip website: www.microchip.com.

The firmware code can be obtained from Bergoz Instrumentation upon request. Users can freely modify the code to fit at best their own application.

To program and debug the microcontroller, remove the BCM-CW-E cover shield and connect an ICD3 Microchip In-circuit debugger to the RJ11-R connector (see I/O AND SWITCHES section). BCM-XTD card extender may be required to extend the BCM-CW-E out of its BCM-RFC chassis.

USB COMMUNICATION WITH THE BCM-CW-E

Communication between host PC and BCM-CW-E is performed via the microcontroller's built-in USB to serial converter. The connection is done with a USB cable. But for data transmission, the BCM-CW-E appears attached to a serial port of the host.

The Microchip USB CDC serial driver might be required on Windows systems to communicate with the BCM-CW-E USB port. This driver is part of the Microchip Libraries for Applications (USB package of Legacy MLA). It is also provided during delivery of the CWCT / BCM-CW-E or can be obtained from Bergoz Instrumentation upon request.

The BCM-CW-E uses the Communication Devices Class USB protocol in POLLING mode.
All data is transmitted as character strings.

A general frame used to send a command from the host to the BCM-CW-E looks like this:

1 char Frame type	1 char Frame number	1 char Write / Read indicator	8 char Value	2 char Termination
'A' to 'Z'	'0' to '9'	':' write data to PIC or '?' demand data from PIC	00000000 to FFFFFFFF HEX value	\n\0 Ascii(10) Ascii(0)

Examples: "D0:00000005\n\0", "D0?\n\0"
If data is demanded from the BCM-CW-E using the read indicator '?', the eight value characters can be omitted.

It is possible to concatenate a few frames in a single line send to the BCM-CW-E. It is sufficient that each frame ends by \0 (ascii(0)) instead of \n\0 (ascii(10) ascii(0)).

Warning!
The BCM-CW-E firmware does not always disregard wrongly formatted frames. It is

mandatory that the value send to the BCM-CW-E is exactly eight characters long and contains only hexadecimal numbers. Otherwise, the BCM-CW-E might misbehave.

A general frame received by the host from the BCM-CW-E looks like this:

1 char Frame type	1 char Frame number	1 char Separator	4 char Counter	1 char Separator	8 char Value	2 char Termination
'A' to 'Z'	'0' to '9'	':'	0000 to FFFF HEX value	'='	00000000 to FFFFFFFF HEX value	\n\0 Ascii(10) Ascii(0)

Example: "D0:0123=00000005\n\0"

The analog BCM-CW-E output signal is periodically sampled by the microcontroller's 12bit ADC. The sampled value is then automatically sent to the host via USB.
Frames automatically sent by the BCM-CW-E to the host:

Frame type	Description	Example
A	BCM-CW-E's ADC sampled voltage in microvolts or, if the transfer function is switched on, the corresponding current value usually in nanoamperes (see R0? command below).	A0:0123=00123ABC\n\0

Note on HEX value format:
The 4 char counter is an unsigned integer value in HEX format, i.e. its decimal range is 0 to 65535. The 8 char value may be either an unsigned integer value in HEX format, i.e. its decimal range is 0 to 4294967295, or a signed integer value stored as two's complement in HEX format, i.e. its decimal range is −2147483648 to 2147483647.

This table describes the write commands, that can be send by the host to the BCM-CW-E. These commands change the BCM-CW-E configuration. The BCM-CW-E does not return a response:

Command	Description	Command Frame (omitting termination)	Comments
D	Set on-board digital delay line value (steps, 10bit)	D0:00000xxx	"xxx" must be an integer number in HEX format within the range "000" to "3FF", i.e. step 0 to 1023
T	Set on-board digital delay line value (picoseconds)	T0:0000xxxx	"xxxx" must be an integer number in HEX format within the range "0000" to "2374", i.e. approx. 0 to 9076ps
E	Save BCM-CW-E configuration to microcontroller EEPROM	E0:00000001	The value should equal "00000001", no other values are defined
G	Set BCM-CW-E Gain Configuration	G0:000000x0	"x" must be an integer number in HEX format. The LSB (Bit0) is not used. DB9/PIC Gain control: Bit1 = 0 => set gain control to PIC Bit1 = 1 => set gain control to DB9 The following gain control bits are used if Bit5 = 0 (gain controlled by PIC) Bit2 = 0 and Bit3 = 0 => 40dB gain Bit2 = 1 and Bit3 = 0 => 20dB gain Bit2 = 0 and Bit3 = 1 => 0dB gain Bit2 = 1 and Bit3 = 1 => input switched off
I	Set transfer function on/off state	I0:00000001 I0:00000000	on off
C	Set calibration constants	C0:xxxxxxxx C1:xxxxxxxx C2:xxxxxxxx C3:xxxxxxxx C4:xxxxxxxx C5:xxxxxxxx	"xxxxxxxx" must be an integer number in HEX format within the range "00000000" to "FFFFFFFF". C0 and C1 are transfer function gain and offset in "0dB gain" mode. C2 and C3 are transfer function gain and offset in "20dB gain" mode. C4 and C5 are transfer function gain and offset in "40dB gain" mode.

This table describes the read commands that can be send by the host to the BCM-CW-E and the corresponding response frames returned by the BCM-CW-E back to the host.

These commands do not change the BCM-CW-E configuration:

Command	Description	Command Frame (omitting termination)	Response Frame (omitting termination)	Comments
D	Read on-board digital delay line value as bit code	D0?	D0:zzzz=00000xxx	"xxx" is an integer number in HEX format within the range "000" to "3FF"
T	Read on-board digital delay line value in picoseconds	T0?	T0:zzzz=0000xxxx	“xxxx” is an integer number in HEX format within the range “0000” to “2374”
G	Read gain configuration as set by PIC	G0?	G0:zzzz=000000x	See previous table for a description of the data format.
X	Read gain configuration as set by hardware. (may differ from “G0?” if the gain is controlled via the DB9 port)	X0?	X0:zzzz=0000000x	See previous table for a description of the data format.
S	Read BCM-CW-E serial number	S0?	S0:zzzz=xxxxxxxx	"xxxxxxxx" is an integer number in HEX format within the range "00000000" to "FFFFFFFF"
F	Read BCM-CW-E firmware revision	F0?	F0:zzzz=xxxxxxxx	“xxxxxxxx” is an integer number in HEX format within the range “00000000” to “FFFFFFFF”
I	Read transfer function on/off state	I0?	I0:zzzz=0000001 I0:zzzz=0000000	on off
C	Read transfer function calibration constants	C0?	C0:zzzz=xxxxxxxx C1:zzzz=xxxxxxxx C2:zzzz=xxxxxxxx C3:zzzz=xxxxxxxx C4:zzzz=xxxxxxxx C5:zzzz=xxxxxxxx	"xxxxxxxx" is an integer number in HEX format within the range "00000000" to "FFFFFFFF". See previous table for further information.

Command	Description	Command Frame (omitting termination)	Response Frame (omitting termination)	Comments
R	Read transfer function scale	R0?	R0:zzzz=xxxxxxxx	"xxxxxxxx" is an integer number in HEX format within the range "00000000" to "FFFFFFFF". It is the exponent of the transfer function scale. E.g. if "xxxxxxxx" is -9, the transfer function value is in units of 1e-9 amperes, i.e. nA.
IDN	Read the BCM-CW-E identifier string	IDN? or *IDN?	<arb. string>	The response is a string of arbitrary format, e.g. "Bergoz, BCM-CW, S/N 000, FW 1.0"

"zzzz" is a counter ranging from 0000 to FFFF which is incremented each time the BCM-CW-E tries to send data. After the counter reaches FFFF it is reset to 0000.

GENERAL SPECIFICATIONS

Beam RF	15 MHz ... 500 MHz
Full scale ranges	Refer to “Measured ranges” table chapter[2]
Range Control	2 TTL lines on rear panel “Remote control” DB9 or USB Control on front panel
Linearity error	< 1.5%

BCM Output (Rear panel SMA):

Nominal range	-1V … +1V proportional to full scale current (into 50 Ω Load) -2V … +2V (into High impedance)
Bandwidth	~ 350 kHz (-3dB)
Noise	+/- 0.5mV
Output impedance	50Ω
Readout Impedance	50Ω
Maximum Current Source/Sink	+/-20mA
Response Time	< 1µs (10%-90%)

Output View (Front panel BNC):

Output nominal	-4V … +4V proportional to full scale current
Output over range	-4.1V … +4.1V
Bandwidth	~350kHz (-3dB)
Noise	+/- 2mV
Output impedance	100Ω
Readout impedance	High impedance
Max. Current Source/Sink	+/-10mA
Response Time	< 1µs (10%-90%)

Remote control “DB9,3” (Rear panel DB9):

Nominal range	-4V … +4V proportional to full scale current
Output over range	-4.1V … +4.1V
Bandwidth	100Hz (-3dB)
Noise	+/- 2mV
Output impedance	100Ω
Readout impedance	High impedance
Max. Current Source/Sink	+/-10mA

[2] Attenuators or low-noise amplifier may be inserted in BCM input to lower or increase the full-scale ranges.

Remote control "DB9,8" (Rear panel DB9):

Output nominal	-4V … +4V proportional to full scale current
Output over range	-4.1V … +4.1V
Bandwidth	10kHz (-3dB)
Noise	+/- 2mV
Output impedance	100Ω
Readout impedance	High impedance
Max. Current Source/Sink	+/-10mA

Trigger in (Rear panel SMA):

Signal:	Sinewave	Pulse
Amplitude range	-35dBm … 0dBm	20mVp-p … 200mVp-p
Amplitude Max	+4dBm	500mVp-p
Triggering Edge	Falling edge	Falling edge
Duty Cycle	-	50%
Input Impedance	50Ω	50Ω

BCM Input (Rear panel SMA):

Input range	-1V… +1V
Input impedance	50Ω

Timing View (Front panel BNC):

Nominal output range	~ 40mVp-p (into 50 Ω)
Readout impedance	50Ω
Risetime	~ 350ps (10%-90%)

Signal View (Front panel BNC):

Nominal range	-0.5V… +0.5V (into 50 Ω)
Output over range	-1.1V … +1.1V (into 50 Ω)
Bandwidth	~ 270MHz (-3dB)
Readout impedance	50Ω

Remote control "DB9,6" (Rear panel DB9):

Logical input TTL compatible

Remote control "DB9,2" (Rear panel DB9):

Logical input TTL compatible

USB (Rear panel):

Type B connector, compatible to USB 2.0 standard

BCM-CW-E specifications

Rear module connector	DIN 41612-M / 24+8 male, with 1.0/2.4 coaxial inserts
Power consomption	+15 V, 220 mA (Max) / -15 V, 220 mA (Max)
Card size	3U x 4F, Eurosize 100 x 160 mm, 20 mm wide

BCM-RFC power supply and fuses

The mains voltage is factory set according to the label stuck on the front panel.
Please remove this label when you change the mains voltage selection.

Type	AKF-15D15, ±15V dual output
Manufacturer	MinMax, Tainan City 702, Taiwan
Output voltage	±15V, ±500 mA
Mains voltage	jumper selected: 110, 220 Vac, 50-60 Hz tested at 90 Vac/50 Hz for 100 Vac Japanese mains voltage
Mains voltage selector	located under the power supply block
Card size wide	3U x 10F, i.e. Eurosize 100 x 160 mm, 50mm
Back-panel connector	The Power supply mains are wired to a IEC connector via an EMI/RFI filter and fuse.

Connectors and pin allocation

		DIN41612M BCM-CW-E module rear connector	DB9 female connector on BCM-RFC rear panel	RF-Chassis Rear SMA connectors	BCM-CW-E Front panel BNC connectors
INPUT SIGNALS					
BCM-CW-E Input 50 Ω (to connect to CWCT)	BCM Input	B8[3]		SMA1	
INPUT CONTROLS					
TTL INPUT A (Gain Control)	DB9,6	C19	DB9,6		
TTL INPUT B (Gain Control)	DB9,2	C18	DB9,2		
OUTPUT SIGNALS					
BCM-CW-E Baseline output Full BW 50 Ω	BCM Output	B11[3]		SMA2	
BCM-CW-E Baseline output (100 Hz)	DB9,3	C16	DB9,3		
BCM-CW-E Baseline output (10 kHz)	DB9,8	C17	DB9,8		
BNC front-panel MONITORING					
CWCT signal view after Amplification 50 Ω	Signal View				BNC 1
BCM-CW-E Baseline output Full BW	Output View				BNC 2
Baseline Sampling Clock output	Timing View				BNC 3
EXTERNAL TRIGGER INPUT					
Trigger input 50 Ω	Trigger in	B22[3]		SMA3	
POWER SUPPLY					
+15 V	+15 V	A13 B13 C13			
-15 V	-15 V	A15 B15 C15			
Common (GND)	COM	A14 B14 C14	DB9,1 DB9,4 DB9,5 DB9,7 DB9,9		

[3] coaxial insert 1.0/2.3 type

RECOMMENDATIONS ABOUT CABLES AND INSTALLATION

CWCT and BCM-CW-E system performance are measured and guaranteed when a Bergoz Instrumentation-supplied interconnect cable BCM-C-xxx, BCM-RHC-xxx, BCM-C400-xxx or BCM-C600-xxx is used. It is double-shielded radiation tolerant coaxial cable to reject RFI. BCM-C-xxx and BCM-RHC-xxx are fitted at each end by two CMC common-mode chokes for EMI rejection:

- MnZn ferrite core for high-frequency >500 MHz rejection;
- Iron-based nanocrystalline core with soft B-H loop for low frequency rejection.

BCM-C400-xxx or BCM-C600-xxx are not equipped by CMCs.

Unnecessary intermediate bulkheads should be avoided. When for practical reasons bulkheads must be used, e.g., on patch-panels, it is preferable that the bulkhead body is isolated from ground. On either side of the patch-panel a set of two CMC common-mode chokes should be installed on the cable. This is required to assure EMI rejection.

SMA connectors at both ends of a Bergoz Instrumentation-supplied cable feature different dielectric types depending on cable reference:

- Standard BCM-C/xx cable is fitted with PTFE (Teflon) dielectric SMA at both ends. PTFE radiation tolerance R.I.~2 (source H. Schönbacher CERN 98-01).
- Radiation-tolerant BCM-RHC/xx cable is fitted with PEEK (Victrex) dielectric SMA at both ends. PEEK radiation tolerance R.I.>7 (same source).

BCM-CW-E system, i.e., chassis and modules should as much as possible be kept away from high power RF equipment, klystrons, cavities.

If the user procures the CWCT interconnect cable from a source other than Bergoz Instrumentation, cable should be double shielded, connectors should be chosen carefully according to the cable specifications, connector dielectric should conform to the radiation environment, appropriate common-mode chokes should be installed at each end of every cable segment. A cable segment is any section of cable between two grounded connectors or bulkheads, for example through a grounded patch panel.

Cable and connectors manufacturer’s instructions should be followed meticulously. If the cable assembly is subcontracted, subcontractors should be informed of the extreme reliability expected from these cables. Transmission and reflections of each cable should be controlled before installation with a vector network analyzer, over a frequency band up to twice the operating frequency.

BCM-CW-E modules must be installed in a RF-shielded chassis BCM-RFC/xx as provided by Bergoz Instrumentation.

More information and latest manuals revisions can be found on our website

www.bergoz.com

If you have any questions, feel free to contact us by e-mail

info@bergoz.com