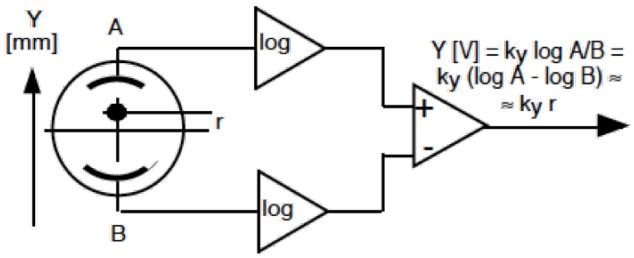
LR-BPM – Log-Ratio BPM Electronics

Non-interceptive beam position measurement
Optimal for single-pass short bunches
Linacs, transfer lines, first turns fast-cycling synchrotrons, boosters
Beam charge range >50dB

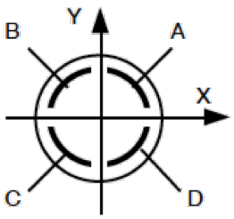
The Log-ratio BPM was developed by Alexander Kalinin, with contributions from Jim Hinkson and Klaus Unser. Based on Robert E. Shafer original concept.

Operating principle

Based on the pioneering work of Robert E. Shafer at Los Alamos Laboratory, the Log-Ratio BPM derives beam position from logarithm of the ratio of opposite pickup signals: Log(A/B).
Position measured by this method is more linear, over a wider range, than difference-over-sum.



The position of the beam from rotated pickups is obtained by axes translation to the vertical resp. horizontal plane by wideband analog circuits.



Signal processing

Signals from the pickups are stretched to produce bursts. This is essential to measure the single pass of a bunch. Four parallel logarithmic amplifiers detect the burst envelopes. Amplifiers' response is log of amplitude. Logs of opposite pickups are subtracted. If pickups are rotated, axes are translated to obtain X and Y positions. The process is all-analog, wideband.

The Log-Ratio Beam Position Monitor (LR-BPM) is an electronics module for fast analog processing of beam pickups signals.

Input signals parallel processing allows single-pass position measurement.

Bunches at any repetition rate up to 500MHz. Individual bunches can be distinguished from one another up to 5 MHz repetition.

L-band, S-band, X-band beams can be processed provided bunch groups are short (<3 ns).

±2V X and Y outputs are held until the next bunch when Sample & Hold mode (optional) is activated.

Provides log signal from each pickup electrode for computer analysis, with 5MHz bandwidth.

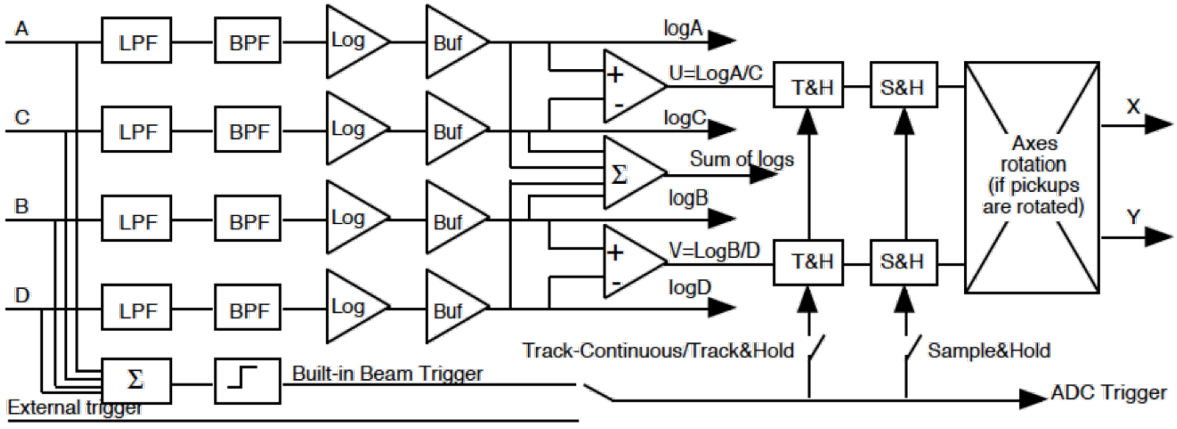
Log-Ratio BPM is plug compatible with Bergoz multiplexed BPM.

LR-BPM may be custom-built on daughter card for installation on user's DSP mother boards.

Cables length matching not critical: pickup signals don't need to be in phase

LR-BPM – Log-Ratio BPM Electronics

Block diagram



Specifications

Measures from single-pass bunch up to X-band under certain conditions.
Below 5MHz repetition rate, individual position is reported.
Above 5MHz repetition rate, average position is reported, with 5MHz response.
The input filter frequency f determines the acceptable bunch width.
Filter frequency f is specified in Ordering Code LR-BPM-xxxMHz. Max. 500MHz.

Beam intensity range	>50dB. Single bunch 30pC ... 10nC
Single bunch (or group of bunches)	width ≤1/2f E.g. for f=50MHz: 10ns max width; f=500MHz: 1-ns max width
Bunch/group trains	f = repetition rate or multiple of rate $f$max=500MHz
Output frequency	<5-MHz rep rate, individual position is measured >5-MHz rep rate, average position is reported with 5-MHz bandwidth
Input signal max.	
Single bunch	10V in 1ns, 50Ω
Bunch trains	depends on f. At 500MHz: +5dBm, 50Ω
Outputs	X and Y: -2V...0...+2V, 40mA max Sum of logs: 0...+2V, 40mA max.
X and Y gain	1.5V = 1/2 of aperture radius for orthogonal pickups 1.0V = 1/2 of aperture for rotated pickups
Noise rms	
Single bunch	<3.5E-3 of aperture, e.g. <150µm in 20mm radius. Below 10pC (≈ 6E7 e-), increases 20dB/decade
Bunch trains	<2E-3 of aperture, in 0...5 MHz bandwidth, e.g. <100µm in 20mm radius Below -40dBm, increases 20dB/decade. Decreases with square root of bandwidth: E.g. <15µm above -40dBm in 100 kHz in 20mm radius.
Beam intensity position dependence	
On center	Near zero.
Off-center	Worst case when beam is 6dB off center (e.g. ±7mm in a 20mm radius aperture): ±3%
Temperature drift	0.6E-3 of aperture per degree, e.g. 25µm/K in 20mm radius aperture
Trigger output	>10-ns trigger after single bunch
Power supply	+15V, <300 mA; –15V, <300 mA

Order codes

LR-BPM-xxxMHz	Log-ratio BPM plug-in module

On-board factory-installed options:

LR-BPM-SH	Sample and Hold on X and Y outputs
LR-BPM-TRG	Beam Trigger, built-in
LR-BPM-SUM	Sum of log (A,B,C,D)

Accessories:

BPM-RFC/xx	RF-chassis, ≤16 stations 19" rack-mountable 3U-high EMIRFI-shielded chassis for 100~240V 50~60Hz mains power, features up to 16 stations for any mix of Log-ratio BPM or Multiplexed BPM
BPM-KIT	Table-top test kit 100~240V 50~60Hz powered kit Pickup inputs on SMAs Outputs on BNCs and DB15
BPM-XTD	Module extender card
BPM-SERV/RF	RF service module Passive module. Brings the pickup signals from the back connectors to front panel BNCs

Packaging

LR-BPM module is 3U-high x 160mm shielded Euromodule; 20-mm wide.
Interchangeable / plug-compatible with Bergoz Instrumentation Multiplexed BPM modules. Both log-ratio and multiplexed BPMs can be installed in same chassis for mixed applications.
LR-BPM can be supplied as a custom-built daughter card for user installation on DSP mother boards.