Calibration System Operation
for the
Recycler Ring BPM Front-end

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Introduction

The Recycler BPM front-end contains a calibration subsystem to aid in evaluating the integrity of the BPM data signal path from preamplifier inputs to high-level application program displays. The subsystem allows application programs to configure specific calibration signal conditions, arm measurements and request calibration data for analysis, display and archiving.

The calibration subsystem hardware consists of a single arbitrary waveform generator (AWG) located in the front-end VME crate, a calibrated signal distribution system and control switches located at each preamplifier's input stage. The AWG can be configured to produce one of three predefined waveforms to simulate bunched 2.5 MHz beam, de-bunched barrier bucket beam or a composite of both. To simulate varying beam intensity the AWG output amplitude can be set to any of four predefined signal levels. The signal distribution system contains resistive pads to assure that calibration signal levels are (substantially) equal at all preamplifier locations. The preamplifier control switches allow the calibration waveforms to be applied to both test inputs equally or to be attenuated at one input with respect to the other to simulate beam on and off center position. Software elements in the front-end receive and interpret application program generated calibration specifications and configure the calibration hardware accordingly.

Since a primary goal of the calibration subsystem is to evaluate the end-to-end integrity of the signal processing chain, there are no special calibration measurement requests or data types. An application program sends a **Calibration Specification** to establish test conditions and then sends an interactive **Acquisition Specification** to arm a measurement trigger. After the measurement trigger identified in the acquisition specification occurs the application program retrieves the measurement data by sending a **Readout Specification** and then reading the desired data. With this scheme all analysis and display applications are capable of displaying calibration data.

Calibration Specification

Calibration conditions are established by setting the R:BPxCAL device which is a 32 bit unsigned integer defined as follows:

```
typedef enum {             // calibration generator signal amplitudes
  kCalibrationAmplitudeMin = 0,
  kLevelOff = kCalibrationAmplitudeMin,        // +/- 0.00 Vpp
  kLevelLow,                                   // +/- 0.15 Vpp
  kLevelMedium,                                // +/- 0.38 Vpp
  kLevelHigh,                                  // +/- 0.75 Vpp
  kCalibrationAmplitudeMax = kLevelHigh,
  kNumCalibrationAmplitudes
} eCalibrationAmplitude;

typedef enum {             // calibration generator signal waveforms
  kCalibrationWaveformMin = 0,
  kBunched = kCalibrationWaveformMin,
  kDeBunched,
  kBoth,
  kCalibrationWaveformMax = kBoth,
  kNumCalibrationWaveforms
} eCalibrationWaveform;

typedef enum {             // preamp test input relative amplitudes
  kCalibrationBalanceMin = 0,
  kCalibrationDisabled = kCalibrationBalanceMin,
  kBalanced,
  kUnbalanced,
  kCalibrationBalanceMax = kUnbalanced,
  kNumCalibrationBalances
} eCalibrationBalance;

// structure sent by ACNet to specify  calibration  signal conditions
// R:BPxCAL
class CalibrationSpecification {
  unsigned long int              mustBeZero : 8;
  eCalibrationAmplitude          amplitude : 8;
  eCalibrationWaveform           waveform : 8;
  eCalibrationBalance            balance : 8;
};
```

Setting the R:BPxCAL device does not invoke a calibration measurement, it simply configures the calibration signal conditions. To disable the calibration subsystem the balance field of the R:BPxCAL device must be set to kCalibrationDisabled. This may be accomplished by sending a value of zero for the entire 32 bit structure.

Acquisition Specification

After configuring the calibration waveform characteristics as described above the application program configures a BPM measurement with normal interactive position measurement requests. To arm a calibration measurement the application program sends an acquisition specification to the interactive element (element zero) of the R:BPxACQ acquisition specification array device. The acquisition specification defines the type of measurement to be made and the measurement trigger conditions. Setting the acquisition specification arms the acquisition, enabling data collection when the specified trigger conditions are met.

A detailed description of acquisition specifications and the measurement request process is available in the "Event Driven Data Acquisition for the Recycler Ring BPM Front-end" document. The console application support library contains routines for making measurement requests.

Readout Specification

After the trigger event specified in the acquisition specification occurs the application program reads the calibration data with normal readout requests. To retrieve calibration data the application program sends a readout specification to the appropriate readout specification device and then reads the data from the related scaled or normalized data device. The readout specification must reference the interactive element (element zero) of the R:BPxACQ acquisition specification array device.

As indicated above there are two data readout devices for each BPM data type. The 'scaled' devices return position and intensity values in engineering units. The 'normalized' devices return position values with a range of +/- 1.0 and intensity values with a range of 0.0 to 2.0 representing a fraction of full scale.

There are five readout specification devices and five readout data devices, one for each type of BPM data. The table below indicates the names for the devices.

Specification Device	Scaled Device	Normalized Device	Data Type
R:BPxBFS	R:BPxBFV	R:BPxBFN	background flash
R:BPxBCS	R:BPxBCV	R:BPxBCN	background closed orbit
R:BPxFLS	R:BPxFLV	R:BPxFLN	flash
R:BPxCOS	R:BPxCOV	R:BPxCON	closed orbit
R:BPxTBS	R:BPxTBV	R:BPxTBN	turn-by-turn

A detailed description of readout specifications and the data readout process is available in the “Event Driven Data Acquisition for the Recycler Ring BPM Front-end” document. The console application support library contains routines for collecting measurement data.

Analog Scale Factors

The raw MADC data are converted to scaled position and intensity proportional form with engineering units of mm and *sum***.** The coefficients for gain and offset scaling are stored in a three dimensional array:

```
scaleCoefficient[ 48 ][ 2 ][ 2 ],
```

or

```
scaleCoefficient[ channel ][ type ][ term ],
```

where:

channel - BPM channel in the range 0 to 47

type - data type as follows:

zero - position

one - intensity proportional

term – gain and offset coefficients as follows:

zero – offset

one - gain

A flattened version of the three dimensional array containing the coefficients for all channels is available as device R:BPxCFS. Length and offset (both in bytes) may be used to specify coefficients for individual channels or ranges of channels.

End.