Emittance Measurement Device

Type DE 010

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Principle:

Via a narrow slit, part of the beam is selected for measurement. Behind the slit, a detector system is positioned, permitting measurement of beam divergence for the selected bundle. This is accomplished by means of current measurement on the multistrip collector array. Slit and detector system move together with high precision transverse to beam direction, and an intensity profile is measured for each selected position.

Measurement system consist of subsequent components:

1. Precision high-vacuum feedthrough which provides desired movements of slit and detector assembly inside an emittance measurement chamber (2 x).

2. Emittance measurement chamber for installation of two (2) measurement systems (1x for X- direction and 1 x for Y-direction; Z-direction = beam direction). Chamber is provided for integration into beam transport system.

3. Slit and detector assembly (2 x).

4. Signal-processing system, including an appropriate interface for computer control.

NOTE: The advantage of the described emittance measurement device is its compact system design. Slit and detector are mounted to a common support arm and move across the beam path by only one (1) highly precise stepping motor unit. This is our standard design.

Devices used at various accelerators are subject to diversity; therefore, it is possible to modify our design to meet customer requirements (i.e. mechanical and electronics control can be modified.)

Technical Specifications

A. Precision High Vacuum Feedthrough:

Material	:	Stainless steel
Stroke	:	4.0 inches (standard)
Drive	:	1.8° stepping motor
Conversion of rotation into translation	:	ball screw
Pitch of spindle	:	5.0 mm
Gear ratio	:	1:2
Displacement per 1.8° step	:	0.0125 mm
Speed (maximum)	:	Approx.. 10 mm/second
Maximum acceleration (5 lbs. inertial load)	:	30 mm/second^2
Magnetic brake	:	24V (max. 0.4A)
Position measurement	:	Linear potentiometer or angular encoder

Technical Specifications (continued):

Resolution of position measurement	:	Potentiometer: 0.1 mm Encoder: 0.0025 mm
Limit switches	:	Adjustable
Dimension of supporting flange	:	CF-150 (8 inches O.D.); also CF-100 (6.0 inches O.D.); other sealing systems possible
Vacuum sealing	:	CF-system; membrane bellow
Leak rate (maximum)	:	10^{-9} Torrs x liters/second.

NOTE: Different strokes and/or configurations are available on request.

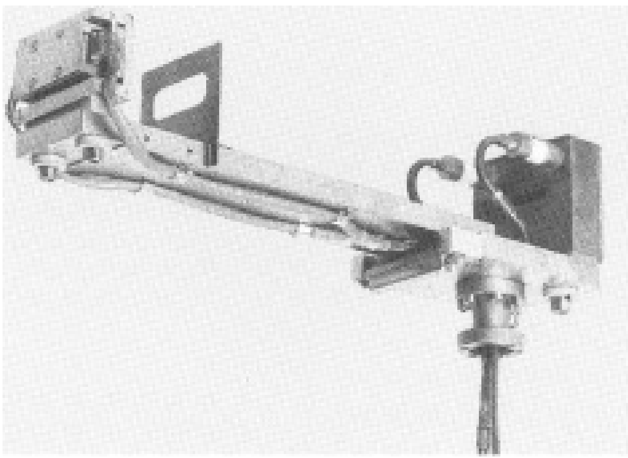

Fig. 2.

EMITTANCE DETECTOR
Tantalum plate with slit mounted on a copper block, supporting bar and multistrip detector array.

B. Emittance Measurement Chamber:

Material	:	Stainless steel
Overall length	:	18.50 ± 0.02 inches
Diameter beam entrance/exit holes	:	3.937 ± 0.004 inches
Chamber diameter	:	9.843 ± 0.02 inches
Chamber height (including pumping port)	:	16.929 ± 0.02 inches
Number of flanges for assembling emittance measurement device/beam diagnostic elements	:	Six (6)
Flange orientations	:	Radial in two (2) planes: Plane 1: three (3) CF-150 (8 inches O.D.) Plane 2: three (3) CF-100 (6 inches O.D.)

Technical Specifications (continued):

Distance between flanges and beam axis	:	7.087 ± 0.004 inches
Parallelism	:	0.004 inches
Number of flanges provided for vacuum gauges/current feedthroughs	:	Two (2) CF-35 (1.35 inches O.D)
Orientation	:	45.0 and 135.0
Distance to beam axis	:	5.90 ± 0.04 inches
Pumping port	:	One (1) CP-150 (6 inches)
Distance to beam axis	:	9.84 ± 0.4 inches
Sealing	:	Conflat flange, Cu-gaskets
Leak rate (maximum)	:	$10E^{-9}$ Torrs x liters/second
Surface treatment	:	Glass bead blasting (dry procedure)

The above tolerances will guarantee a reproducible mounting of the Measurement System. Dimensions of the chamber as well as the type of flanges used may be changed according to special requirements.

C. Slit and Detector System:

Slit support	:	Cooled copper block (cooling through hollow spindle of precision high-vacuum feedthrough)
Material of slit aperture	:	Tantalum
Slit dimension	:	0.004 x 1.38 inches
Beam power (maximum)	:	6 kW (DC)
Tubes for cooling	:	Copper with ceramic insulator
Cooling medium	:	Deionized water (recommended conductivity: 2.5 – 2.5 x 10^{-6} mho/inches)
Water for cooling (60 psi)	:	70 gal./hour
Distance between slit and detector system	:	11.8 inches – adjustable
Number of detector strips	:	32
Dimensions of detector strips	:	0.004 x 1.97 x 0.2 inches (Thickness of strip determines the angular resolution and can be selected)
Collector strip material	:	Tungsten

Technical Specifications (continued):

Insulation between strips	:	Aluminum
Position resolution	:	0.004 inches
Angular range	:	± 15 mrad (typical)
Angular resolution	:	± 1 mrad (typical)

D. Signal-processing System:

Principle	:	Current to voltage conversion using operational amplifiers or switched integrators, depending on the time structure of the beam. Current to voltage conversion is performed for all channels of the multi-array detector. For normalization, the current measured on the slit jaws is also digitized.
Beam particle species	:	Positive or negative (has to be specified)
Number of ranges for I/V		
Conversion	:	Six (6)
Ranges (profile detectors)	:	10 nA/V, 100 nA/V, 1 μA/V 10 μA/V, 100μA/V, 1mA/V
Range (slit current)	:	1 μA/V, 10 μA/V, 100 μA/V, 1 mA/V, 10 mA/V, 100 mA/V
Range selection	:	Automatic by local front end processor or PC
Offset compensation	:	In case of pulsed beam, automatically performed by a local microprocessor (Motorola type) between the beam pulses. For a DC beam, the offset compensation is performed while the stepping motors move the detectors into the beam.
Integration times	:	50 μs – 20 ms in steps of 50 μs
Delay (after trigger)	:	50 μs – 20 ms in steps of 50 μs
Remark	:	The delay is provided to allow measurement of emittance within a selected window of a pulsed particle beam. In case of a DC beam, the trigger will be derived from the line voltage and the integration time is fixed to one period of the line voltage. No delay is available in this case.
Digitization	:	All I/V channels with a 14 Bit ADC, controlled by the local microprocessor. The ADC overflow is used to set the I/V converters to the correct range.
Position measurement	:	Using a linear potentiometer, the voltage measured at the slider is digitized. Using an absolute angular encoder (recommended), the measured bit pattern determines the position of the feedthroughs.
Protection of hardware	:	The status of the inner and outer limit switches is used to derive an interlock to avoid destruction of parts by moving more as one diagnostic device to the same position as the beam pipe.

Technical Specifications (continued):

Stepping motor control	:	Performed by a special board for each stepping motor equipped with its own Motorola microprocessor.
Magnetic brake activation	:	By local microprocessor to stop further movement of the feedthrough after a specified position has been settled.
Cabling	:	Due to the very low signals transmitted from the detectors to the I/V converters, the distance between mechanical parts and the front end electronics should not exceed 10 m. High quality cables of low capacitance are used to minimize noise.
Connection to PC	:	Light links or an Ethernet interface is provided to connect the front end electronics with the Motorola multiprocessor system on the boards with the PC.
Control software	:	The relevant measurement parameters like phase plane (horizontal or vertical), start position, step width of the feedthrough, final position, or number of steps, etc. have to be specified via menu selection by the operator. After that has been done, the local multiprocessor system performs the complete measuring algorithm automatically and transmits the digitized data to the PC.
Evaluation software	:	In the PC, complete software for emittance evaluation and display of relevant data will be implemented. For example: emittances may be calculated and displayed for given percentages of intensity including fit of ellipses as well as determination of TWISS-parameters and rms emittances. An editing mode will allow the reduction of noise from the rough data by manual operation. Display of results can be performed in 2D or 3D.
Optional software	:	Additional software like the determination of the percentage of beam within a specified acceptance or transformation of the measured emittance pattern by beam transport elements (drift space, quadrupoles, etc.) can be implemented on demand.
Remark:	:	In case a harp mounted on its own feedthrough is used to measure beam profiles, beam profile monitoring will be possible by moving only the harp into the beam and transmitting the measured profiles continuously to the PC for observation in video mode.

Technical Specifications (continued):