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Beam Charge Monitor
(Modular Electronics)
Integrate-Hold-Reset
User's Manual

Rev. 2.0

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SUMMARY Page

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. Products not manufactured by Bergoz Instrumentation are covered solely by the warranty of the original manufacturer. 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, neglect, accident or abnormal conditions 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 fax.

SERVICE PROCEDURE

Products requiring maintenance should be returned to Bergoz Instrumentation or its local distributor. Bergoz Instrumentation will repair or replace any product under warranty at no charge. The purchaser is only responsible for transportation charges.

For products in need of repair after the warranty period, the customer must provide a purchase order before repairs can be initiated. Bergoz Instrumentation can issue fixed price quotations for most repairs. However, depending on the damage, it may be necessary to return the equipment to Bergoz Instrumentation to assess the cost of repair.

RETURN PROCEDURE

All products returned for repair should include a detailed description of the defect or failure, name and fax number of the user. Contact Bergoz Instrumentation or your local distributor to determine where to return the product. Returns must be notified by fax prior to shipment.

Return should be made prepaid. Bergoz Instrumentation will not accept freight-collect shipment. Shipment should be made via Federal Express or United Parcel Service. Within Europe, the transportation service offered by the Post Offices "EMS" (Chronopost, Datapost, etc.) can be used. The delivery charges or customs clearance charges arising from the use of other carriers will be charged to the customer.

YOU JUST RECEIVED YOUR BCM....

Check that the voltage corresponds to your mains voltage. The power supply voltage is indicated on a plastic label located on the power supply module front panel.

If it does not correspond, go to Annex III: Delta Elektronika U-Series linear power supply data sheet to adjust the power supply to your mains. Then change the fuse and front-panel and rear panel plastic labels accordingly.

QUICK CHECK

You can check immediately that your BCM is working. This is what you need:

- Beam Charge Monitor Integrate-Hold-Reset: At least one BCM-IHR-E electronics module and one BCM-RFC/xx chassis
- DB9 Remote control key
- Integrating Current Transformer (or Fast Current Transformer)
- 4-channel oscilloscope with 100 MHz bandwidth or better.
- Pulse generator capable of making the trigger pulse (≥30 ns, ≥2.4V, 1 kHz)

You will also need short (4-8 ns) BNC cables and SMA-BNC adapters.

Verify that this manual corresponds to your BCM version

The Modular Electronics "Beam Charge Monitor, Integrate-Hold-Reset" (BCM-IHR) version is the object of this manual. It consist of at least one BCM-IHR-E electronics module and one BCM-RFC/xx 3U x 19" chassis.

This User's manual does not describe older BCM versions, housed in an ABS plastic enclosure. Those are described in other manuals:

- Beam Charge Monitor, Integrate-Hold-Reset User's Manual, version 1.x.x.
- Beam Charge Monitor, Continuous Averaging User's Manual, version 1.x.x

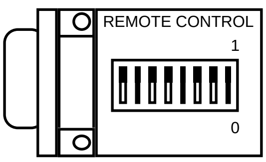
These older versions consist of three modules in an ABS plastic enclosure, marked:

- "C.A.C." for Charge Amplifier and Calibration
- "BSP-CA" or "BSP-IHR" for Bunch Signal Processor
- a Delta or Schroff power supply module

These older configurations may include a Wideband Amplifier.

DB9 Remote control key

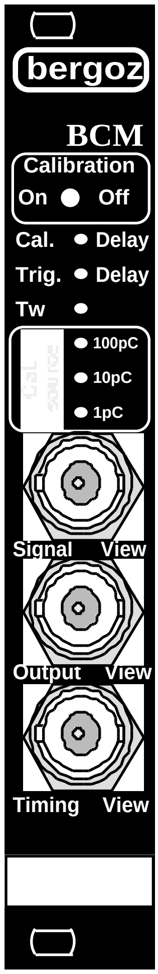
A "DB9 Remote control key" is supplied with the Beam Charge Monitor. It is a small auxiliary printed board attached to a DB9 connector. An 8-bit switch is mounted on the printed board.
It must be plugged to the DB9 Remote control connector at the rear of the BCM to allow range switching and calibration range switching during tests.



Switches A0...A6 are active. They correspond to Bits 0...6 of the remote control (See “Remote Range and Calibration Switching”, this manual). Position 1 corresponds to bit HIGH. Position 0 corresponds to bit LOW. Switch A7 is not connected. Bit 7 controls “Calibration Enable”. This function can be enabled during tests by the BCM front panel switch.

DB9 Remote control key

Front panel
Module BCM-IHR-E



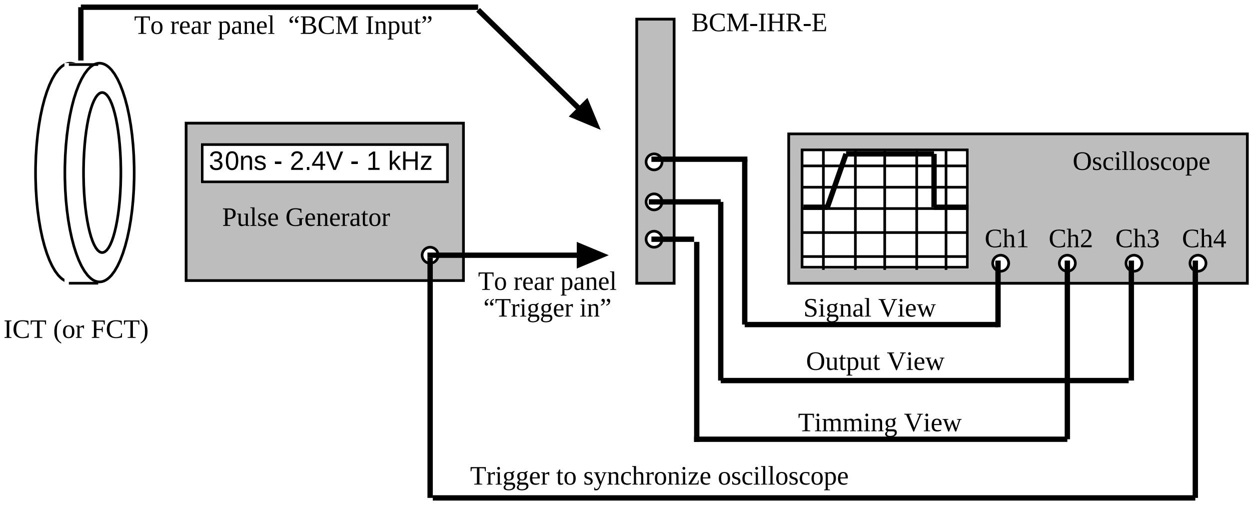
Font panel

WARNING: Jumpers configuration & Potentiometers settings

Your BCM is in the "Ex-factory" configuration. Jumper and timing adjustments (potentiometers) have been configured according to your order.

Do not change those settings until you are familiar with the Beam Charge Monitor.

Setup



Connect as shown on picture:

ICT (or FCT) to "BCM Input" on rear panel.
Insert "Remote Control" key in rear panel DB9 connector.
Note: All Remote Control switches should be OFF.

Make sure your AC mains voltage corresponds to BCM mains voltage.
Connect BCM chassis AC input to the mains.

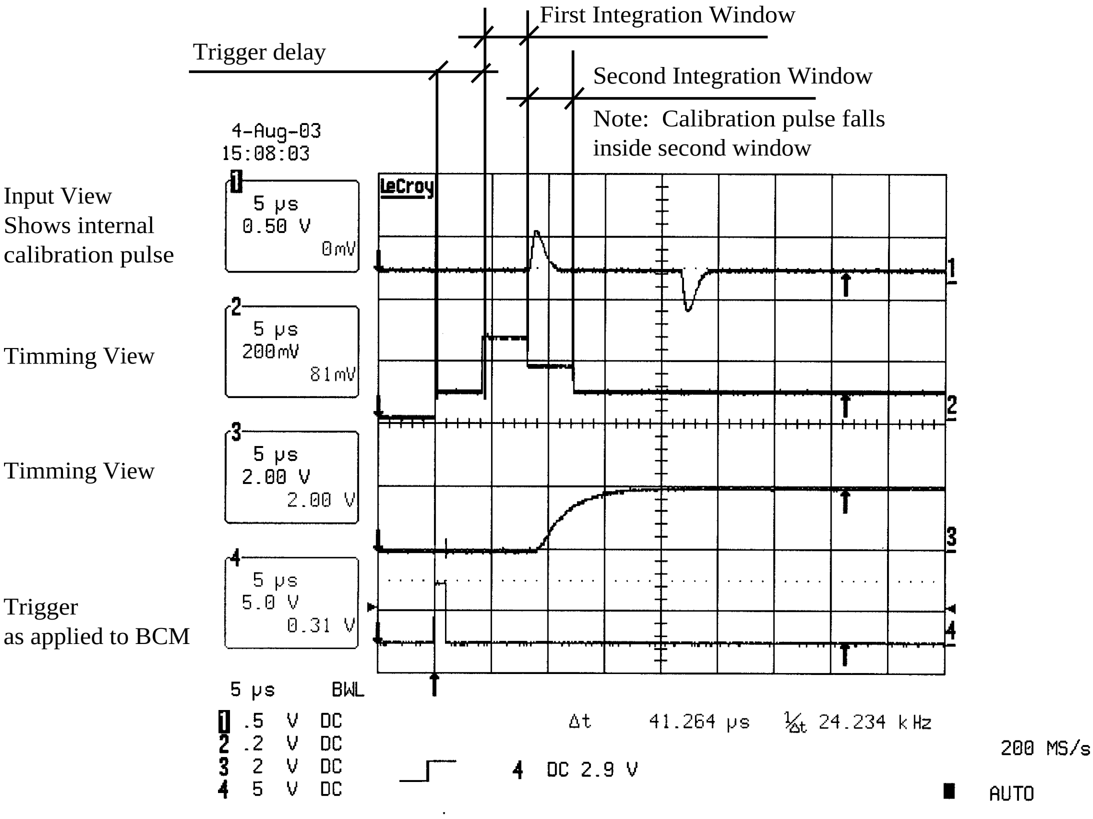
Apply a 50-ohm pulse (>30ns, >2.4V, 1 kHz) to "Trigger in" on rear panel.
Apply same pulse to oscilloscope input channel, to trigger oscilloscope.
Set this oscilloscope input channel to high-impedance.

Turn front-panel "Calibration" switch ON.
Look at the signals with the oscilloscope, all channel inputs must be high-impedance.
All View points are on the front panel BNCs.

Waveforms

Reminder: The front panel "Calibration" toggle switch should be ON.

The signals should look like this:

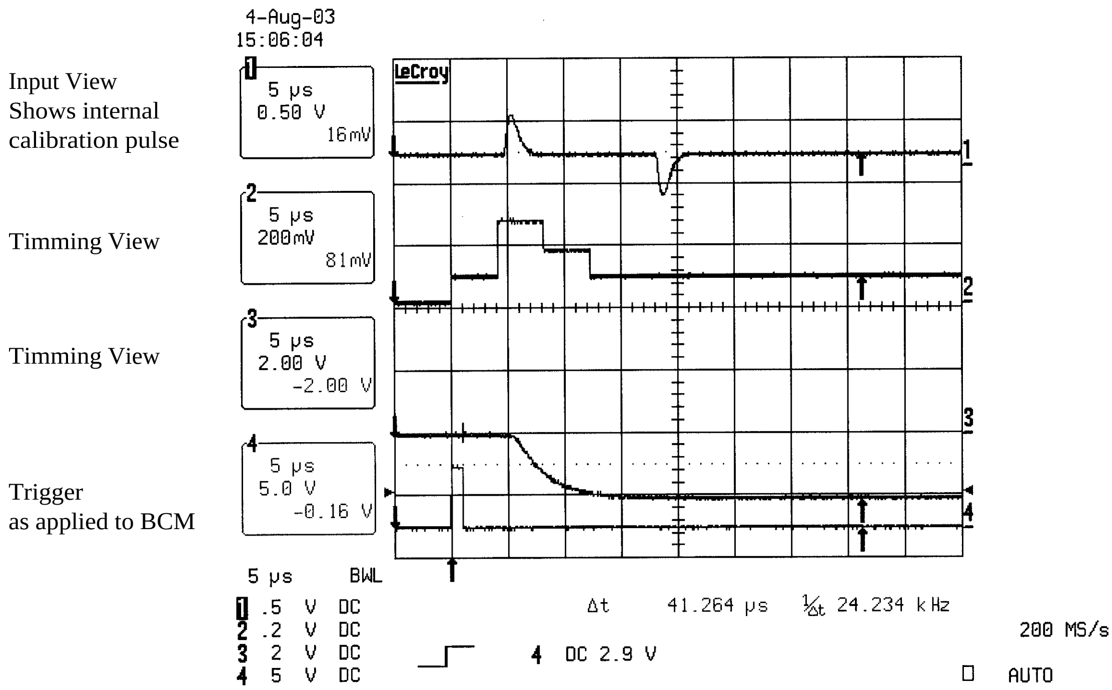


Waveforms (Cont'd)

Exercising the module:

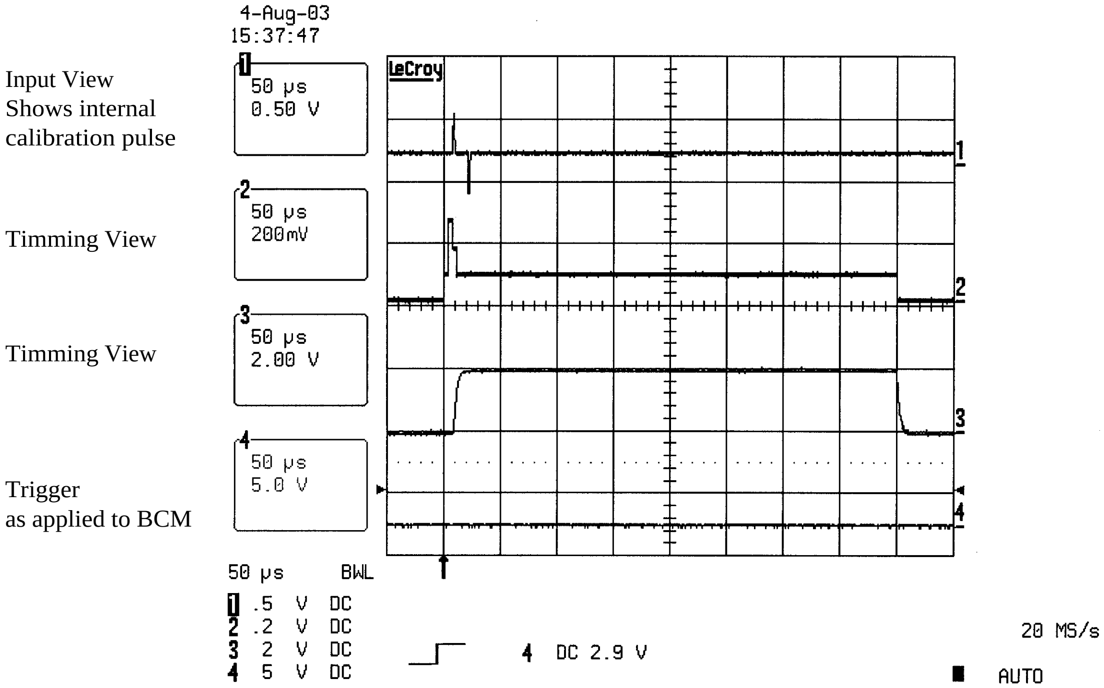
Turn the BCM-IHR-E "Cal. Delay" 20-turn front panel potentiometer: It changes the delay between the trigger and the calibrated pulse. The calibrated pulse can be moved from the second window (the "adding" window) into the first window (the "subtracting" window).

When the calibrated pulse fits entirely into the first (subtracting) window, it should look like this:



Waveforms (cont'd)

Adjust your oscilloscope time base to a slower sweep: 50 µs / div. It should look like this:



The complete BCM-IHR cycle is visible on the oscilloscope including the BCM output reset to zero.

Explanation of the Timing View:

The Timing View is a signal to help the user:
a) adjust the beam pulse inside the integration window
b) adjust the timing of his readout ADC or sampling voltmeter with the BCM output signal.
The voltage levels of the Timing View are arbitrary.

- Signal lowest level, at the beginning of the trace: Beam Charge Monitor is ready to receive a Trigger.
- First step up: BCM has received Trigger, the Trigger delay is elapsing (4µs in ex-factory conditions)
- Second step up: The trigger delay has elapsed, the first integration window starts. In ex-factory conditions it lasts 4 µs. During this window, the signal is summed in the output with a *negative* sign. It is the "Subtracting" window.
- Next step is down: The first or "Subtracting" window has closed. The second window starts. In ex-factory conditions, this window has equal duration to the first window duration. During this window, the input signal is summed with a *positive* sign. It is the "Adding" window.
- Next step down: The second window has closed. The Hold time starts. During the hold time, the BCM output value is held. In ex-factory conditions the Hold time terminates 400 µs after the trigger.
- Next step down: The Hold time is finished. The BCM output is reset to zero. The Beam Charge Monitor is ready to receive another Trigger.

Your BCM-IHR does not behave as described

If your BCM-IHR-E is in ex-factory conditions, it should behave as described. If it does not, check the switch settings on the "Remote Control" key: All switches should be in the OFF position.

If your BCM-IHR-E is not anymore in ex-factory conditions, the front panel potentiometers settings may have been changed.
To re-establish the ex-factory settings:

- Turn potentiometer "Trig. Delay" located on BCM front-panel until the Trigger delay equals 4 µs.

- Turn potentiometer "Tw" located on BCM front-panel until the integration window width equals 4 µs.

- Turn potentiometer "Cal. Delay" on BCM front panel until the calibrated pulse fits into an integrating window.

If those adjustments cannot be effected, the instrument's time constants have probably been changed after delivery of the instrument. Either restore original values according to the schematics or contact manufacturer for recalibration.

Testing all other BCM functions

You can test all gain ranges, inverse the signal polarity, change the value of the calibration pulse and its polarity:

Toggle the switches of the DB9 Remote control key. Place the switches A0 to A6 according to "Remote Range and Calibration Switching". Switch position 1 corresponds to bit HIGH. Position 0 to bit LOW.

Note that Switch A7 is not connected. The "Calibration Enable" command can be activated with the BCM front panel switch.

GENERAL DESCRIPTION

BCM electronic modules (-E) are made in two versions:
- Integrate-Hold-Reset "IHR" version for pulse repetition rates from 1 kHz down to single pulses
- Continuous Averaging "CA" version for pulse repetition rates from 10 MHz down to 5 kHz.

This manual describes the Integrate-Hold-Reset "IHR" version.

Purpose

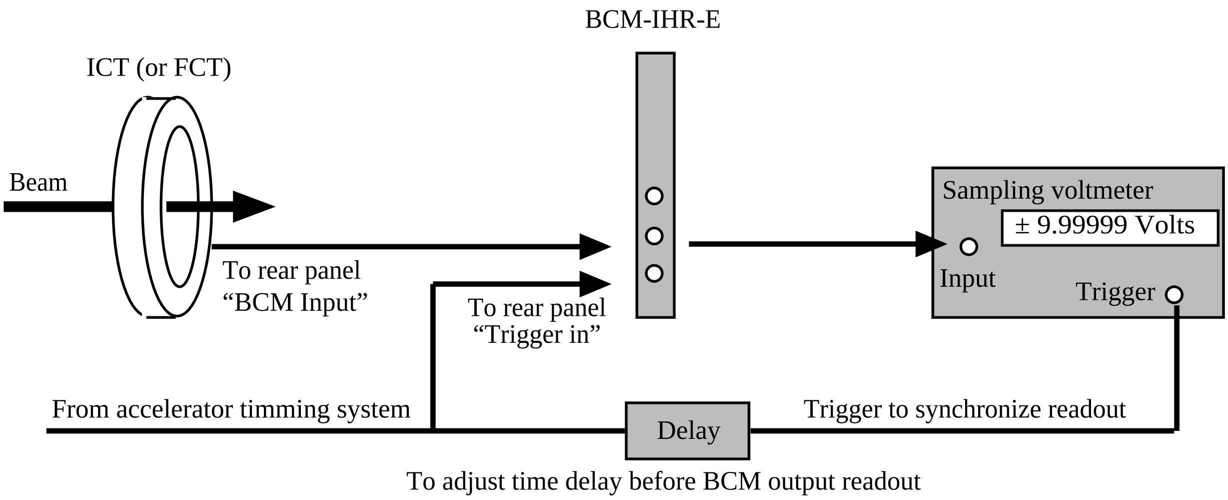
The Integrate-Hold-Reset version measures the charge in a single selected pulse or macro-pulse.
The Continuous Averaging version measures the average charge over time, of repetitive selected pulses or macro-pulses. The Continuous Averaging version, therefore, measures current.

System components

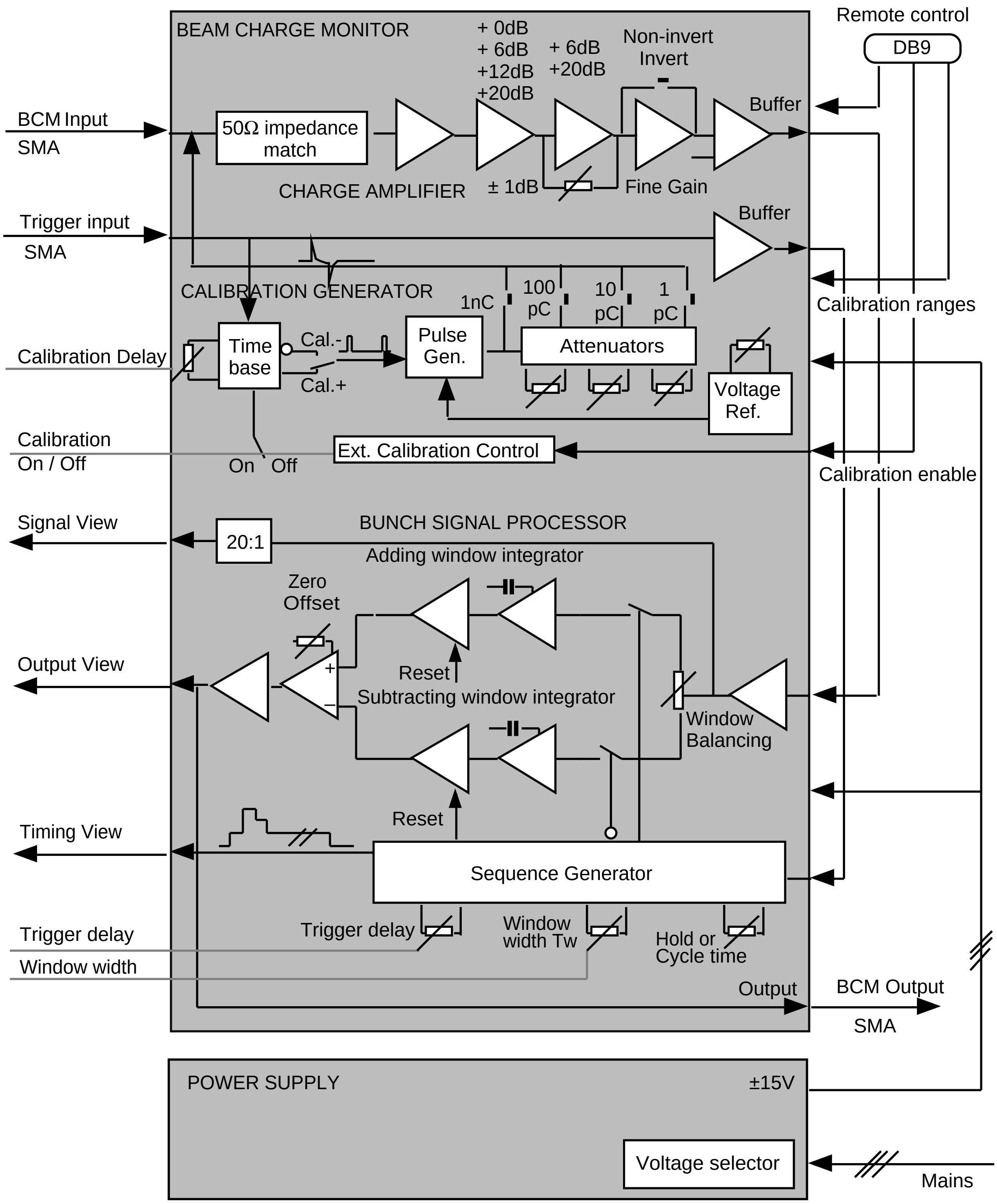
In a beam line or particle accelerator application, the BCM detects the beam signal with a non-destructive sensor:
- Integrating Current Transformer (ICT), or
- Fast Current Transformer (FCT)

Electronics are housed in a 3U-high, 19"-wide RF-shielded chassis, which can hold:
- BCM-IHR-E or BCM-CA-E modules, in any mix.
- Power Supply.

The BCM output is a voltage up to ±7V, proportional to the beam charge.
In the Integrate-Hold-Reset "IHR" version, the voltage level it held up to 400µs, then reset.
In the Continuous Averaging "CA" version, the voltage level averages the successive input pulses with a long time constant.



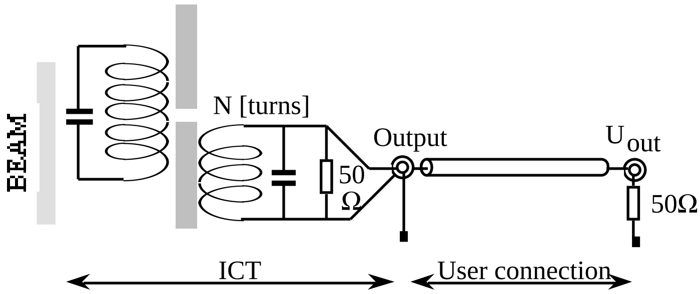
ARCHITECTURE



OPERATING PRINCIPLE

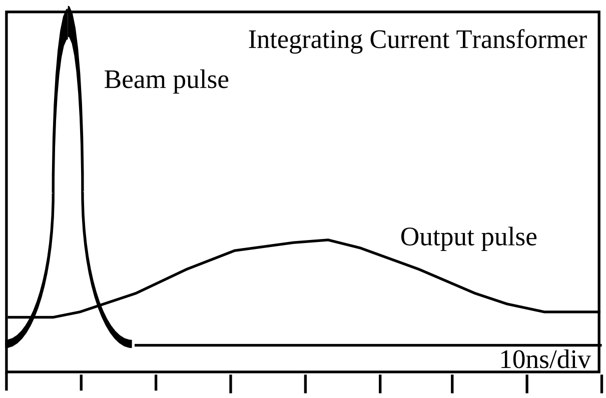
Integrating Current Transformer

The Integrating Current Transformer (ICT) is a passive transformer designed to measure the charge in a very fast pulse with high accuracy. It is capable of integrating a pulse with risetime in the order of picoseconds with no significant loss.



The ICT is a capacitively shorted transformer coupled to a fast readout transformer in a common magnetic circuit[1].

The ICT delivers a pulse with ca. 20 ns rise time irrespective of the beam pulse rise time. The ICT output pulse charge is in exact proportion to the beam pulse charge.



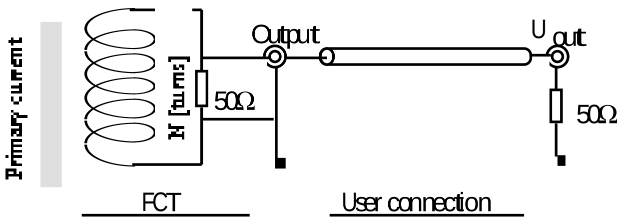
The sensitivity of the Integrating Current Transformer is also called the transfer impedance. It depends on the ICT model. It is expressed in terms of the integral of the output pulse voltage as a function of the input pulse charge, therefore in V.s/C, or Ω.

ICT Model	Sensitivity in 50-ohm termination	Beam Charge to BCM input Charge Ratio
ICT-XXX-XXX-50:1	0.50 V.s/C	100:1
ICT-XXX-XXX-20:1	1.25 V.s/C	50:1
ICT-XXX-XXX-10:1	2.50 V.s/C	20:1
ICT-XXX-XXX-05:1	5.00 V.s/C	10:1

1 Measuring Bunch Intensity, Beam Loss and Bunch Lifetime in LEP, K.B.Unser, Proceedings of the 2nd European Particle Accelerator Conference, 1990, Vol.1, p.786

Fast Current Transformer

The Fast Current Transformer (FCT) is a passive AC transformer with <1ns rise time and droop lower than 5 %/µs. Fast Current Transformers are made with 20:1, 10:1 and 5:1 turns ratios into a 50Ω load. The FCT is specifically designed to observe bunched beams in particle accelerators.



FCT can be used with BCM under the condition that beam bunch risetime > 30 ns.
For bunches with risetime < 30ns, Integrating Current Transformer must be used.

The sensitivity of the Fast Current Transformer is also called the transfer impedance. It depends on the FCT model. It is expressed in terms of output pulse voltage as a function of the input pulse current, therefore in V/A, or Ω.

FCT Model	Sensitivity in 50-ohm termination	Beam Charge to BCM input Charge Ratio
FCT-XXX-50:1	0.50 V/A	100:1
FCT-XXX-20:1	1.25 V/A	50:1
FCT-XXX-10:1	2.50 V/A	20:1
FCT-XXX-05:1	5.00 V/A	10:1

Cable connection

When a Fast Current Transformer is used as beam sensor, the choice of the cable may be critical. The cable must be capable of carrying the frequency spectrum of the signal with acceptable integration and differentiation. With fast beam pulses, the FCT limits the risetime somewhere below 1ns.

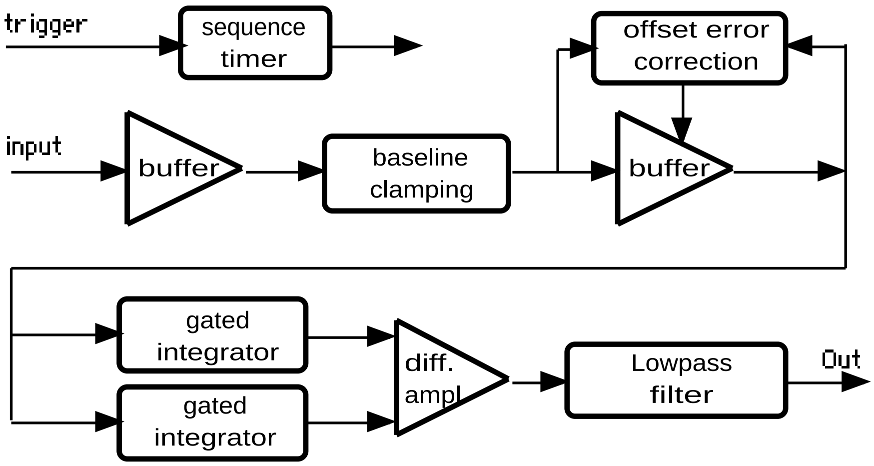
When using an Integrating Current Transformer as beam sensor, the choice of the cable is much less critical, because the ICT output pulse has a risetime of 20 ns (unless it is a special model with short output pulse). We made tests with long, low-quality cable. Those tests are reported in Annex I, Test of cable length incidence on BCM linearity.

Signal processing

The signal is amplified by the Charge Amplifier. The amplified signal is entered in the Bunch Signal Processor, which integrates this signal every time the BCM is triggered by an external trigger. This gives the possibility to measure selected pulses only, not necessarily at a fixed repetition rate.

The signal processing is initiated by the external positive-going trigger pulse. A sequence timer creates three successive time windows: a trigger delay, a subtracting window and an adding window. The pulse to be integrated must fall either in the adding window, or the subtracting window. Pulses falling in the first window or trigger delay are not integrated.

At the start of the first integration window, the baseline is clamped to set the zero reference. The two integration windows are used to integrate the input signal in two independent integrators.



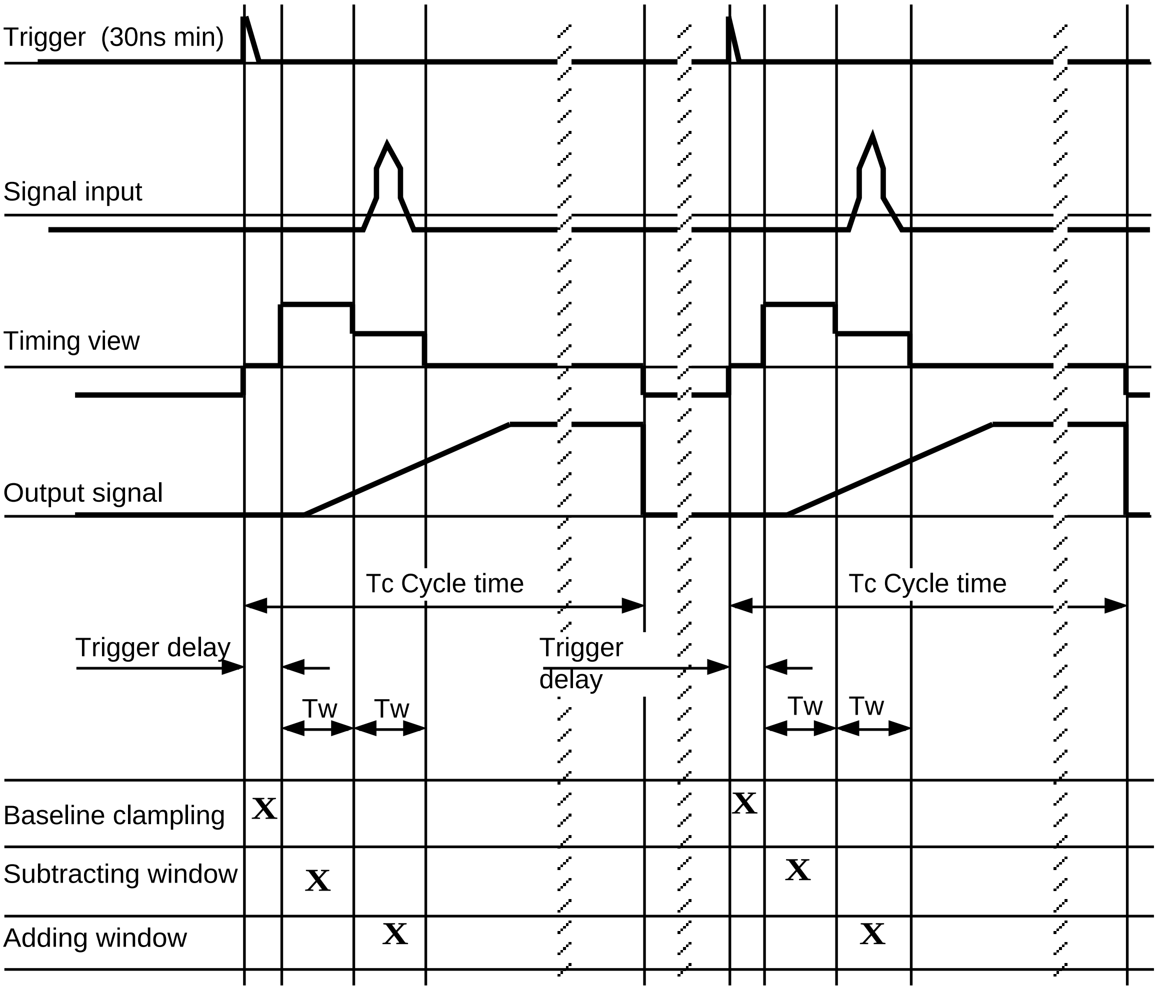
One integrator integrates the pulse signal. The other integrates the input noise and baseline offset.

The pulse charge is obtained by summing the two integrators: the first with negative sign, the second with positive sign.

This particular combination of sampling window integrators gives a high degree of noise suppression. All signals which do not correlate in frequency and in time with the window timing are rejected. This is true for the amplifier noise and also for the general background.

The balance of integrators gains is user-adjustable with the Window Balancing potentiometer.

Timing of the BCM-IHR



The Trigger delay is adjustable with front-panel potentiometer "Trig. Delay".

The two integration windows are of equal width "Tw". Tw is adjustable with front-panel potentiometer "Tw".

The Hold time or Cycle duration Tc can be adjusted by potentiometer "Cycle (Hold) Time". It is located on the BCM board. The cycle duration Tc must not be made shorter than the sum of the trigger delay and the two integration windows. For Cycle (Hold) time longer than can be adjusted with the potentiometer, pls. consult factory.

To locate on-board potentiometers, pls. refer to chapter "Settings", in this manual.

Beam Charge Monitor Output

The output is a DC level up to ±7V, proportional to the pulse charge. The output voltage is the difference between the value of the Subtracting Integrator and the Adding Integrator. The output may have an offset. This output zero offset is user adjustable with on-board "Output Zero Offset" potentiometer. To eliminate this offset and make precision measurement, see chapter "Making precise measurements with the BCM", in this manual.

The output is available on the SMA connector at the rear of the Beam Charge Monitor. A front-panel BNC is available for oscilloscope viewing: "Output View".
Warning: Loading the front-panel "Output View" may change the rear panel "BCM Output".

In the "IHR" Integrate-Hold-Reset version, the output is the value of the last selected pulse only. The signal settles in < 20 µs after the end of the second window; it is held at that level until the end of the cycle, then it is reset to zero. The Cycle time Tc or "Hold time" can be adjusted with on-board potentiometer "Cycle (Hold) Time".
To locate on-board potentiometers, pls. refer to chapter "Settings", in this manual.

On-line calibration

On-line calibration is possible at any time when there is no beam. Even when the no-beam time is short, on-line calibration may still be possible. BCM is equipped with a precise Calibration Generator. The Calibration generator is enabled when the front-panel switch "Calibration" is turned ON. The Calibration Generator can also be enabled by applying a high level to the "Calibration" pin on the BD9 connector. When the Calibration Generator is enabled, it sends two calibrated pulses, one positive, the other negative, a short time after it receives a trigger. The delay between the trigger and the first calibration pulse can be adjusted with the front-panel potentiometer "Cal. Delay". The calibrated pulse is applied to the BCM input charge amplifier. For correct calibration, the beam current transformer and its cable must be connected to the BCM input. The pulse charge splits in two parts: One part is lost in the cable and the current transformer. The remaining charge is amplified by the Charge Amplifier. "Cal. Delay" must be adjusted to make the calibrated pulse fall within either of the BCM integration windows.

The purpose of the pulse charge generator is not to provide accurate calibration. The calibration pulse generator provides pulses calibrated to ca. ±2%.

The "Calibration Enable" command, the calibration charge value, from 1 pC, 10 pC, 100 pC up to 1 nC and the calibration pulse polarity are selected by TTL external command line applied to the DB9 connector at the rear of the BCM.

Beware, this is charge as applied to the input of the Charge Amplifier. It is not beam pulse charge equivalent ! To obtain beam charge equivalents, use the table hereafter:

Calibration pulse in pC		1	10	100	1'000
Equivalent beam pulse using the 50Ω input, in pC					
With sensor:					
ICT-XXX-XXX-50:1	Exactly	100	1'000	10'000	100'000
ICT-XXX-XXX-20:1	Exactly	40	400	4'000	40'000
ICT-XXX-XXX-10:1	Exactly	20	200	2'000	20'000
ICT-XXX-XXX-05:1	Exactly	10	100	1'000	10'000

SENSITIVITY OF THE BCM-IHR

Full scales

Gain	Bits (Gain setting) 2–1–0	Full scale with ICT-XXX-070- -50:1	Full scale with ICT-XXX-070- -20:1	Full scale with ICT-XXX-070- -10:1	Full scale with ICT-XXX-070- -05:1
6 dB	H-H-H	400 nC	160 nC	80 nC	40 nC
12 dB	H-H-L	200 nC	80 nC	40 nC	20 nC
18 dB	H-L-H	100 nC	40 nC	20 nC	10 nC
20 dB	L-H-H	80 nC	32 nC	16 nC	8 nC
26 dB	L-H-L or H-L-L	40 nC	16 nC	8 nC	4 nC
32 dB	L-L-H	20 nC	8 nC	4 nC	2 nC
40 dB	L-L-L	8 nC	3.2 nC	1.6 nC	0.8 nC
Bits:	L=low, H=high				

Most sensitive configuration

The most sensitive configuration is obtained when using the most sensitive beam current transformer.
With a 5:1 turns ratio Integrating Current Transformer, and BCM set to maximum gain (+20 dB on first stage and +20 dB on second stage), then:

- Full scale is ±800 pC for ±8V output
- Sensitivity is ca. 10 mV per pC of beam charge
- Noise is < 1 mVrms, i.e < 1 pC beam charge
- Dynamic range is > 800.

Least sensitive configuration

The least sensitive configuration (without external signal attenuators) is limited by the saturation of the circuits.
With a 50:1 turns ratio Integrating Current Transformer, and the BCM set to minimum gain (+0 dB on first stage and +6 dB on second stage), then

- Full scale is ±400 nC for ± 8 Volts output
- Sensitivity is ca. 20 mV per nC of beam charge
- Noise is < 0.2 mV rms, i.e. 10 pC beam charge
- Dynamic range is ≈ 40000.

REMOTE RANGE and CALIBRATION SWITCHING

All BCM functions can be controlled by 8 bits. Apply TTL levels to these 8 bits via the rear-panel DB9 connector. An 8-bit DIP switch, attached to a DB9 male connector, is provided for user convenience, to simulate the presence of the control system. The BCM gain level, signal polarity, Calibration pulse charge and Calibration pulse polarity can be controlled.

Function				Bit#7	Bit#6	Bit#5	Bit#4	Bit#3	Bit#2	BIt#1	Bit#0
DB9 connector pin# (ground on pin#9)				5	1	6	2	7	3	8	4
Gain	Total	2nd stage	1st stage								
	+6dB	**+6dB**	**+0dB**						**H**	**H**	**H**
	+12dB	+6dB	+6dB						H	H	L
	+18dB	+6dB	+12dB						H	L	H
	+20dB	+20dB	+0dB						L	H	H
	+26dB	+20dB	+6dB						L	H	L
	+26dB	+6dB	+20dB						H	L	L
	+32dB	+20dB	+12dB						L	L	H
	+40dB	+20dB	+20dB						L	L	L
Output signal	Polarity		**Non invert**					**H**			
			Invert					L			
Calibration	Polarity		**Positive**				**H**				
			Negative				L				
	Charge selection		**1 nC**		**H**	**H**					
			100 pC		H	L					
			10 pC		L	H					
			1 pC		L	L					
	Enable/Disable		Enable*	H							
			Disable	**L**							
*Calibration Enable and "Calibration" front-panel switch ON are OR'ed. Therefore, BCM will be in calibration mode whenever either Calibration Enable of "Calibration" switch is ON											
Bits: L=low, H=high											

Notes:
The default status, i.e. the status when no external control signal is applied, is printed in **BOLD.**

MAKING PRECISE MEASUREMENTS WITH THE BCM

It is recommended to use a sampling voltmeter with programmable statistics capabilities to read the BCM output signal. The Hewlett-Packard sampling voltmeter HP 3458A is suitable for this application. It exceeds specifications in terms of sampling rate; therefore a suitable voltmeter, at a lower cost, can possibly be found.

The voltmeter reading must be started (triggered) when the BCM-IHR output pulse is stable, i.e. ≥20μs after the BCM-IHR trigger pulse.

For precise measurement, the voltmeter should sample the BCM-IHR output over 2-300μs and calculate the average.

For ultimate precision, the BCM-IHR should execute two measurement cycles:
First measurement is with beam pulse.
Second measurement is without beam pulse, to measure the zero offset.

The offset is deducted from the first measurement to obtain precise value.

This technique has two advantages:

A) The value of the zero, which depends on the balancing between the Adding and the Subtracting integrators, is compensated. Any drift of the zero (due to temperature or ageing) is eliminated.

B) The mains frequency noise can be eliminated.
For 60 Hz mains, the noise can be rejected very effectively by making the two measurements at a time interval equal to N x 16.66ms, where N is an integer 1, 2, 3....
For 50 Hz mains, the time interval must be equal to N x 20 ms.

SETTINGS

Front-panel potentiometers

Window width "Tw"
Determines the width "Tw" of the integration windows.
Allows an adjustment from <0.1 µs up to >7 µs.
Factory set as shown on the "Factory Settings" label affixed to the BCM module.

Trig. delay
Adjusts the delay from the trigger until the beginning of the first integration window.
Factory set as shown on the "Factory Settings" label affixed to the BCM module.

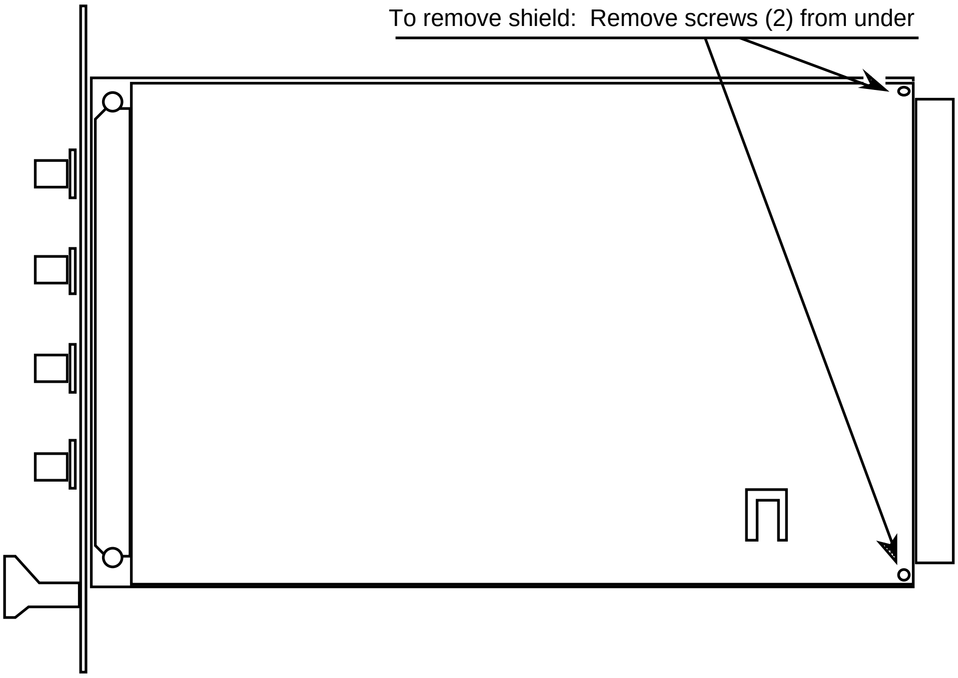
Cal. Source
Allows fine trimming of the calibration generator. *Please note: Ex-factory calibration will be lost when Cal. Source potentiometer settings are modified.*

On-board potentiometers

Access to on-board potentiometers is normally not required. Exceptional circumstances could make it necessary.

Please note: Ex-factory calibration will be lost when on-board potentiometer settings are modified.
To access on-board potentiometers, pull the BCM out of the chassis. BCM module can be removed and inserted "live", while the power is ON.

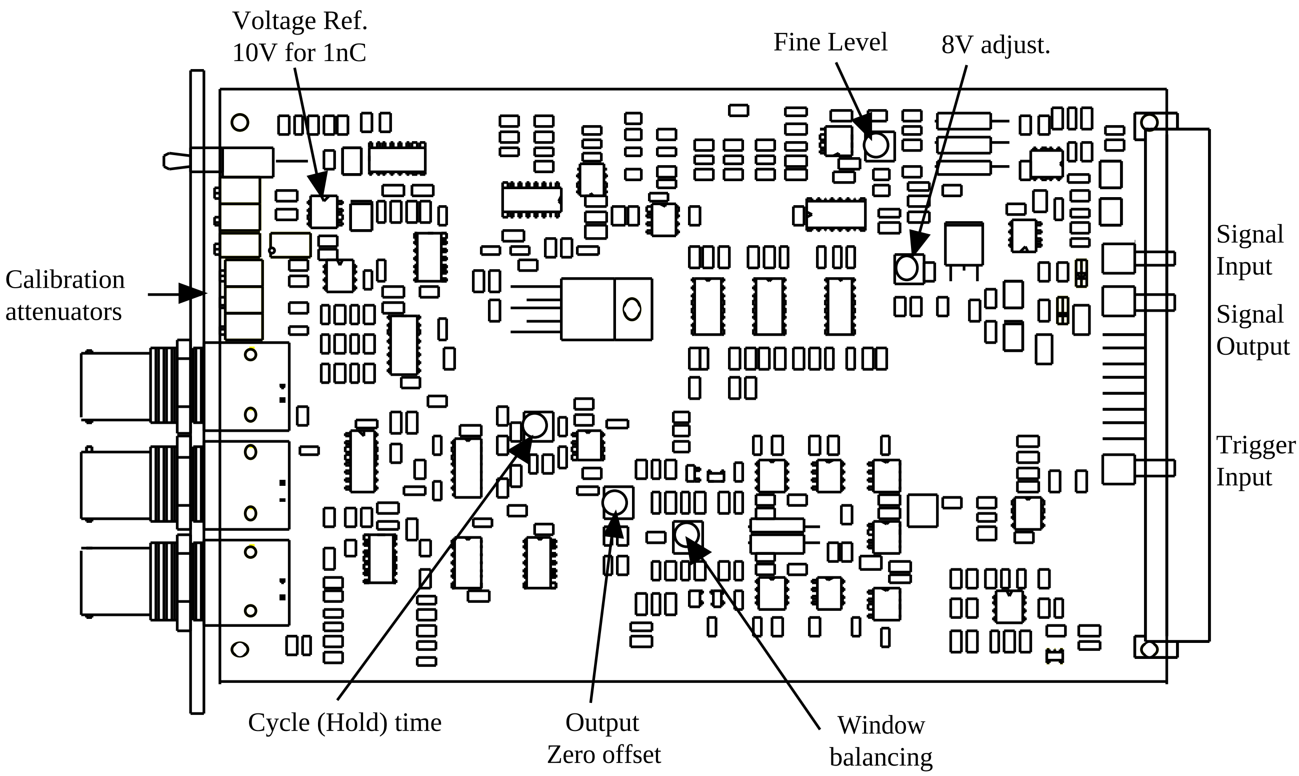
Remove the shield:



To adjust the on-board potentiometers, a card extender is necessary, such as Bergoz Instrumentation's BCM-XTD.

SETTINGS (Cont'd)

On-board potentiometers



Fine Level
Continuous gain adjustment: ±1 dB
Factory adjusted for 2.000 V BCM output corresponding to 1 nC in the 50Ω input, at lowest gain: 0 dB in first stage and 6 dB in second stage.

Window Balancing
Balances the respective gains of the Adding and Subtracting Integrators.
Factory set as shown on the "Factory Settings" label affixed to the BCM module.

Cycle (Hold) time
Determines the cycle duration "Tc". Tc must be greater than the or Hold timetrigger delay + 2 x Tw. Allows an adjustment from <20µs up to >600µs.
Factory set as shown on the "Factory Settings" label affixed to the BCM module.

Output Zero Offset
Trims the input charge amplifier's zero offset.
Factory set to zero offset for 1 kHz trigger frequency.

Please note: Ex-factory calibration will be lost when on-board potentiometer settings are modified.

SPECIFICATIONS

Beam Charge Monitor

Input charge	4 nC max
Input rise time	< 1ns in 50Ω termination
Gain steps	7 steps from 37 dB to 71 dB
Gain, fine adjustment	± 1 dB
Output	bipolar, up to ± 10 V, for high-impedance readout Output load 10 mA max. Best linearity up to ±7V
Output settling time	< 30 µs after the trigger
Output signal hold time	up to 600 µs after the trigger (pot. adjustable)
Front-panel connectors (BNC)	Signal View, for oscilloscope viewing Output View (for oscilloscope) Timing View (for oscilloscope)
Rear module connector	DIN 41612-M / 24+8 male, with 1.0/2.4 coaxial inserts
Back-panel connectors (SMA)	BCM Input, 50-ohm coaxial cable from ICT (or FCT) BCM Output, for high-impedance readout Trigger Input, 50-ohm
Back-panel DB9 female:	8 TTL commands for Range control, Calibration Control and Calibration Enable
Front-panel switch	Calibration on/off
Front-panel potentiometers	Calibration delay (to fit the calibration pulse in the integrating window) Trigger delay (To adjust time from trigger to beam pulse) Window width "Tw" (To adjust integration window time)
Recessed front-panel potentiometers	Calibration Source (To fine-trim the calibration generator)
On-board potentiometers	Fine Level: gain adjust ±1dB Window Balancing Cycle (Hold) time Output Zero Offset
Calibration pulse absolute accuracy	±2%
Power consumption (module)	+15V, 110mA -15V, 85mA
Card size	3U x 4F, i.e. Eurosize 100 x 160 mm, 20mm wide
Chassis size	3U x 19"

SPECIFICATIONS (Cont'd)

Power supply and fuses

See Annex III: Delta Elektronika U-Series linear power supply data sheet
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	5U 15-15 modular plug-in ±15V linear power supply
Manufacturer	Delta Elektronika, 4300A Zierikzee, The Netherlands
Output voltage	±15V, 200 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	3U x 10F, i.e. Eurosize 100 x 160 mm, 50mm wide
Back-panel connector	The Power supply mains are wired to a IEC connector via an EMI/RFI filter and fuse.

CONNECTOR PINS ALLOCATION

DB9 male Remote Control connector

Mating connector: use any DB9 female connector. Locking with UNC4-40 screws.

Gain selection	
Bit 0	4
Bit 1	8
Bit 2	3
Signal polarity	7
Calibration polarity	2
Calibration charge selection	
Bit 0	6
Bit 1	1
Calibration Enable	5
Ground	9

ACCESSORIES

BCM Chassis BCM-RFC/XX

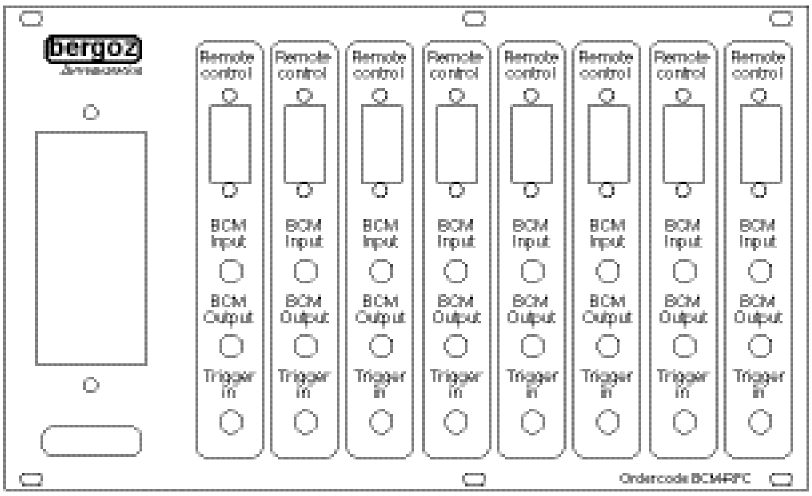
The BCM-RFC/XX chassis is built around a 19” Schroff rackable RF-shielded chassis.
Dimensions of the bin: 3U x 84F
Schroff reference: Europac Lab HF/RF #20845-283

The BCM-RFC/XX is available equipped for 1 up to 16 BPM stations. XX being the number of stations.

BCM-RFC/XX with less than 16 stations are partially equipped BCM-RFC/16. As a result, all BCM chassis are field-upgradable to the full 16-station chassis.

Chassis rear view

Shown here is a 1/2-width 19" rear panel. A chassis equipped with >8 BCM stations has two such half-width rear panels.



Chassis front

Unequipped stations are masked with RF-shielded blank panels.

Card Extender BCM-XTD

The card extender allows access to the BCM-E on-board potentiometers while it is connected to the chassis, thus to the readout and control system.

INSTALLATION ON THE VACUUM CHAMBER

The installation of an Integrating Current Transformer on the outside of a vacuum chamber requires some precautions.

a) The electrical conductivity of the vacuum chamber must be interrupted in the vicinity of the ICT, otherwise the wall current will flow thru the ICT aperture and cancel the beam current.

b) The wall current must be diverted around the ICT thru a low impedance path.

c) A fully-enclosing shield must be installed over the ICT and vacuum chamber electrical break to avoid RF interference emission.

d) The enclosing shield forms a cavity. Cavity ringing at any of the beam harmonics must be avoided.

e) The ICT must be protected from being heated beyond 80°C during vacuum chamber bake-out.

f) The higher harmonics of the beam should be prevented from escaping the vacuum chamber, because (1) they are not "seen" by the ICT therefore unnecessary, (2) they heat the ICT and any other conductive material inside the cavity, (3) they cause quater-wave mode ringing in the cavity.

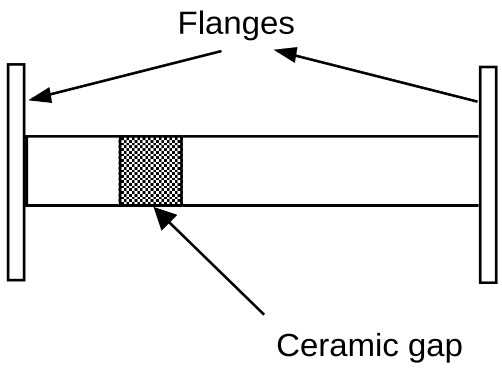
Note: The ICT does not need to be protected from external magnetic fields. When it is exposed to external magnetic fields it may saturate; this causes the droop to increase up to a factor of 2. It has no effect on the ICT linearity.

Break in the vacuum chamber electrical conductivity

If the vacuum chamber does not require bake-out and the vacuum requirements are moderate, a polymer gasket in-between two flanges is adequate to assure the desired galvanic isolation.

If the vacuum chamber needs bake-out, the most commonly use solution is to braze a section of ceramic on the vacuum chamber tube. This is called a "ceramic gap".

The ceramic gap may be installed on centre or off-centre of a short pipe section:



INSTALLATION ON THE VACUUM CHAMBER (Cont'd)

Vacuum chamber impedance

The ceramic gap causes a disruption of the impedance seen by the beam. This is particularly undesirable for leptons accelerators. The most usual corrective measure consists of metallizing the inside of the ceramic gap. Metallization has been used successfully on many electrons / positrons accelerators. Depending on the type of current transformer being installed (AC or DC), the resistance of the desirable metallization varies:

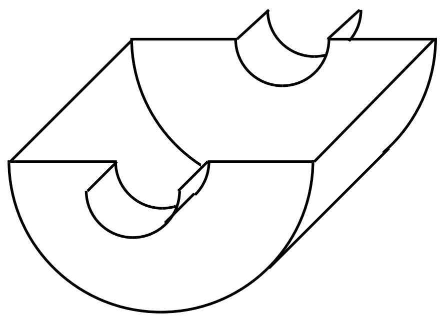
ICT current sensors tolerate a metallization with ca. 1Ω without problem, provided the wall current bypass is of very low impedance.

If a DC current transformer PCT or MPCT-S is installed over the same ceramic gap, these latter instruments are adversely affected by an ohmic value R < 100Ω because it shorts the PCT or MPCT sensor. The commonly used solution is to etch a narrow groove in the metal deposit to prevent DC conductivity of the gap metallization.

Wall current bypass and RF shield

The two functions of wall current by-pass and RF shield can be performed by a solid metal shield attached to the vacuum chamber on either side of the electrical break.

The easiest is to make a cylindrical enclosure which splits into two half shells:



The shells can be firmly attached to the vacuum chamber with water hose clamps.
Material can be aluminium, stainless steel or copper. Copper oxidation does not seem to be a problem.

Thermal protection of the ICT

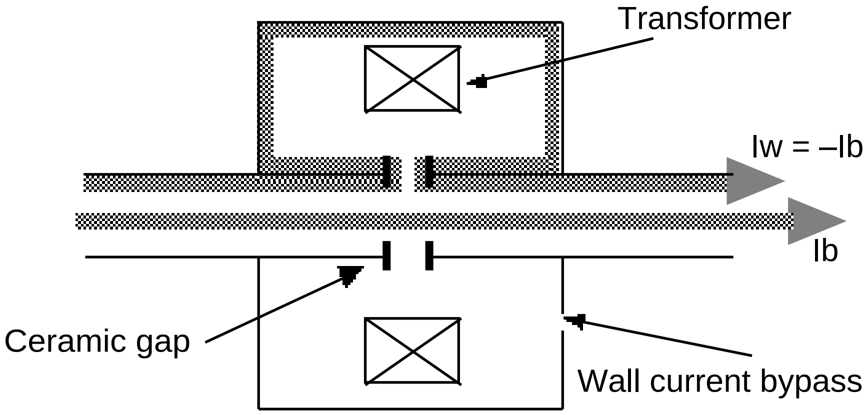
The ICT must not be heated beyond 80°C. If the vacuum chamber requires bake-out, a thermal shield must be installed between the vacuum chamber (or the heating sleeves) and the ICT.
The thermal shield can be a simple copper cylinder cooled by water circulating in a copper tube brazed onto the cylinder.
The water circuit must not pass thru the ICT aperture. It must enter and go out on the same side of the ICT, otherwise it makes a shorting loop around the ICT toroid.

MAXIMUM STORAGE AND OPERATING TEMPERATURE 80°C (176°F) AT ANY TIME. The alloy looses its characteristics when heated beyond this temperature.

Keeping high harmonics of the beam out of the cavity

The transformer, the gap capacitance and the wall current bypass form together a cavity.
It is important to prevent unnecessary harmonics from entering the cavity:

The beam current flows thru the vacuum chamber.
The wall current follows the conductive vacuum chamber walls.

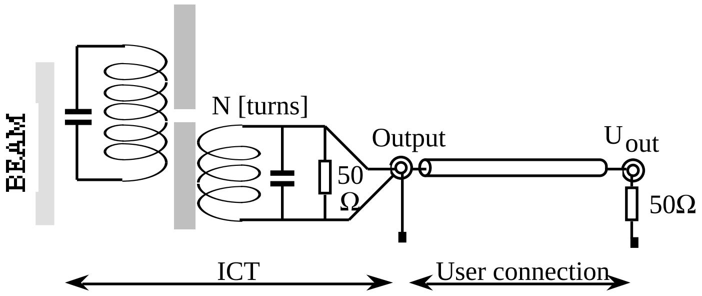


The transformer "sees" the wall current Iw. The higher frequencies of the wall current frequency spectrum will pass thru the capacitance of the ceramic gap, while the lower frequencies will enter the cavity and induce a flux in the transformer core.

Note that the full charge of the wall current pulse passes thru the cavity, irrespective of the value of the gap capacitance.

The value C of the gap capacitance determines the higher cutoff frequency of the wall current entering in the cavity. The -3dB point is obtained when the impedance of the cavity Z_{cavity} is equal to the impedance of the gap Z_{gap}.

The impedance of the wall current bypass itself can be ignored because it is much lower than the transformer's reflected impedance, therefore:



$Z_{cavity} = R / N^2$, where:

R is the load impedance of the transformer = 25Ω (50Ω termination || 50Ω internal load)
N is the transformer's turns ratio
Example, an ICT with 20:1 turns ratio (i.e. ICT-XXX-070-20:1), $Z_{cavity} = 0.0625\ \Omega$

Keeping high harmonics of the beam out of the cavity (Cont'd)

The gap impedance is determined by its capacitance:

$$Z_{gap} = 1 / \omega C, \text{ and } \omega = 2\pi f$$

For $Z_{cavity} = Z_{gap}$: $C = N^2 / 2\pi f R$

Example: ICT with 20:1 turns ratio, f_{-3dB} = 1GHz, R = 25Ω : C = 2.54 nF

Different laboratories use different techniques to obtain the required gap capacitance. A simple method consists in building a capacitor over the ceramic gap with layers of copper foil separated by layers of 100µm-thick kapton foil. To obtain the desired capacitance value, the overlapping area is obtained by:

$$S = C\,d / \varepsilon_r\,\varepsilon_o$$

Where:

C is the capacitance [F]

S is the area [m^2]

d is the dielectric thickness [m]

ε_r is the relative dielectric constant, 3.5 for Kapton polyimid

ε_o is the dielectric constant 8.86 x 10^{-12}

Example, for C = 2.54 nF and d = 100µm and ε_r = 3.5, S = 82 cm

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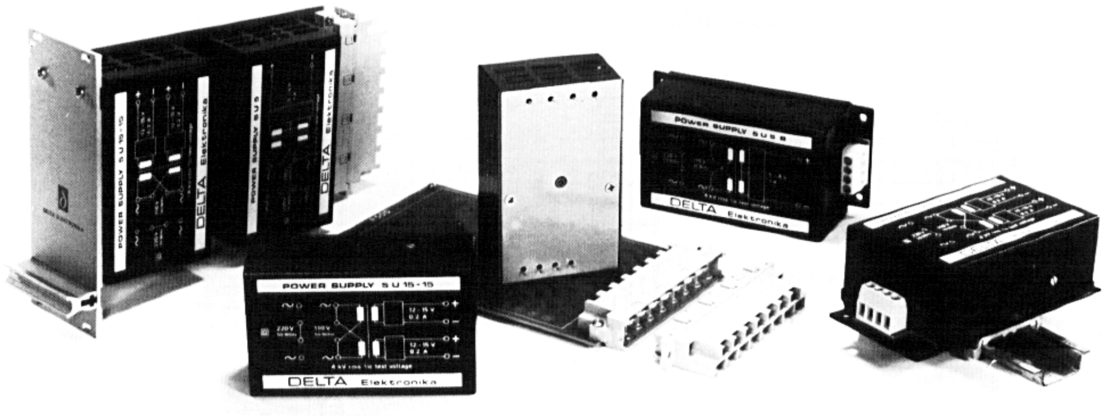


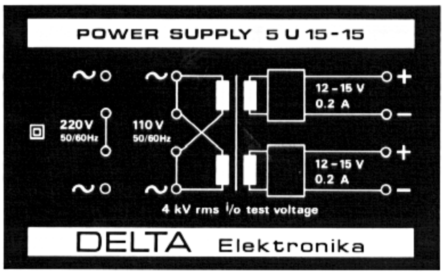
U - SERIES LINEAR MODULAR POWER SUPPLIES

with potted split bobbin transformer, providing very low leakage current and coupling capacitance.

5 U 5	**5 - 6 V**	**1 A**
5 U 15 - 15	**2 x 12 - 15 V**	**0.2 A**

Accessories: P500 Eurocard for 2 U-units
Front panel 10 TE for P500

5 U 5 B
5 U 15-15 B
Models with screw terminals for wall and rail mounting (including two clamps for 35 mm rail)



The **5 U 15 - 15** has two isolated, regulated outputs which are independently adjustable from 12 to 15 V (also unequal voltage).
It can be used in 4 different configurations:

1) Two isolated outputs, each		**12 - 15 V**	**0.2 A**
2) Outputs in parallel		**12 - 15 V**	**0.4 A**
3) Outputs in series		**24 - 30 V**	**0.2 A**
4) Outputs in series, dual	**+/-**	**12 - 15 V**	**0.2 A**

Input : 110 / 220 V AC 50/60 Hz
For 120 / 240 V AC 50/60 Hz **add -X** to model no. (**5U5-X** etc.)

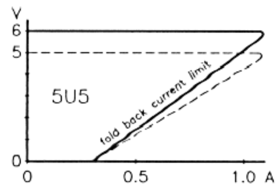
Transformer : Split bobbin, potted, according to VDE0551 and CEE15

Test voltage:
- Input / Output : 4000 Vrms (output / case shorted)
- Input / Case : 4000 Vrms (output / case shorted)
- Output / Case : 500 Vrms

Input to output
- Leakage current : Typical 5 micro-amps
- Coupling capacitance : Less than 60 pF
- Insulation resistance : 1000 MOhms
- Attenuation input spikes : Better than 100 dB

Safety : IEC 950 / EN 60950

Current limit:
Foldback characteristic



Regulation
- Load 0 - 100% : 5 mV
- Line ±10% : 5 mV (at 4 W output)

Ripple + noise : 0.5 mV rms, 2 mV p-p

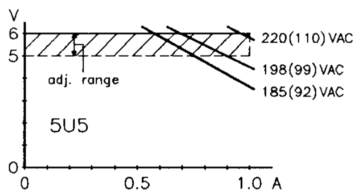
Temp. coeff., per °C : 0.01%

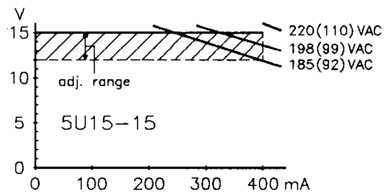
Output impedance
up to 100 kHz : 0.5 Ohm

Recovery time
10 - 100% load step : 25 μs

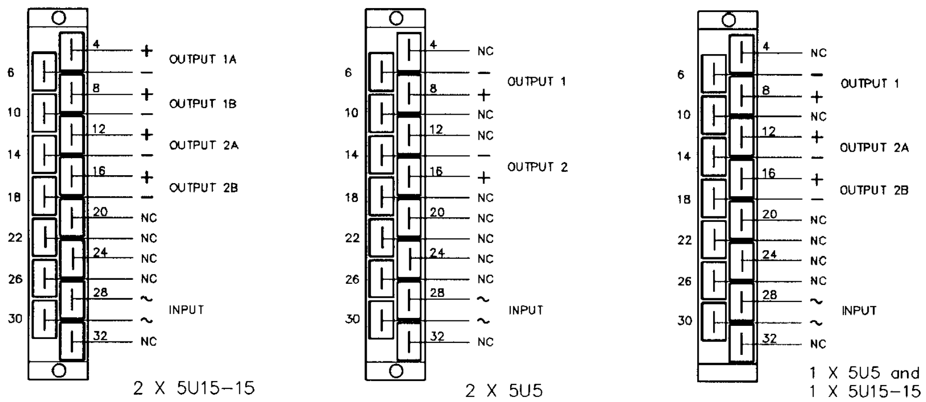
Operating ambient temp.: – 20 to + 50 °C

Dim. and Weight : 94 x 58 x 35 mm, 0.38 kgs

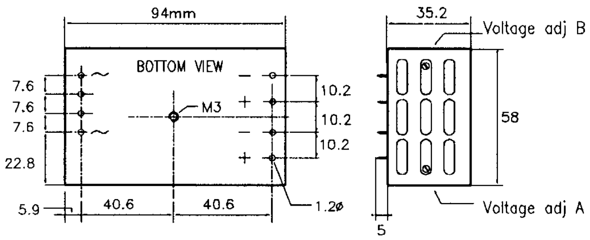




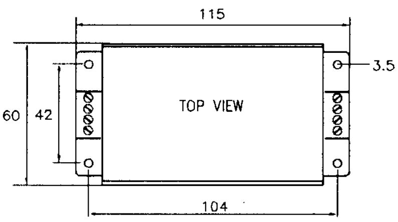
Ouput voltage and current derating at low AC input voltage

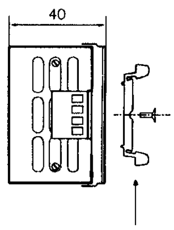


Input and ouput connections of P 500

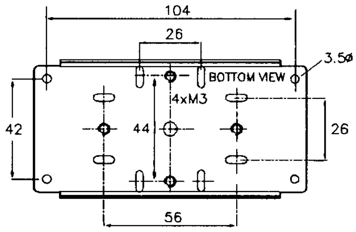


Standard U-model has solder pins of 1.2 mm ∅
for PC mounting

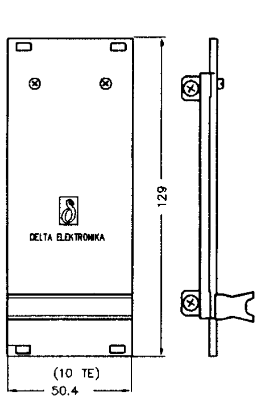




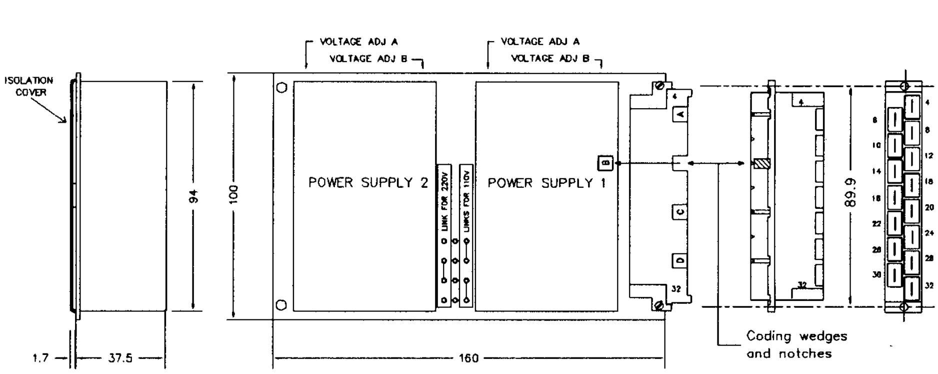
Clamp for
rail mounting



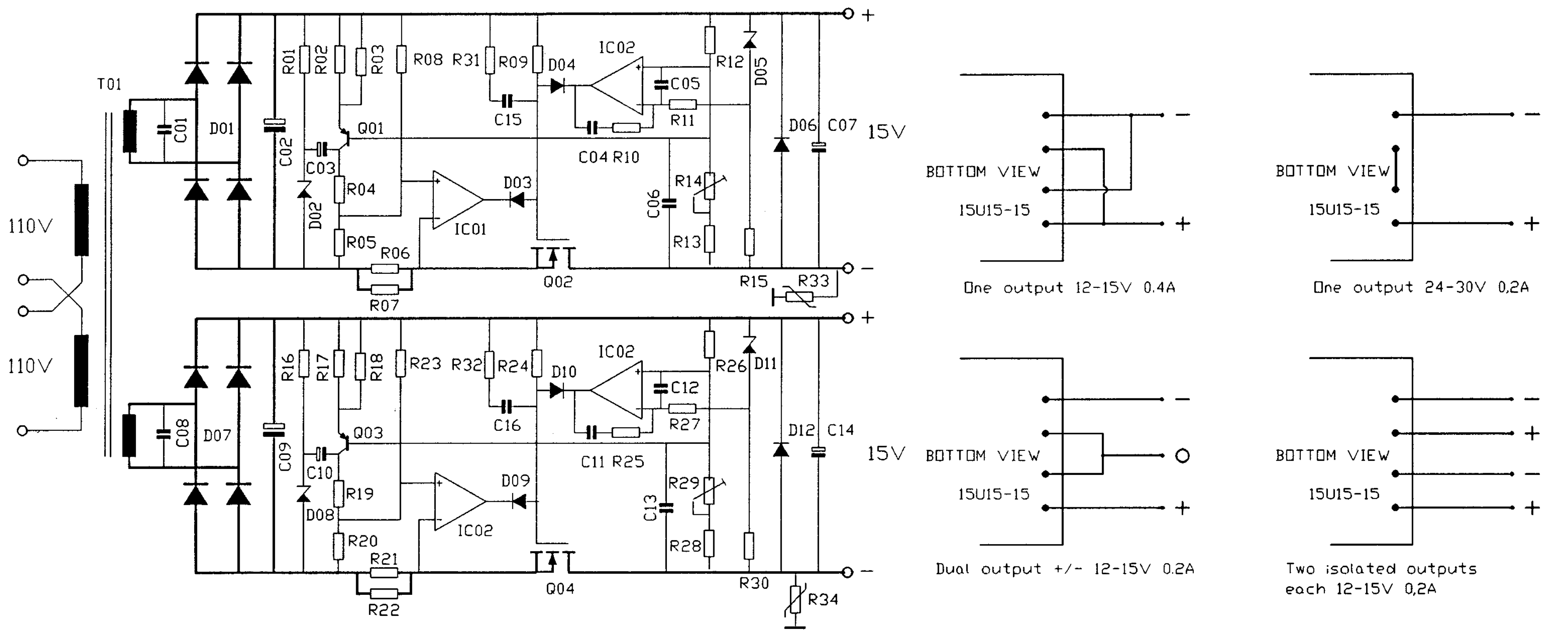
B-model with screw terminals
for wall or rail mounting, incl.
2 clamps for 35 mm DIN rail

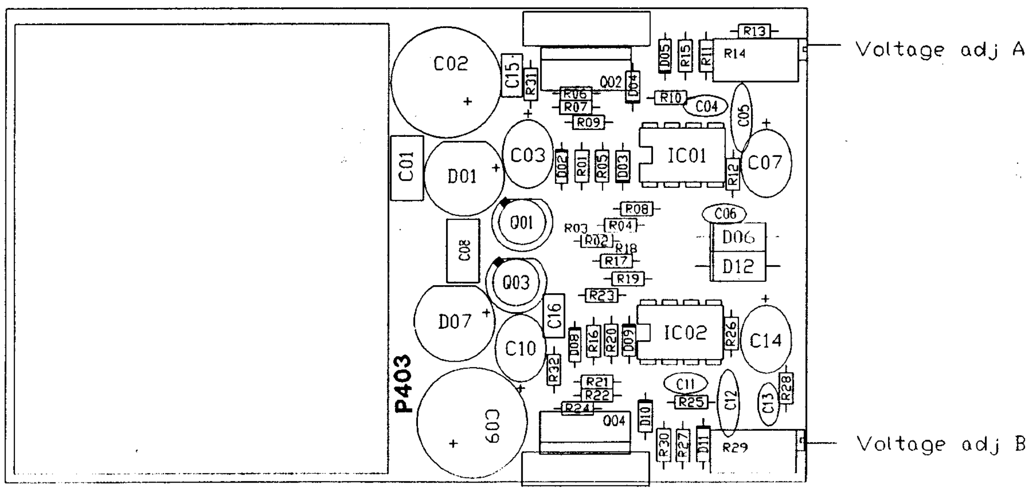


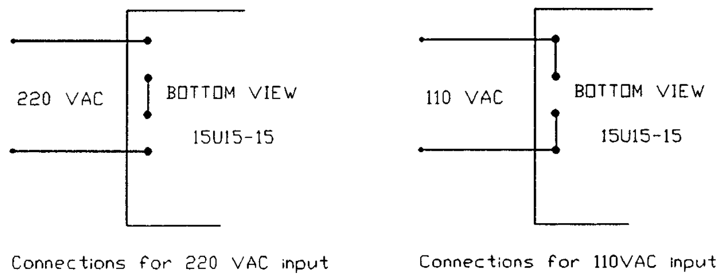
F 10-3 front panel



P 500 Eurocard for 1 or 2 U-units, incl. contra connector H15







R31,R32,C15,C16	3/92	WH	Title: 5U 15-15	
R33,R34,D06,D12	12/94	WH		
P403C	8/95	WH	Date: 18 AUG 88	
Modifications	Date	App.	DELTA ELEKTRONIKA BV	