156 rue du Mont Rond
Espace Allondon Ouest
01630 Saint Genis Pouilly, France

Tel: +33 450 42 66 42
Fax: +33 450 42 66 43
Email: info@bergoz.com

Baseband
Beam Position Monitor

User's Manual

Rev. 4.1

Record of updates

Version	Date	Updates performed
2.1	09/2007	CONNECTORS PINS ALLOCATION Rev.3.1: SUM, Sum of logs, is on pin 7 of front panel DB9 connector
2.2	10/2007	CONNECTORS PINS ALLOCATION Rev.3.2: BB-BPM-ABCD optional coaxial outputs are changed: LOGA is in b22 (used to be in b31) LOGB is in b25 (used to be in b28) LOGC is in b28 (used to be in b25) LOGD is in b31 (used to be in b22). Analog ground on c20 is suppressed. Analog ground on chassis rear panel DB15 pin 3 is suppressed. Beam Trigger output positive-going is now on: Pins c19 and c20; pin c20 used to be a ground pin. Chassis rear panel DB15 pins 2 and 3. Pin 3 used to be a ground. Beam-based Center Enable is now on pins a13 and b13; it used to be on pin a13 only. Correction of manual: Chassis rear panel DB15 pin 14 is not a ground pin.
2.3	11/2007	CONNECTORS PINS ALLOCATION Rev.3.3 Power supply pin changes: Those pins are no longer grounds:DB9 pin 7; DIN41612M pin c18 and Rear chassis DB15 pin 12.
3.0	08/2014	Units formerly designated “BB-BPM” are now designated BB-BPM-E New BB-BPM-E based on PCB 111.1.2 first customer shipment +15V DC injection in the A, B, C and D RF inputs, conditional to +15V on-board jumper Warning on +15V damage risks in manual.
3.0.1	08/2014	BB-PBM-FEFA based on PCB 206.1 first customer shipment
3.0.2	08/2014	BB-BPM-FEFA Addendum to BB-BPM User’s Manual
4.0	01/2020	Review of the full manual. Obsoletes all previous versions
4.1	11/2020	Correction of chapter “Algorithm, Sensitivity & Polarity”

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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. 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 email to info@bergoz.com.

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

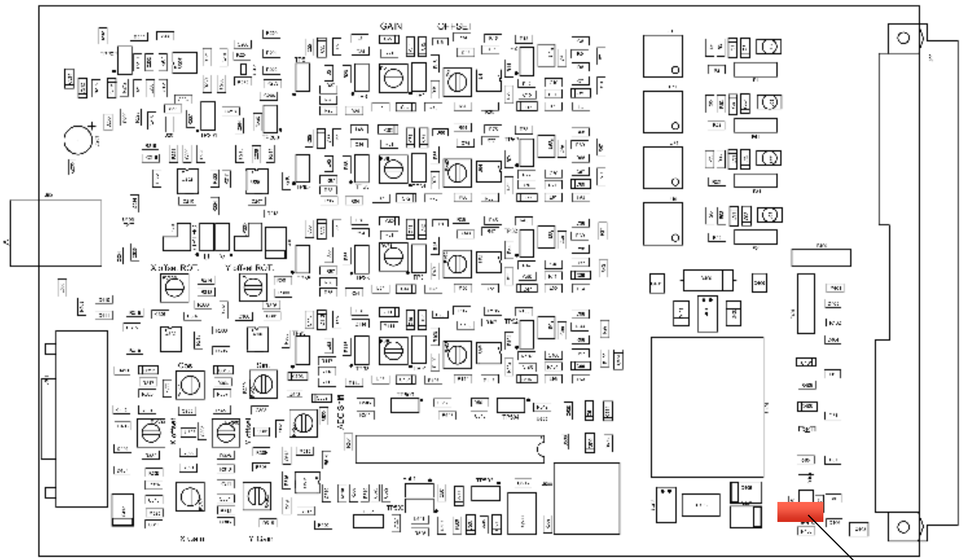
All products returned for repair should include a detailed description of the defect or failure, name and fax number of the user. Contact Bergoz Instrumentation or your local distributor to determine where to return the product. Returns must be notified by fax prior to shipment.

Return should be made prepaid. Bergoz Instrumentation will not accept freight-collect shipment. Shipment should be made via UPS, FedEx or DHL. 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.

WARNING

DO NOT CONNECT ANYTHING TO THE BB-BPM-E RF CABLES BEFORE YOU CHECK THE BB-BPM-FEFA POWER SUPPLY JUMPER!!

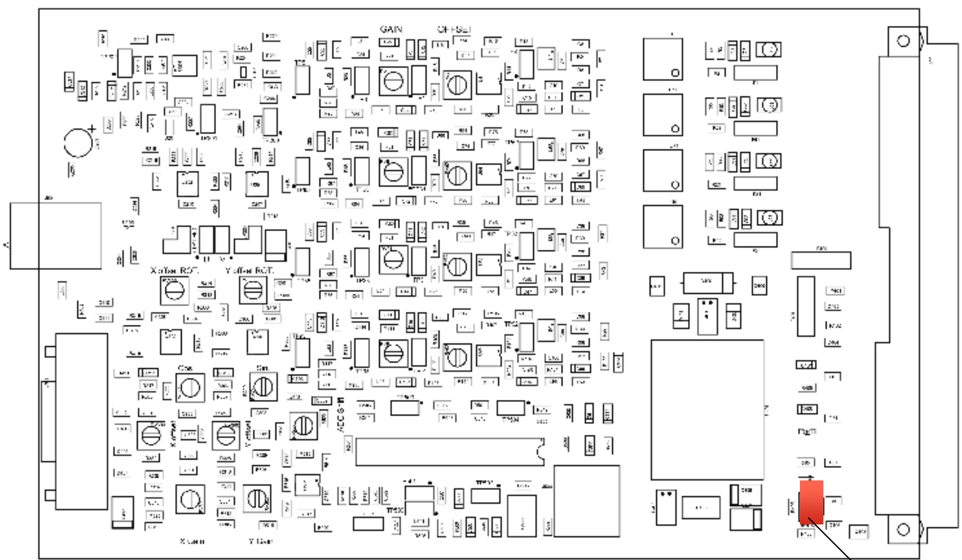
BB-BPM-E +15V jumper OFF position: Does NOT send +15V down the RF cables



+15V Jumper is in OFF position

This is the ex-factory setting: +15V jumper OFF.

BB-BPM-E +15V jumper ON position: SENDS +15V down the RF cables
+15V may destroy any instrument connected to the RF cables: Attenuators, RF generators, amplifiers, splitters. +15V is the power supply for BB-BPM-FEFA preamplifiers.



+15V Jumper is in ON position

BEAM POSITION MONITOR SYSTEM

This manual applies to the Baseband BPM only: BB-BPM
Other models, e.g., MX-BPM, LR-BPM, S-BPM, BPM-AFE are described in other manuals.

The Baseband BPM system includes:

Description	*Order code*
Baseband BPM electronics module	BB-BPM-E
Output with sum of A, B, C and D logs, option	BB-BPM-SUM
Direct A, B, C, D wideband outputs, option	BB-BPM-ABCD
Options are installed onto the BB-BPM-E board	
Front-end Amplifier and Filter	BB-BPM-FEFA

This component is described in Annex BB-BPM-FEFA at the end of this manual.

Accessories

19" chassis with power supply	BPM-RFC/XX XX is number of wired stations
Table-top test kit	BPM-KIT
3U-Card extender with coaxial contacts	BPM-XTD
RF service module with four front-panel BNC	BPM-SERV/RF

Check the fuse configuration, that it corresponds to your national regulations.

The table-top test kit does not have any fuse.
The 19" BPM-RFC chassis fuse compartment is configured at the time of shipment according to its destination:

- North America: phase wire fused, mains ground wire unfused.
- All other destinations: both mains
  To verify which fuse configuration is installed on your chassis, pull out the removable fuse block, using a small screwdriver.
- The unfused ground configuration has a shorting bar and a 2A 6x32 fuse.
- The configuration with both AC lines fused is equipped with two 2A 5x20 fuses.
  To change this configuration, unscrew the fuse holder off the fuse block, flip the holder over and screw it back onto the fuse block. Insert the following fuses:
- For unfused ground configuration: one 2A 6x32 fast fuse.
- For both AC lines fused configuration: two 2A 5x20 fast fuses.

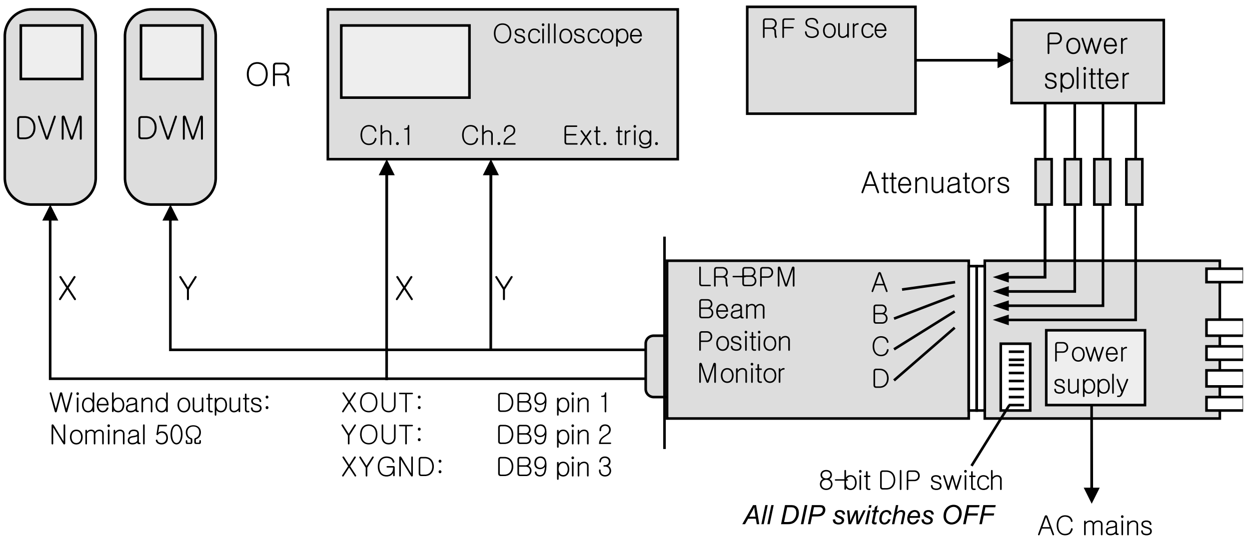
The power supplies in BPM-RFC/XX chassis are autoranging from 98V…264V.

QUICK CHECK

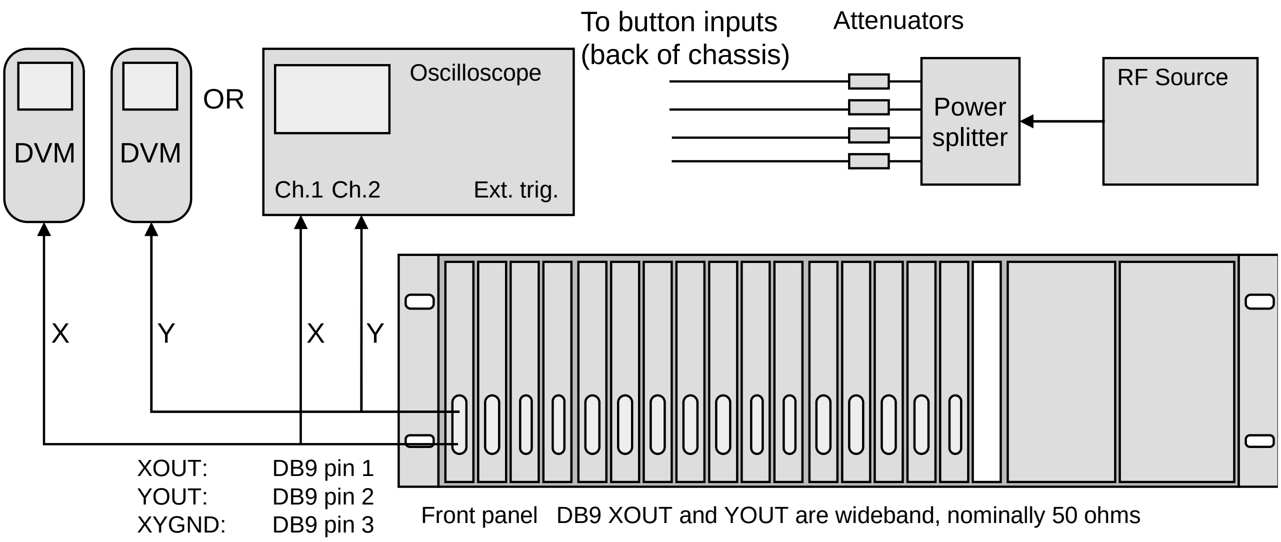
You can check immediately that your BB-BPM system is working.

Setup

If you have the table-top test kit (BPM-KIT), use the following set-up:



If you have a 19" chassis (BPM-RFC/XX), use the following set-up:



To display X and Y signals, either use two DVMs, or an oscilloscope.
The front-panel DB9 outputs are 50 ohms nominal impedance.
Attach the equipment together as shown above.

Set the DVMs on Volt-DC, or the oscilloscope on:

- Time base on 0.2 ms / div., free running,
- Channel 1 to Xout signal, sensitivity 0.2 V / div.
- Channel 2 to Yout signal, sensitivity 0.2 V / div.

Set the RF source within the BB-BPM-E:

- Operating frequency range, e.g., 1 MHz
- Amplitude ≈ -10 dBm.

Use 4 similar attenuators, e.g., ≈ 3 dB. The same test can be done with 5 and 10 dB.
Please note that attenuators are seldom more precise than ±0.1 dB. This will be reflected upon
the BB-BPM X and Y readings.

Please note that signals applied to BB-BPM-E inputs will be attenuated by the 4-way splitter:
4-way transformer-type splitters typically attenuate by 7 dB,
4-way resistive splitters or cascaded 2-way splitters attenuate by 12 dB.

Connect the Test Kit or 19" BPM-RFC chassis to AC mains; the DVM (or oscilloscope) will display X and Y values.
If the RF signals applied to all four BB-BPM inputs were exactly equal, and if the BB-BPM-E module were perfect, the values of X and Y would be exactly 0 Volt.
This is generally not the case, X and Y will be many 10s or even 100s of millivolts off.

You can determine how much of this offset is caused by attenuator inequality:
Swap the attenuators A and C, then B and D and observe the offset change.

You can determine how much of this offset is caused by power splitter imbalance:
Instead of connecting attenuator A to power splitter output 1, connect it to output 3
and connect attenuator C to output 1.
Do the same for attenuators B and D with power splitter outputs 2 and 4.

The next tests will consist of:

- Simulating beam displacements cause by inputs imbalance of 6 dB, 10 dB and 14 dB
- Exploring the BB-BPM-E dynamic range by varying the RF source output.

Beam displacement

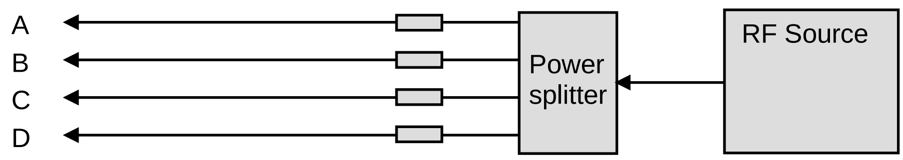
The RF source output power should be in the range -10dBm ... -35 dBm

The BB-BPM-E on-center sensitivity is factory-set to 55.5 mV per dB of signal difference between opposite pickups. For pickups with small subtending angle (e.g. buttons), 6 dB corresponds to beam displacement equal to 1/6 of vacuum chamber radius. As the beam goes off center, this sensitivity becomes lower due to the algorithm X = Log (A/C). Please consider that the BPM pickup sensitivity becomes higher as the beam goes off center, and one non-linearity tends to compensate the other.

Modules BB-BPM-E are manufactured in two versions:

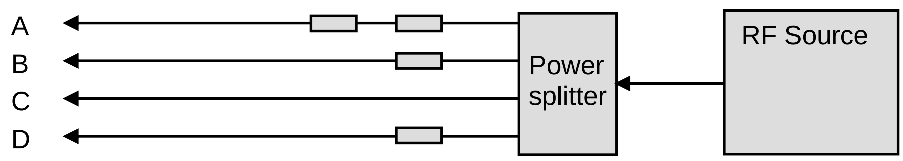
- For orthogonally placed pickups: up, down, left and right
- For rotated pickups: upper-right, upper-left, lower-left and lower-right

Before simulating a beam displacement, start by noting the X and Y zero offsets, using four equal attenuators:



Then simulate the displacement by removing an attenuator from one input and inserting it in the opposite input: A <=> C, and B <=> D.

Example:



Attenuator C is removed from input C, and added to input A, thus simulating a displacement of the beam towards C (stronger signal on C pickup).

The following combinations can be tried, yielding the X and Y values listed here.
Please note these are displacements. Take the zero offsets due to power splitter imbalance and attenuators inequality into consideration.

Table of X/Y output voltage vs. input power

Input	Attenuators	Equivalent displacement	Rotated pickups	Orthogonal pickups
A	3 + 3	1/6 of radius towards C		
B	3		X = -0.245 V	X = -0.347 V
C	0		Y = -0.245 V	Y = 0 V
D	3	(button pickups << chamber diameter)		
A	3 + 3	1/6 of radius towards C		
B	3 + 3	1/6 of radius towards D	X = 0 V	X = -0.347 V
C	0		Y = -0.490 V	Y = -0.347 V
D	0	(button pickups << chamber diameter)		
A	5 + 5	1/4 of radius towards C		
B	5		X = -0.407 V	X = -0.576 V
C	0		Y = -0.407 V	Y = 0 V
D	5	(button pickups << chamber diameter)		
A	5 + 5			
B	5 + 5		X = 0 V	X = -0.576 V
C	0		Y = -0.814 V	Y = -0.576 V
D	0	(button pickups << chamber diameter)		
A	10 + 7	1/3 of radius towards C		
B	10		X = -0.570 V	X = -0.806 V
C	3		Y = -0.570 V	Y = 0 V
D	10	(button pickups << chamber diameter)		

The above voltages are representations of the algorithms:

- $X = K_X \text{Log}(A/C)$ and $Y = K_Y \log(B/D)$ for orthogonal pickups, and
- $X = K_X (\text{Log}(A/C) + \text{Log}(B/D)) \cos\alpha$, and $Y = K_Y (-\text{Log}(A/C) + \text{Log}(B/D)) \sin\alpha$ for rotated pickups.

Where: α is the tilt angle of the pickups,
K_X and K_Y are set to 1.1513 Volts

Note: This value was chosen because it corresponds to a difference-over-sum ratio equal to 1 V, for small amplitude off-center displacements. E.g. 0.001 V for 0.005 x R.

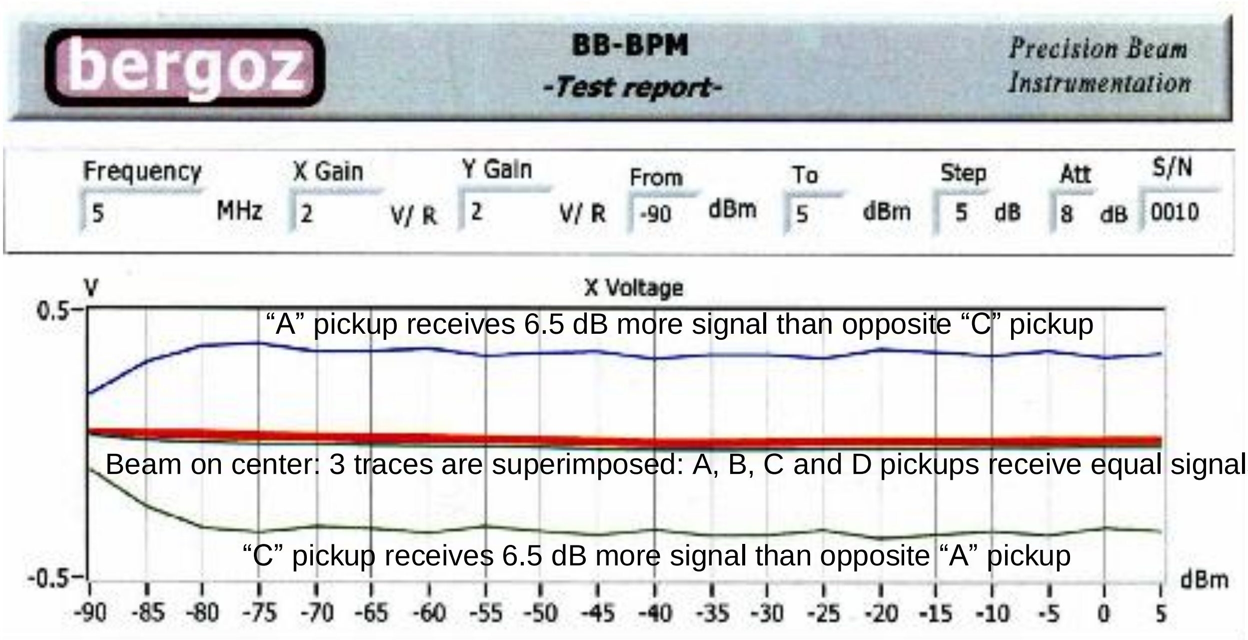
To maintain the condition A+C = B+D when two attenuators are cascaded in one input, their attenuation should be increased to compensate for the BPM pickup non-linearity also called "pin cushion effect". E.g.,3+3 dB should really be ~6.5 dB with ~0.5 dB in opposite input. 5+5 dB should really be ~11.4 dB and 1.4 dB in opposite input, 10+10 dB should really be ~25 dB and ~5 dB in opposite input.

Explore the dynamic range

Set the input attenuators in such way that X and Y are off center.
Vary the power from the RF source to simulate beam intensity variations.
Explore the range from +7 dBm down to -70 dBm.
Remember that 4-way transformer-type splitters absorb typically 7 dB and resistive splitters absorb 12 dB.

While the RF source output power is changed, observe the intensity dependence of X and Y outputs on the voltmeters. The X and Y output voltages vary with input power applied to the BB-BPM-E inputs:

The plot hereunder is taken with BB-BPM-E set for orthogonal pickups:



ADVANCED CHECK

Before performing the advanced check, it is recommended to get familiar with BB-BPM in CW (Continuous Wave) mode as described in earlier chapter "Quick Check".
After the initial setup, the checking procedure is the same.
Advanced check will make you familiar with the BB-BPM behavior in single pass mode:

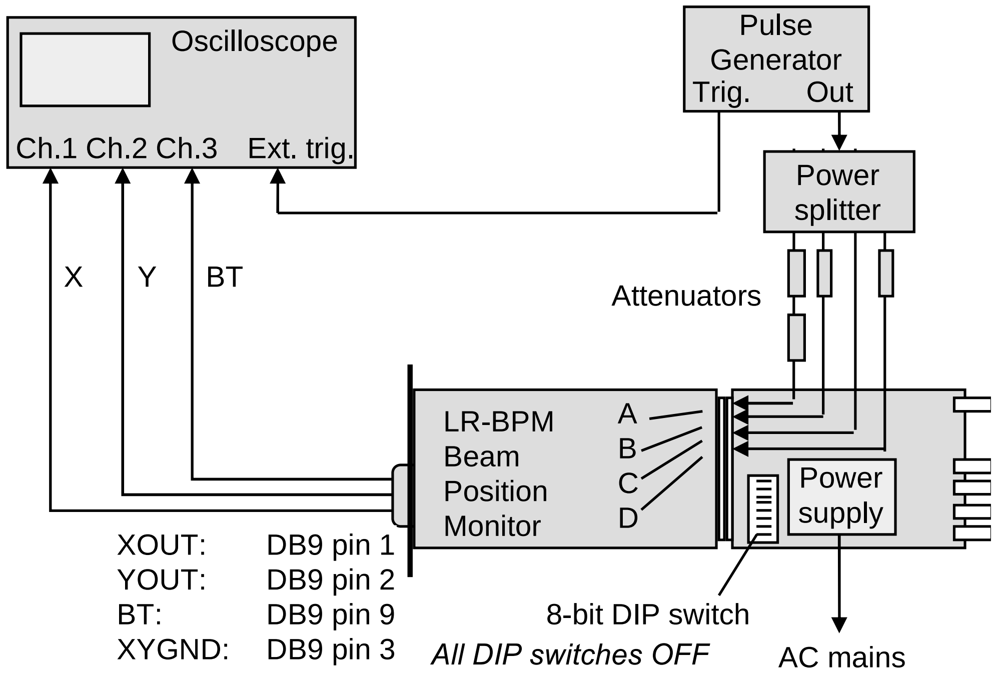
- Select a pulse generator capable of making short pulses with ca. 1nC charge in 50 ohms.

The generator output pulse length should not exceed T/2, where T is the period of the BB-BPM-E operating frequency.
Example: BB-BPM-E/1-10MHz. Shortest period = 100ns, the pulse length should not exceed 50 ns.

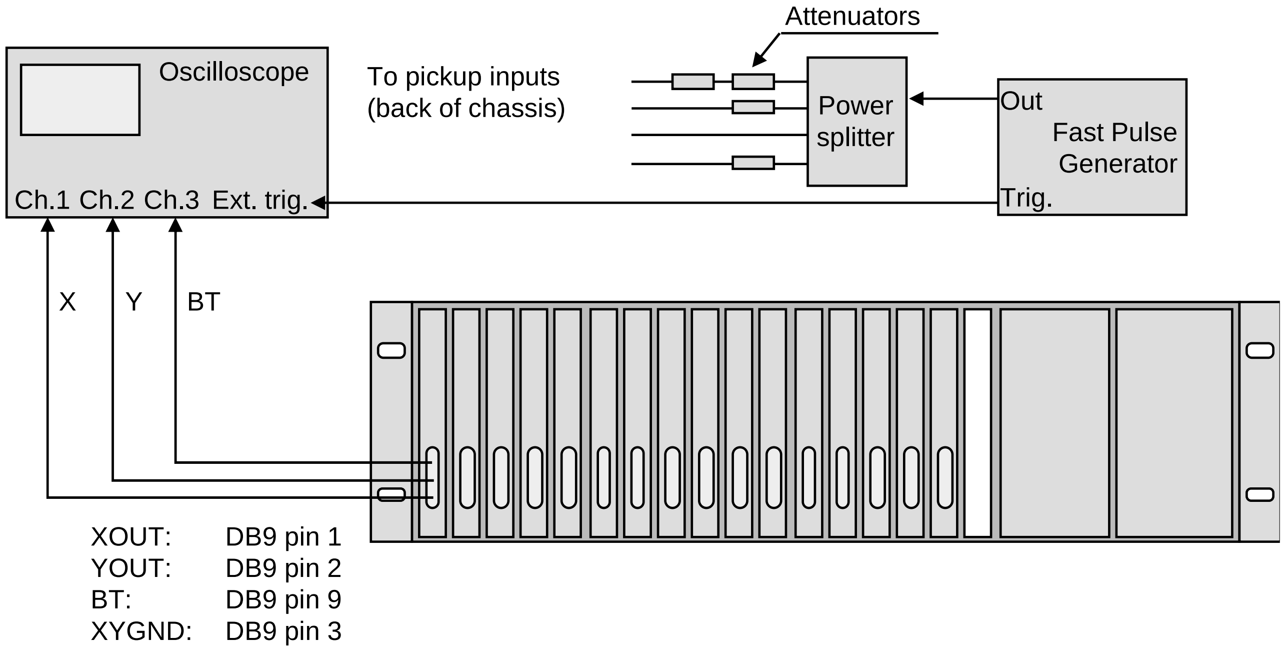
If 50 ns is chosen, pulse amplitude would be 1V in 50 ohms, to make it 1 nC.
The examples hereafter use 1-ns pulses and 50V amplitude from a mercury pulse generator.

Setup

Using the BPM-KIT Table-top test kit:
Remove the BB-BPM-E cover shield as described in the On-board adjustments chapter.



Using a 19" BPM-RFC chassis:



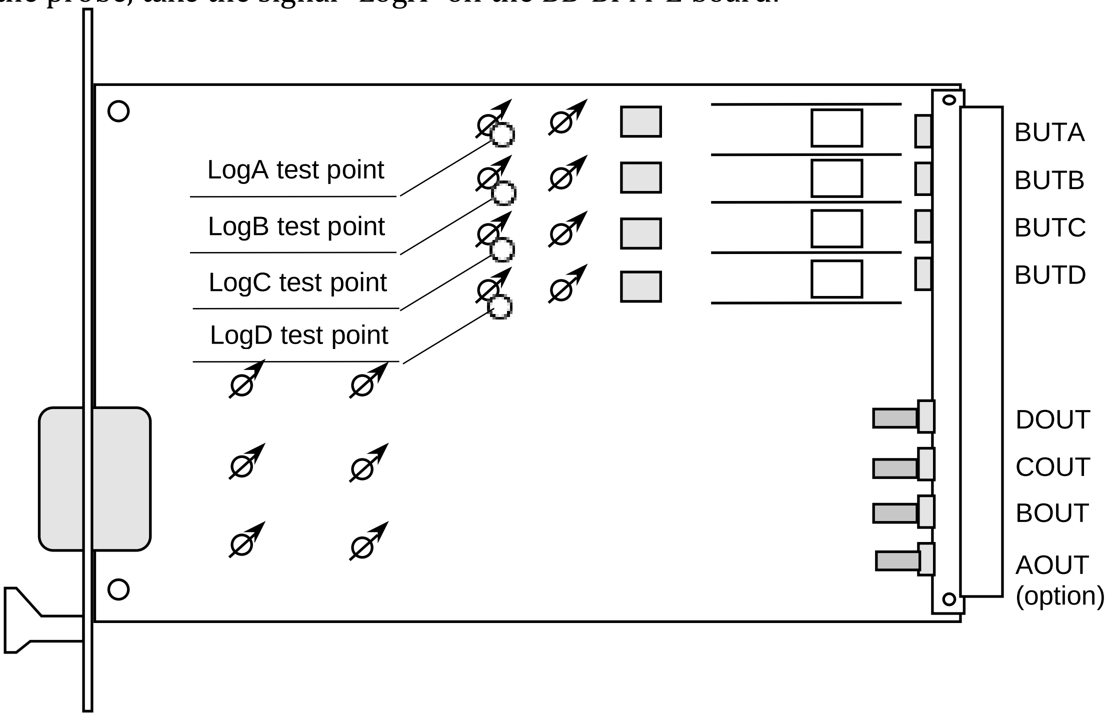
Remove the BB-BPM-E cover shield as described in the Quick Check.
Place the BB-BPM-E module on a card extender type BPM-XTD.

Use an asymmetrical combination of attenuators to simulate beam off center.

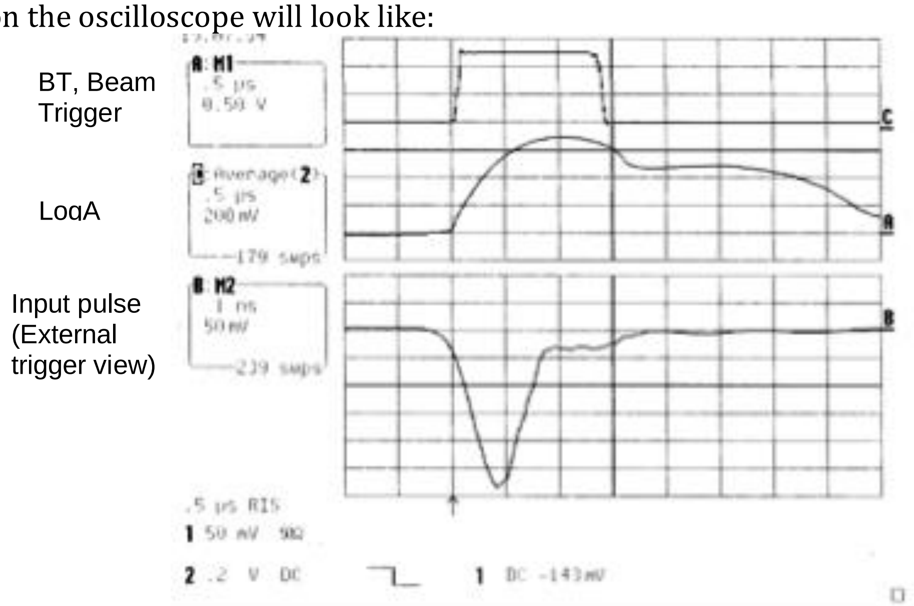
Start the pulse generator and look for the Beam Trigger signal on the oscilloscope.

Observe the signals on the BB-BPM-E board with a high-impedance probe. It can be 500-ohm, or -20dB high-Z.

With the probe, take the signal "LogA" off the BB-BPM-E board:



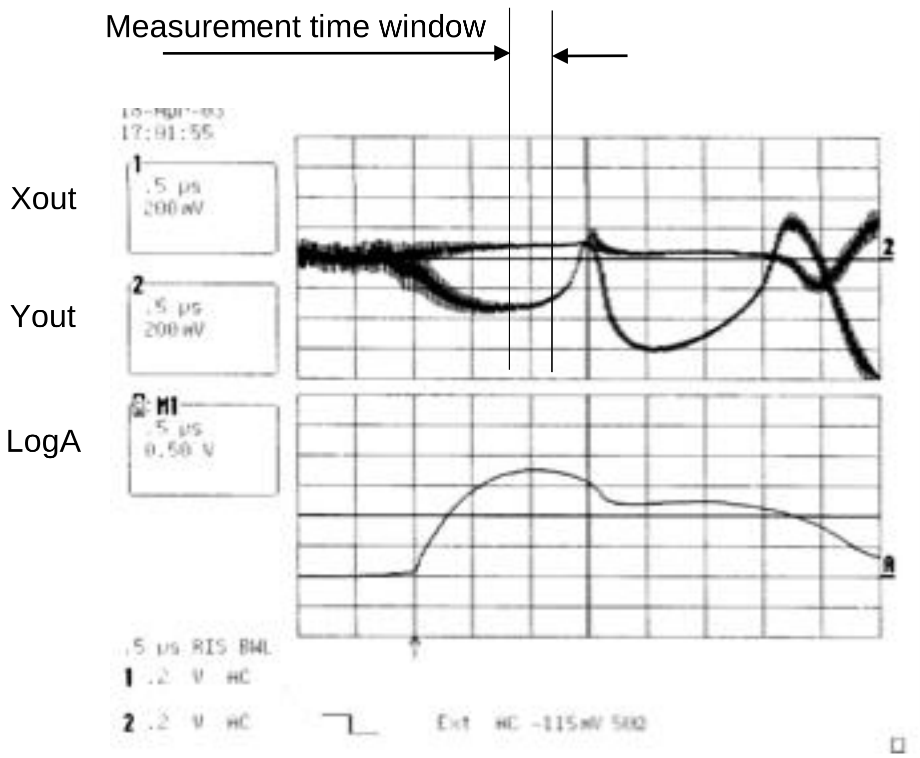
The signals on the oscilloscope will look like:



Observe the Beam Trigger BT rising ~1 us before the apex of LogA.

Note: These waveforms are taken from BB-BPM-E models equipped with AD8307 log amplifiers.
Other BB-BPM-E models –depending on their frequency range– may be equipped with other log amplifiers, e.g., AD8313, AD8318. With those other log amplifiers, the waveform may be slightly different.

X and Y output signals for single pass



Observe the Xout and Yout signals represent X/Y positions for ~500 ns about LogA pulse apex.

LogA apex is itself ~1 us after Beam Trigger rising edge.

Observe the signals Xout and Yout are very noisy before the pulse is applied. It is characteristics of the logarithmic representation of large variations.

Note: These waveforms are taken from BB-BPM-E models equipped with AD8307 log amplifiers.
Other BB-BPM-E models –depending on their frequency range– may be equipped with other log amplifiers, e.g., AD8313, AD8318. With those other log amplifiers, the waveform may be slightly different.

Further tests

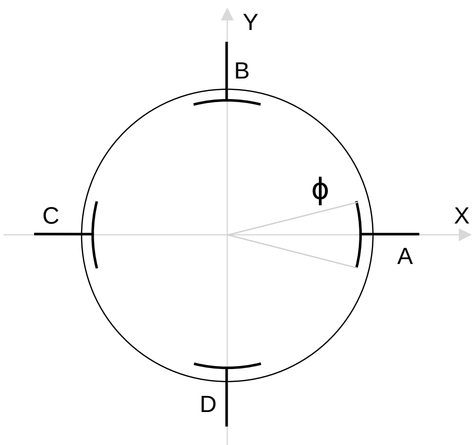
More tests can be conducted with other input attenuators configurations.
The pulse amplitude from the Pulse Generator can be reduced to explore the dynamic range.

ALGORITHM, SENSITIVITY & POLARITY

Orthogonal pickups version

$X = K_X \cdot \text{Log}\ (A/C)$
$Y = K_Y \cdot \text{Log}\ (B/D)$

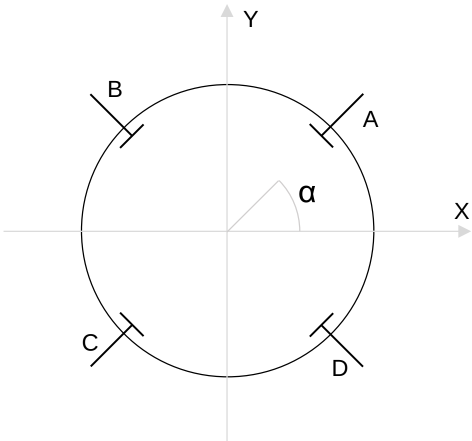
Where K_X and K_Y are factory-set for on-center sensitivity 55.5 mV/dB
For pickup electrodes with small Φ, 55.5 mV corresponds to 1/36 of radius beam displacement.



Rotated pickups version

$X = K_X \cdot [\text{Log}\ (A/C) \cdot \cos\alpha - \text{Log}\ (B/D) \cdot \sin\alpha]$
$X = K_Y \cdot [\text{Log}\ (A/C) \cdot \sin\alpha + \text{Log}\ (B/D) \cdot \cos\alpha]$

Where K_X and K_Y are factory-set for on-center sensitivity 55.5 mV/dB of difference between opposite pickups.
When $\cos\alpha = \sin\alpha = 1/\sqrt{2}$, the sensitivity in X and Y equals $55.5\ \text{mV}/\sqrt{2} = 39.2$ mV.
For pickup electrodes with small Φ, 39.2 mV in X or Y corresponds to 1/36 of radius beam displacement along the X, resp. Y axis



Note: Pickups with larger f, such as stripline and shoebox, have higher coupling impedance (they collect more signal from the beam) but lower sensitivity to beam displacement.
Pickup sensitivity increases with f as sin(f/2) / f[1].

[1] Log-ratio Signal-Processing Technique for Beam Position Monitors, Robert E. Shafer, Proceedings of the Fourth Accelerator Instrumentation Workshop, Berkeley 1992.
AIP Conf. proceedings No. 281, pages 120-128.

ON-BOARD ADJUSTMENTS

The BB-BPM-E module is equipped with many on-board potentiometers.
Some can be readjusted easily by the users, while others require precise tools and procedures for their adjustment. The function of each adjustment is described hereafter.

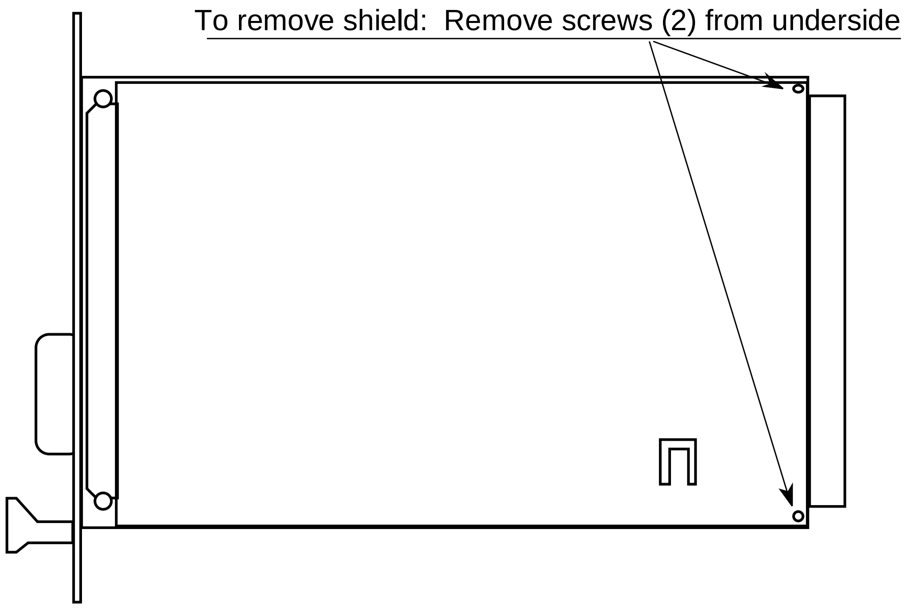
Procedure

Proceed as described in "Quick Check".
Using the table-top test kit (BPM-KIT) is the easiest setup to readjust potentiometers.
An alternative is to extend the BB-BPM-E module out of its chassis, using the card extender (BPM-XTD).

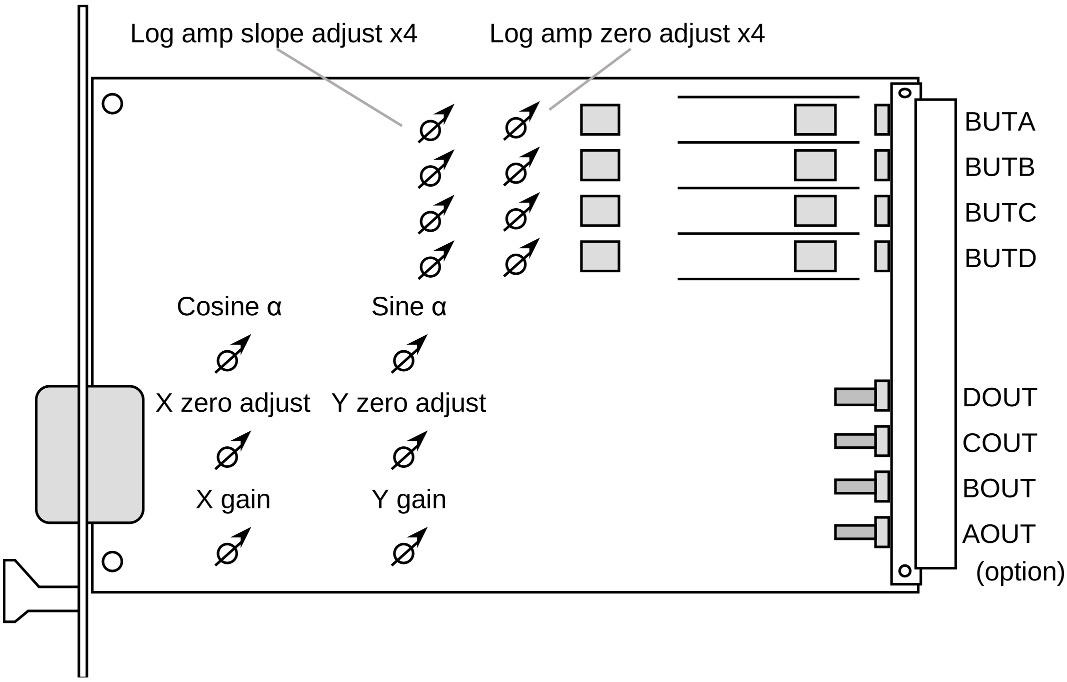
Note: No damage will occur to BB-BPM-E modules if they are inserted or removed while the power is on.

Note: The card extender has unequal button-to-button attenuations. It introduces an offset in X and Y. The card extender offset was measured at the time of shipment. To recheck it, measure the X and Y offsets with and without extender.

To adjust the on-board potentiometers, remove the shield:



BB-BPM-E board



It is not recommended to change the following adjustments:

Log amplifier zero adjust	to match the origin of two opposite log amplifiers
Log amplifier slope adjust	to match the slope of all four log amplifiers

Users' adjustments

Note: To adjust these potentiometers, use a screwdriver with a ceramic tip. A metal tip changes the signal!

Cosine α and Sine α	Sets the pickups tilt angle (both are $1/\sqrt{2}$ factory-set) . Rotated pickups only.
X gain & Y gain	Sets the X and Y gains X and Y gains factory settings: 347mV for 6 dB between opposite orthogonal pickups (1 on 1), 490mV for 6 dB between opposite rotated pickups (2 on 2).
X zero adjust	Matches the Log (A/C) input levels
Y zero adjust	Matches the Log (B/D) input levels

BB-BPM PRINCIPLE OF OPERATION

The signals from the pickup electrodes are processed simultaneously thru four independent channels. Each channel consists of an input band-pass filter, followed by an amplification chain with logarithmic response.
When a single short pulse is applied to the band-pass filter, it will oscillate at its own resonant frequency for about 250 ns, allowing enough time for the logarithmic amplifier to detect the log of its envelope.

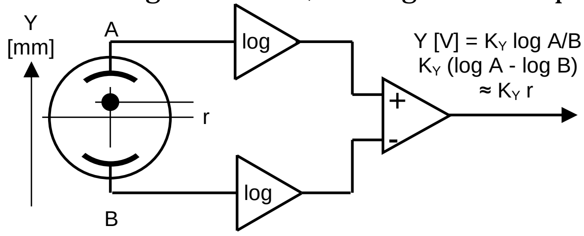
Each amplifying chain produces a signal which peak amplitude is proportional to the log of the input signal, be it a single pulse, a pulse train, or a continuous wave.

Log signals from opposite pickup electrodes are deducted from one another to obtain Log(A) - Log(C) = Log(A/C) which is said to be a very faithful representation of beam displacement between two pickup electrodes.

If the pickup electrodes are placed along the axes in which the beam displacement is to be measured, the displacement $X = K_X \text{ Log}(A/C)$, directly. The K_X gain is obtained by an amplifier with adjustable gain. The same goes for the Y axis.

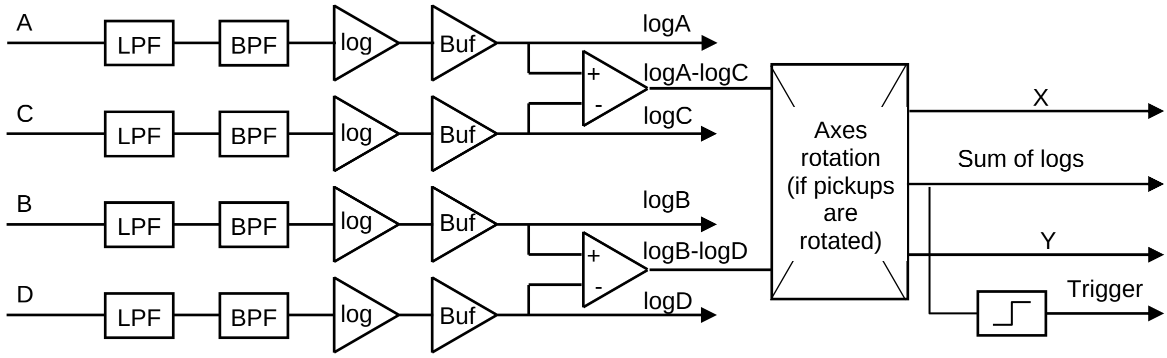
If the pickup electrodes are placed along axes rotated as compared to the beam position measurement axes, the A-C and B-D axes must be rotated to obtain the beam displacement values along X and Y. This is achieved by applying the cosine of the tilt angle to one axis and the sine of the tilt angle to the other axis, before summing them. This is done wideband with >10 MHz response.

Schematic representation of the log-ratio BPM, an original concept of Robert E. Shafer:



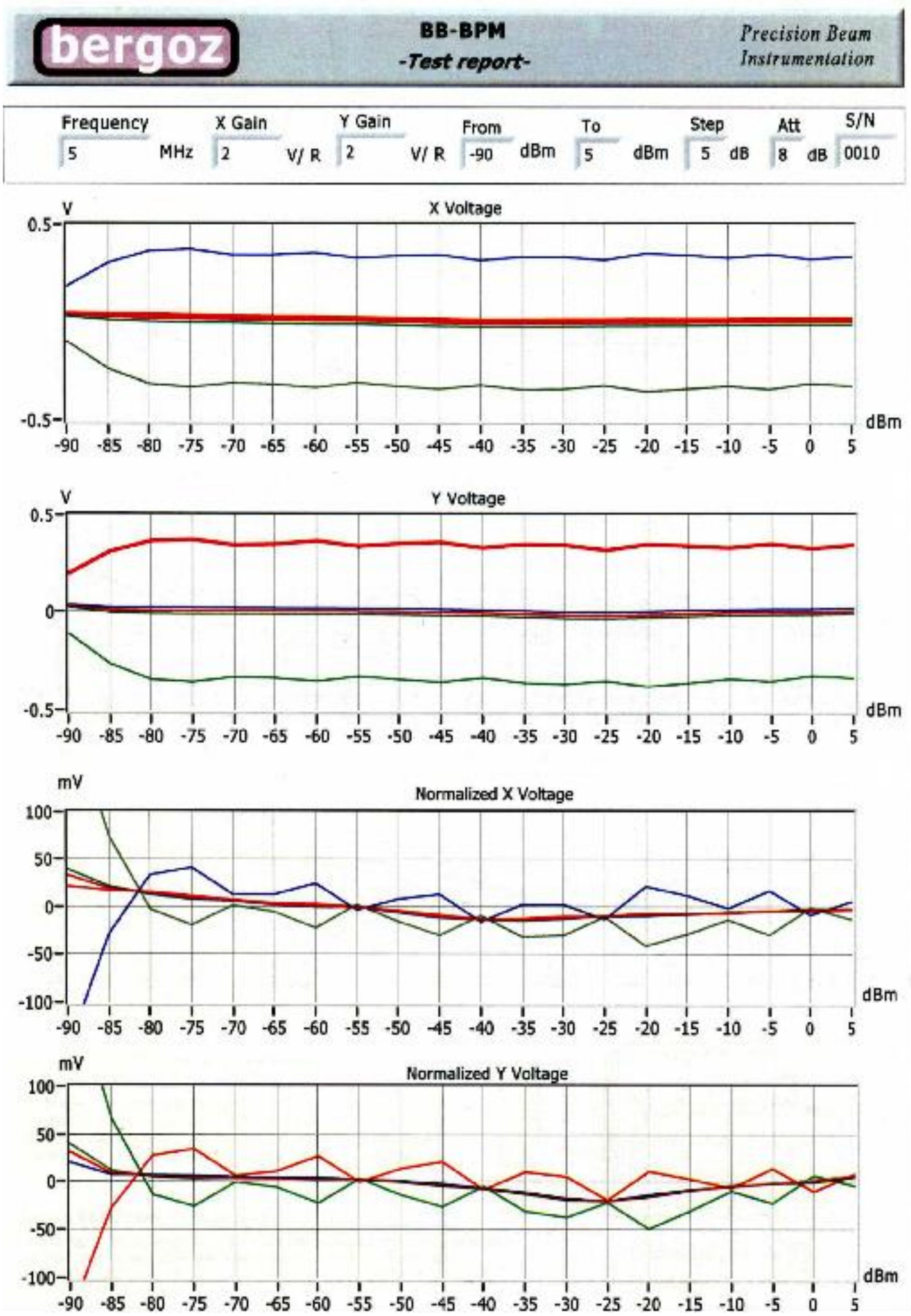
Position measured by this method is more linear, over a wider range, than difference-over-sum.

BLOCK DIAGRAM



PERFORMANCE

Performance with CW input signals is reported for each module. Plots are attached to the Certificate of Calibration. Example:



Note: X and Y signal displays are limited to ~1 kHz (10 kHz on option) by the virtual instrument LabVIEW.

SIGNALS

Pickup Inputs

BUTA	Pickup inputs A, B, C, and D. Impedance 50Ω.
BUTB	See Algorithms, Sensitivity & Polarity, this manual, for pickup assignment.
BUTC	
BUTD	

Output narrowband signals

	(0...200 Hz) High-impedance (0...10 kHz on option)
XOUT	X displacement. Range -2V…0…+2V. 0 Volt represents pickup center.
YOUT	Y displacement. Range -2V…0…+2V. 0 Volt represents pickup center.
XYGND	Analog ground for the above signals.

XOUT and YOUT signals should be connected to ADC, preferably via a twisted pair cable for better EMI immunity.

Output wideband signals

	(0...5 MHz) 50-ohm impedance
XOUT	X displacement. Range -2V…0…+2V. 0 Volt represents pickup center.
YOUT	Y displacement. Range -2V…0…+2V. 0 Volt represents pickup center.
XYGND	Analog ground for the above signals.

Optional Output wideband signals

Note: These optional signals are made available to compute beam position when the algorithm implemented in the circuit Log(A/C) is unsuitable. This can be the case of 6-button BPM pickups or asymmetric geometry of pickup electrodes.

LOGA	Logarithmic representation of BUTA input.
LOGB	Logarithmic representation of BUTB input.
LOGC	Logarithmic representation of BUTC input.
LOGD	Logarithmic representation of BUTD input.
SUM	Sum of logs (LogA + LogB + LogC + LogD)
	Equal to log of beam intensity, for centered beam.
GND	Ground for above signal(s).

Input and output signals

Input and output signals hereafter are specific to each BPM module

SUM	Sum of logs (LogA + LogB + LogC + LogD) Equal to log of beam intensity, for centered beam.
GND	Ground for above signal(s).
BT	Beam Trigger. >500-mV positive going pulse with rising edge ~1 us before log signals reach their apex.
BT*	Beam Trigger. >500-mV negative going pulse with falling edge ~1 us before log signals reach their apex.
BTGND	Ground for BT and BT* signals

Common external controls

Common external controls are controls which are common to all BPM modules in a BPM chassis.
BB-BPM-E does not feature any external control.

BPM CABLES LAYOUT & INSTALLATION

Cable layout

Unnecessary intermediate connectors should be avoided. When for practical reasons patch-panels must be used, the patch panel should not ground the body of bulkhead connectors. Every cable segment should be passed through tubular common-mode filters (also called "chokes"). Common-mode filters must be placed at each end of every cable segment. A cable segment is a stretch of cable terminated at each end by a connector. To be effective over a wide spectrum of EM and RF interference, each common-mode filter should be composed of two tubes, cores or "beads" with the cable passing through: One tube of MnZn ferrite and one core of iron-based nanocrystalline alloy, e.g., Hitachi Metal Finemet.

The four cables pertaining to the same BPM stations must be laid side by side. Cables, BPM chassis and modules should be kept away –as much as possible– from RF equipment, klystrons, cavities.

Connectors must be chosen carefully to match the cable used. Connectors manufacturer's instructions must be followed meticulously. If cable layout is subcontracted, subcontractors must be informed of the extreme reliability expected from these cables. All cables with connectors must be checked before installation with a network analyzer, up to twice the operating frequency at least.

BB-BPM-E modules must be installed in an RF-shielded chassis.

Note: Unlike most BPM electronics, the BB-BPM-E module does not require the BPM RF signals to be in phase. Cables do not need to be phase-adjusted. The BB-BPM-E module tolerates any phase change, even 180°.

BB-BPM-E & BPM-RFC CHASSIS CONNECTORS PINS ALLOCATION REV. 3.3

		DB9 female connector on BB-BPM-E front panel	DIN41612M BB-BPM-E module rear connector	DB15 female connector on BPM-RFC rear panel (one connector per BPM station)
RF INPUTS				
Input A	BUTA		b2*	
Input B	BUTB		b5*	
Input C	BUTC		b8*	
Input D	BUTD		b11*	
*Coaxial insert 1.0/2.3 type				
WIDEBAND OUTPUT SIGNALS				
X output	XOUT	1		
Y output	YOUT	2		
Analog ground	XYGND	3		
OPTIONAL OUTPUT SIGNALS				
Sum of logs	SUM	5	b20	5
Log A	LOGA		b22*	
Log B	LOGB		b25*	
Log C	LOGC		b28*	
Log D	LOGD		b31*	
NARROWBAND OUTPUT SIGNALS				
X output	XOUT		a15	8
Y output	YOUT		a18	7
Analog ground	XYGND		a20	4
			a17	6
			b19	15
SINGLE BUNCH TRIGGER OUTPUTS				
Beam Trigger, positive-going	BT		c19	2
			c20	3
Beam Trigger, negative-going	BT*	9		
General ground	GND	4	b14	
POWER SUPPLY				
+ 15 V	+15V		c13	
- 15 V	-15V		c15	
Common	COM		c14	
Ground	GND	4	a19	
			b18	

ACCESSORIES

Table-top test kit (BPM-KIT)

Old versions may be equipped with a single AC mains voltage power supply, e.g., 100 Vac in Japan.
Please check AC mains voltage before using old BPM-KIT.
New BPM-KITs do not have on-board ±15V power supply.

BPM-KIT features an 8-bit DIP switch. All switches should be OFF for proper BB-BPM-E operation.

The BPM-KIT is very convenient. It allows the BB-BPM-E module to be placed flat on the table.
In this position, the shield can be removed, and the user can re-adjust the BB-BPM-E settings.
See chapter ON-BOARD ADJUSTMENTS, this manual.

These adjustments cannot be made when the BB-BPM-E processing unit is in the chassis.
They require a BPM-KIT or a card extender BPM-XTD.

Extender BPM-XTD

The card extender allows access to the BPM module adjustments while it is connected to the chassis, thus to the RF inputs, readout and control system.

The BPM-XTD is not as convenient as the BPM-KIT for adjustments.

The coaxial connections extensions of the button signals cause an offset of the X and Y outputs when the extender is used. This is due to the difference in signal attenuation between the 4 extension cables. These differences are recorded on a label affixed to the extender.

RF Service module BPM-SERV/RF

The RF Service module can be inserted in a BPM station of a chassis, in place of the BPM module.

It brings to the front panel –on BNC jacks– the four signals applied to this BPM station by the BPM pickup electrodes, e.g., striplines or shoeboxes.

For oscilloscope and spectrum analyzer viewing of the BPM RF input signals.

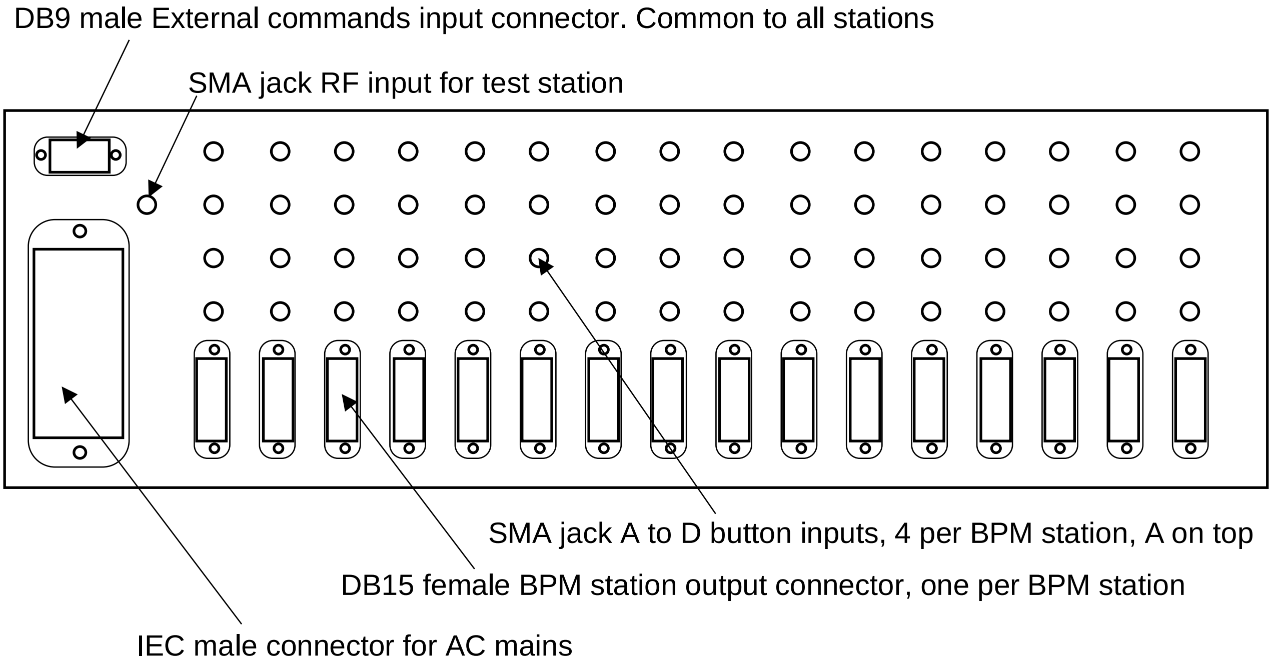
Very useful, because the RF cables at the rear of the chassis are too crowded to be disconnected.

Chassis BPM-RFC/XX

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

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

Chassis rear view



SPECIFICATIONS

Power Supply module

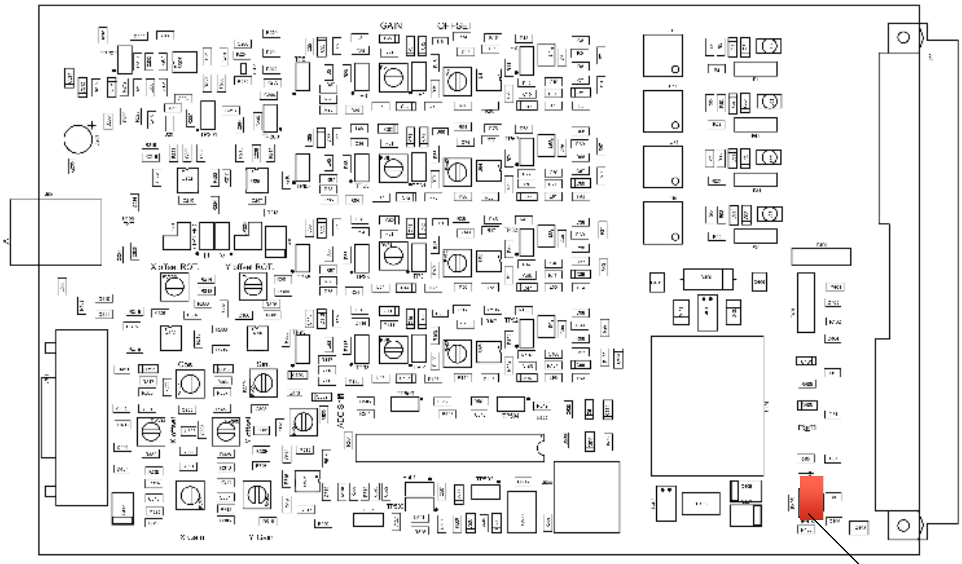
AC mains voltage	Autoranging 98…132Vac and 185…265Vac with automatic range changeover
Power derating	No derating down to 85 Vac (at full chassis load)
Output	± 15 V, unequal loading tolerant
Power	75 W
Efficiency	84% at 220Vac, 81% at 110 Vac
Inrush current	limited to 10A max.
Dimensions	per DIN41494: 3U high, 8F wide, 160mm deep
Manufacturer	Delta Elektronika BV, the Netherlands
Model	75 SX 15-15

BB-BPM-E rear connector

Model DIN41612M 24+8

FRONT-END FILTER & AMPLIFIER BB-BPM-FEFA

IMPORTANT INFORMATION
To power BB-BPM-FEFA, the +15V jumper on BB-BPM-E board must be ON, i.e., in vertical orientation:

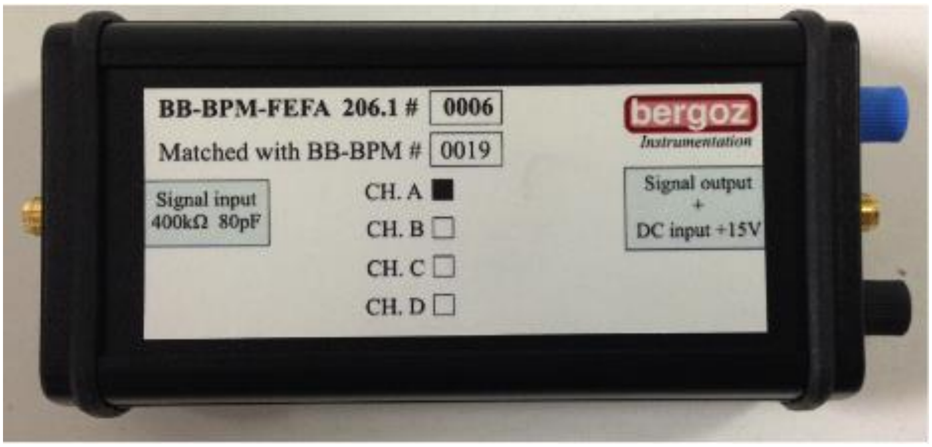


When BB-BPM-FEFA are not powered, their output is only noise.

WARNING
When BB-BPM-E On-board +15V jumper in ON (Vertical orientation) the four BPM RF cables are POWERED with +15V.
DO NOT INSERT ANY ELEMENT IN CABLE e.g., ATTENUATOR, SPLITTER, COMBINER, AMPLIFIER. The +15V power can blow these elements!

Outlook

Top

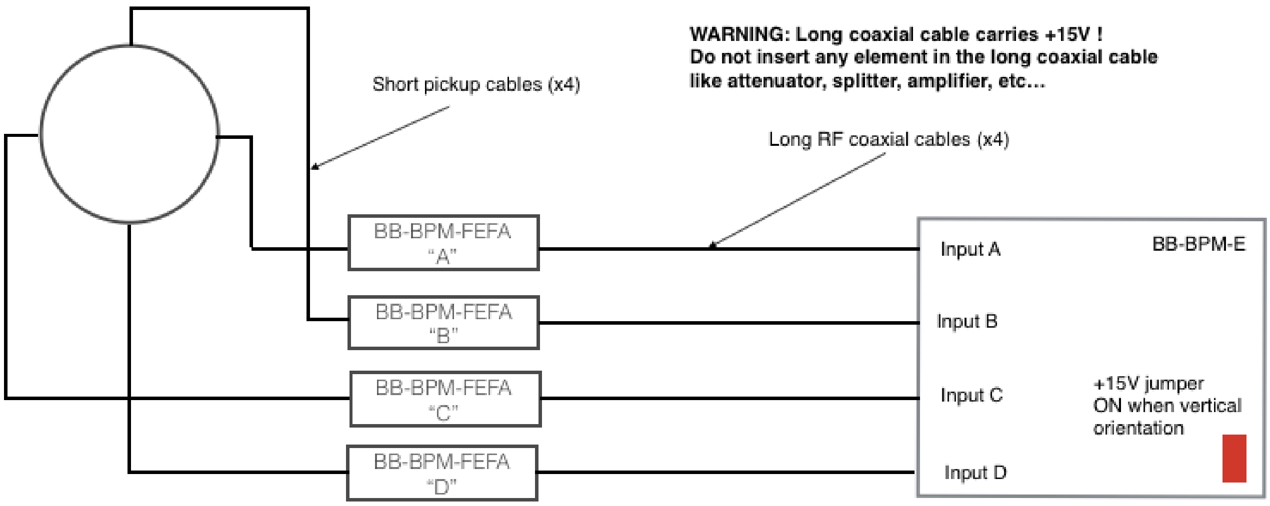


Sides

Purpose of BB-BPM-FEFA

BB-BPM-FEFA purpose is to capture the full amplitude of the beam bunch signal, even though the BPM electrode collecting the signal is much shorter than the physical bunch length. Such is the case of a shoebox BPM pickup on an ion synchrotron beam.
Capturing the signal full amplitude is achieved by measuring the voltage induced on the electrode in a high impedance load.

Connecting BB-BPM-FEFA



Gain

Gain is obtained (a) by converting the charge collected by the BPM pickup electrode into a voltage, and (b) by a 50-ohm amplifier switched ON or OFF under the control of a fiber optic.

a) Charge-to-voltage conversion gain is the inverse of the impedance of the sum capacitance of BPM pickup electrode, BPM pickup electrode-to-FEFA cable and BB-BPM-FEFA input capacitance, at the beam frequency, in quadrature with BB-BPM-FEFA input resistance.

Note: Under calibration test conditions, BB-BPM-FEFA conversion gain ≈ 7dB.

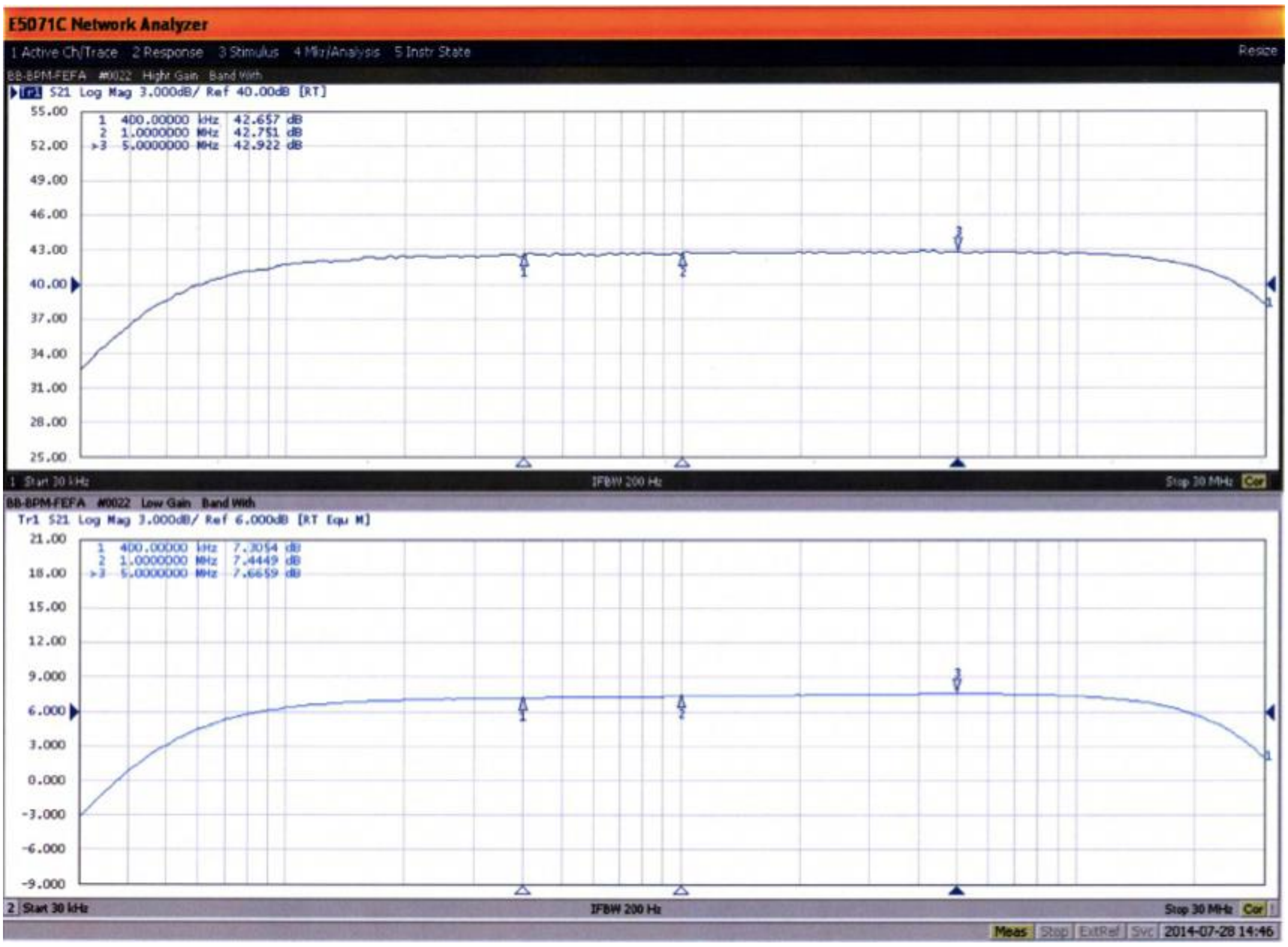
b) BB-BPM-FEFA 50-ohm amplifier adds 33 dB to the conversion gain, for a total > 40dB. Exact gains are reported in the measurements attached to the Certificate of Calibration.

Gain LOW is BB-BPM-FEFA conversion gain only (FO control light OFF)
Gain HIGH is BBPM-BPM-FEFA conversion gain + 50-ohm amplification (FO control light ON).

Gain vs. frequency

Gain and frequency bandwidth are customized to synchrotron specifications. Example:

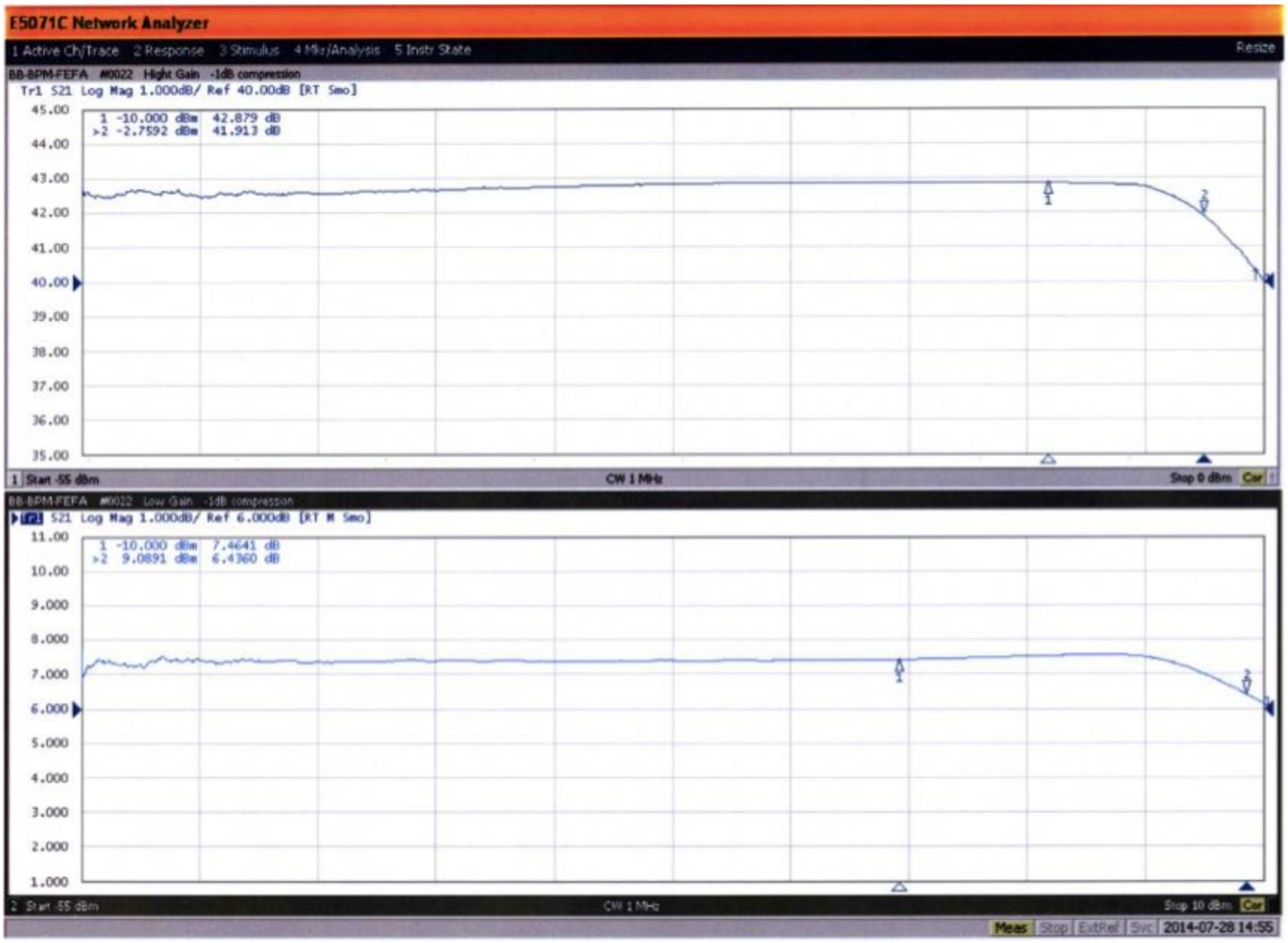
- Top chart: HIGH gain in range 30 kHz to 30 MHz
- Lower chart: LOW gain in same range.



-1 dB compression point

Gain compression can be a problem in position measurement when compression for opposing BPM pickup electrodes is different. Compression is monitored for each BB-BPM-FEFA:

- Power sweep thru L-pad from -55 dBm to +10 dBm at 1 MHz
- Top chart: HIGH Gain
- Lower chart: LOW Gain (conversion gain only).



Gain matching

BB-BPM-FEFA are gain/frequency matched in groups of four units to each BB-BPM-E board. Each BB-BPM-FEFA label indicates the BB-BPM-E serial number and input (A, B, C or D) it is matched to.

Input characteristics

Connector SMA jack for 50-ohm coaxial cable, as short as possible.
Input impedance 400 kΩ + 80 pF

Note: Capacitance of BPM electrode to FEFA cable adds to the FEFA input capacitance: It must be minimized.

Output characteristics

Beware: Output also acts as +15V power input!
Connector SMA jack for 50-ohm coaxial cable.
Output impedance 50 ohms

Note: The output SMA connector also serve as the input for the +15V power supply. +15V is supplied to FEFA by BB-BPM-E via the RF cable, when the +15V jumper on-board BB-BPM-E is ON (vertical orientation).

Controls

Input control	GAIN-Trigger-input

FO input connector IF-D97 Detector Photolog FO 400-1050nm, manufactured by Industrial Fiberoptics

Color	BLACK.
Light ON	Gain ON
Light OFF	Gain OFF
Default state	Gain OFF

Output control	GAIN-Trigger-output

FO output connector IF-E98 manufactured by Industrial Fiberoptics

Color	BLUE.
Gain ON	Light ON
Gain OFF	Light OFF

Note: GAIN-Trigger-output purpose is to set the gain of next BB-BPM-FEFA
Note: GAIN-Trigger-output of last BB-BPM-FEFA may be used to check that all BB-BPM-FEFA received the GAIN-ON control signal.

FO specifications

1-mm multimode simplex fiber coated.
E.g., ESKA-Series FO, e.g., Industrial Fiber Optics 810004.

Power consumption

BB-BPM-FEFA +15V typical current:

HIGH Gain	90 mA
LOW Gain	77 mA

BB-BPM-FEFA power is supplied by BB-BPM-E via the coaxial cable.

Enclosure dimensions

Length:	115 mm
Width	57 mm
Height	32 mm

SCHEMATICS & BOARD LAYOUT

Schematics and board layouts of our instruments remain the exclusive property of Bergoz Instrumentation at all times. They are protected by the copyright laws.

Schematics and board layouts are not delivered with our instruments. They can be obtained at the specific request of the instrument's user.

A request should be sent by email, worded in the following way:

To: Bergoz Instrumentation

*From: *User's name**

Date: ....

I am a user of instrument type xxx-xxx serial nr. xxx,xxx,xxx,xxx, etc.
Please send me one copy of the corresponding schematics and board layout.
I will use it for the instrument's maintenance only.
I will make copies only for my own use.
I will inform others who need these schematics that they should request them from Bergoz Instrumentation.

Signed: ....

ACKNOWLEDGEMENTS

BB-BPM-E are based on the Log-ratio principle. The fundamental principle of Log-ratio BPM was developed by Robert E. Shafer†, initially at Fermi National Laboratory, then at Los Alamos National Laboratory. We sincerely thank him for his considerable contribution.

Our BB-BPM-E module initial versions were developed by Alexander Kalinin. The version available at the time of printing this manual is a redesign of Kalinin's work with considerable additions by Sebastien Artinian and Remi Lubes.

Last revised: Saint Genis Pouilly, November 2020