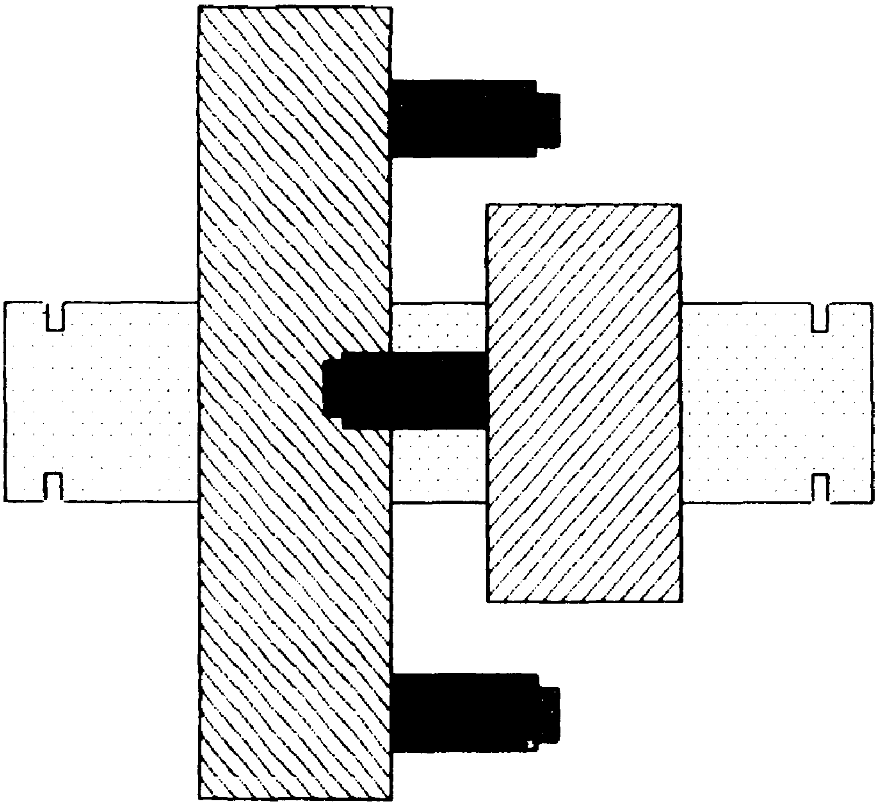
NIKHEF TRAVELING WAVE MONITOR

USER GUIDE

27-11-1984/T.Sluijk



NIKHEF-K
- LINO 121.

NIKHEF
Amsterdam
Holland

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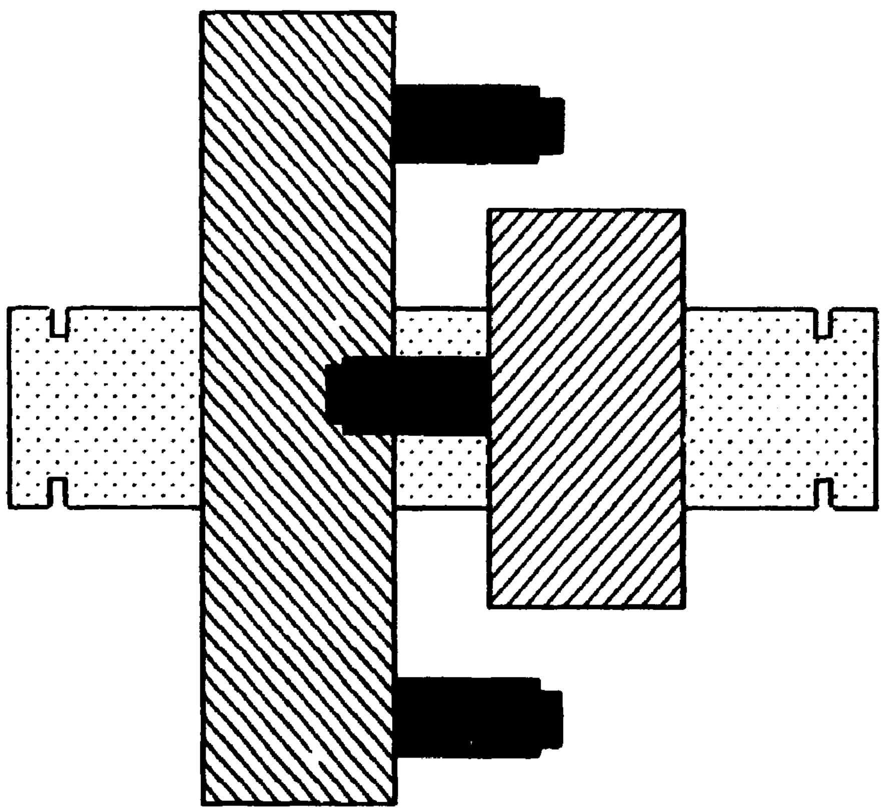

LINO 121

NIKHEF
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TRW–monitor user–guide

21–1–85/TS

contents

part1 Introduction 1

part2 Instructions for use
- –principle 3
- –Installation 3
- –using the monitor
  - –controls 4
  - –xy signals 5
  - –current signals .. 6

part3 Service
- –documentation reference list 7
- –avoiding difficulties 8
- –list of connectors 10
- –drawings 11

Part 1
Introduction.

Introduction:

The NIKHEF "Travelling wave Monitor" (TWM) is a sensitive, non intercepting device to measure beam displacement. The measurement is independent of the beam intensity. The TWM consists of a waveguide assembly and separate electronics assembly.

Specifications:

Type of monitor:	Non-intercepting
Absolute accuracy:	+/- .5 mm referring to the mechanical center of the waveguide.
Relative accuracy:	+/- .1 mm
Position sensitivity:	1 V/cm
Current sensitivity:	Not specified but linear output.
Dynamic range:	30 µA - 10 mA. In this case the error will be within .5 mm.
Risetime:	.3 µSec.
Radiation Resistance:	High, due to the application of radiation resistant materials.
Vacuum performance:	Suitable for high vacuum systems. (10e-8 to 10e-10 Torr)

PART 2

INSTRUCTIONS FOR USE

1. Principles of operation

2. Installation

3. Remarks

4. Using the monitor

1. Principles of operation.

The TWM utilizes the RF interaction existing between the waveguide and the beam. The RF energy abstracted from the beam passes trough the waveguide in the direction of the pick-up aerials (left/right/top/bottom). Special attention has been given to matching. The reflection in the system is less then 30 dB. The beam position is determined by the phase difference between the left-hand and right-hand outputs and the phase difference between the top and bottom outputs.
The phase difference is a linear measure for horizontal and vertical beam positions. In order to determine the phase differences the four outputs are mixed with a frequency of 2866 MHz. to obtain an Intermediate Frequency of 10 MHz. The phase differences between left and right and between top and bottom are determined at the 10 Mhz. level. Signal limiters at the 10 MHz. level render the measurement independent of the beam intensity. A set of controllable phase shifters enables compensation to be made for variations in cable lenghts between the sensors and the electronics assembly.

2. Installation.

The monitors are prepared for 110 V AC.
Mating connectors are shipped along to avoid incompatibility and to facilitate installation. The four waveguide outputs must be connected to the electronics assembly with a high-quality coaxial cable. (for instance 1/4" Prod Lin rigid cable). They should be kept as short as possible, although a length of 30 meters has proved to be no problem (J1-J4). For remote calibration two so called DIN connectors are provided. The first connector for mode control, the second for phase shifter control (J6-J13). The following switch panel on the operator's console must be designed to control callibration.

Switch panel: A 3-position switch for:
1. Xcal on
2. Off
3. Ycal on

A 3-position switch for:
1. X forward
2. Off
3. X reverse

A 3-position switch for:
1. Y forward
2. Off
3. Y reverse

See also schematic diagrams and drawings.

For peak beam currents greater then 10 mA it's necessary to install 40 dB miniature attenuators directly on the mixer outputs.
This is done to protect the mixers and to stay in the linear range.
(see also remarks in part 3 of this document.)

For noise suppression (without introduction of dead time) a gate input (J 9) is provided. The gate input is active at a +5 Volt TTL pulse level.
The pulse should overlap the beam pulse width by at least 1 µSec.

3. Remarks

Some optional provisions have been made:

1. A voltage input determining the threshold level for noise suppression of the phase detector. (squelch threshold, J 10)
2. Remote switching of the sensitivity is possible (see intensity–module report). *Control is automatically switched from local to remote as soon as changes* are made. (J 11)
3. A status output for the gain–switch of the intensity module. (closed contacts, J 12)
4. Four current outputs (one for each antenna) are provided of which only one is really needed. The others are for future experiments. (J 14–J 17)

Control inputs are active by applying +24 Volts to the appropriate pin. (For connections refer to the appropriate diagram.)

Status information can be obtained from relay contacts.

4. Using the monitor.

Controls.

The device can be used without remote control.

Exception: In the current mode the sensitivity may be adjusted with a three position gain–switch on the front panel.
For best results remote switches should be installed on the operator's console.

Using the x/y position—signals.

Sensitivity:

The output voltage is calibrated to give 1 Volt (on a 50 ohm load) at 1 cm. displacement. (+/– 10%).
Better calibration can be obtained when using the real beam.

Calibration:

Long cables canot be cut exactly the same lengths.
A difference of 1mm in length gives an output equivalent to about 1 mm. beam displacement.
Thermal fluctuations can also cause drift. (see "avoiding difficulties"). This points out the need for a facility to calibrate the geometrical centre of the monitor.
The built in calibration system decouples one plane of the monitor and applies a reference signal to it.
Owing to the coupling existing between the two waveguide planes, a small amount of the applied RF power is coupled to the second waveguide.
Since the two waveguide planes are symmetrical to each other, the reference signal is coupled into the centre of the second waveguide. By measuring the displacement and adjusting it to zero mm. by means of the built in phase shifters, it has become possible to calibrate the monitor.
The frequency of the reference signal has to be 2856 MHz. and has to have the same pulsed duty cycle as in the accelerator with a power level of about .1 to 1 mwatt.

A typical procedure for calibrating the X—plane:

1. Switch to X calibration.
2. Put the X position signal on the oscilloscope.
3. Press X forward or X reverse until the calibration line is centred.
 (in the middle of the noise band which is shown on the oscilloscope.)

Warning: While calibrating don't look at the wrong plane.

Calibrating the Y—plane is done by following the same procedure for Y.
(see service part for connections and further description.)

Squelch:

Since the position measurement is done by phase detection, a large noise signal will be shown on the osilloscope as soon as the signal gets small, or disappears. Therefore the monitor is provided with a noise suppressor system. Internally, one can select from four options:

1. Sqeulch off.
2. Squelch controlled by an external voltage. (threshold level.)
3. Squelch controlled by an internal adjustable voltage. (threshold level.)
4. Automatic squelch, taking the incoming level into account.

For highest speed the gated option is "factory—selected" (squelch off) so the gating signal is needed.
This option cancels the dead time of the internal squelch control circuits.

Using the current–signals.

The monitor has 4 outputs for a current proportional signal, one for each antenna.
Only one should be enough, but since movement of the beam to or from an antenna gives a slight in/decrease in output (10%), all four outputs are installed for future experiments to compensate for this effect.

Sensitivity:

The output voltage is set to give about 1 Volt full scale (on a 50 ohm load) for 1, 10, or 100 mA with no attenuators installed.
With the suggested 40 dB Attenuators installed for 100 mA beam it will be about 0.1, 1, 10 Amp. full scale.
The cable loss has to be adjusted with inside screw-potentiometers. (+10dB or -10dB adjustable range).

Warning: The reference signal produces a signal when switched on.

Speed:

The risetime of the signal is about 0.3 μsecond.
(See further information DIGEL 40 Intensity Module 820423)

For service please refer to the following manuals:

1. Lino 72 De Travelling Wave Monitor (NIKHEF).
2. Lino 96 TWM uitbreidingen en modificaties (NIKHEF).
3. Digel 40 Intensiteit Module (NIKHEF).
4. TWM Fase discriminator (prelimanary Digel—report NIKHEF).
5. Digel 56 50Ω Line driver (NIKHEFK).

Avoiding difficulties:

Long–cable drift (mm's)
Beam displacement is as small as a few mm.'s Thermal drift along the length of the cable can cause the output signal to drift away. Nikhef used 4 lengths of 1/4" aluminium rigid cable which were thermally coupled (30 meter each) by tying them together. Besides a calibration facility is added. One only needs a calibration session before starting the measurements.
(Be aware that each mm difference in cable length gives about the same amount of beam displacement signal)

Mechanical vibrations:

Avoid the problem of audio noise by using rigid cables. This type of cable gives an extremely good result with no noticeable audio resonances. Some trouble has been encountered when using flexible cables for the monitor. Bending can easily create a phase difference of a few degrees (on our 2856 MHz). This could easily amount to displacement equivalent to 1 mm.

RF–leakage from outside the monitor:

The monitor is able to detect nano–watts of power. Stray electrons from a nearby beam channel can cause some signal on the monitor outputs. This could be confusing, giving the impression of having a real beam in the wrong channel (see the reports for sensitivity specifications).
Leakage can occur from highpowered cables or accelerator sections which are nearby and running on Megawatt levels. (See LINO 72 for attenuation of a peace of round coupling–pipe).
Care should be taken not to place the monitor or cables near high–power elements (2856 MHz).

Limited rise time.

Nikhef has pulses of 50 μsecond lengths so .25 μsecond risetime is sufficient for the system.
The chosen IF of 10 MHz. was high enough for speed, and low enough to make the detection circuits easy. The system seems fit for 3 to 5 times higher speed's using a higher intermediate frequency, but no real experiments have been executed in this respect.

Higher current gives burnout and saturation effects.

The monitor is intended for about 10 mA peak which gives an antenna output of about 10 mWatt max.

A beam current of 100 mA. peak will produce a peak power of about 1 Watt which is above the specified maximum input level of the mixers (50 mW), even after cable attenuation. (for attenuation see next part)
Between 30 µA and 3 nA (in the nikhef case without an attenuator) the phase detector shows no detectable phase–measurement error (<1 degree).
Near 10 mA some saturation effect starts to occur which can give position errors.
It is advised to place 40 dB miniature attenuators directly onto the mixer inputs (not on the external connectors, since this will cause problems with crosstalk of the calibration signal which then has to be increased in power). This will bring the usable range from 3 to 300 mA (see phase detector test report for detection errors). At the same time the power level for mixers is reduced to a safe level.

Frequency drift:

The monitor mixer system can allow for thermal drift from the local oscillator. However, the temperature should stay within reasonable limits.

Remark about the intensity output:

The intensity signal is by no means meant for absolute calibration purposes. This is not possible because of differences in cable–loss, mixer–loss, non linearity of the mixers, and dependence on the distance from the antenna to the beam.

Internally there is still the possibility to adjust the signal to really give one Volt for 1 mA current (0 dB in the nikhef case) When an attenuator of 40 dB is fitted, this factor should of course be taken into account. It is suggested to use the real beam to calibrate the output levels. The outputs are intended for 1 Volt across 50Ω load.

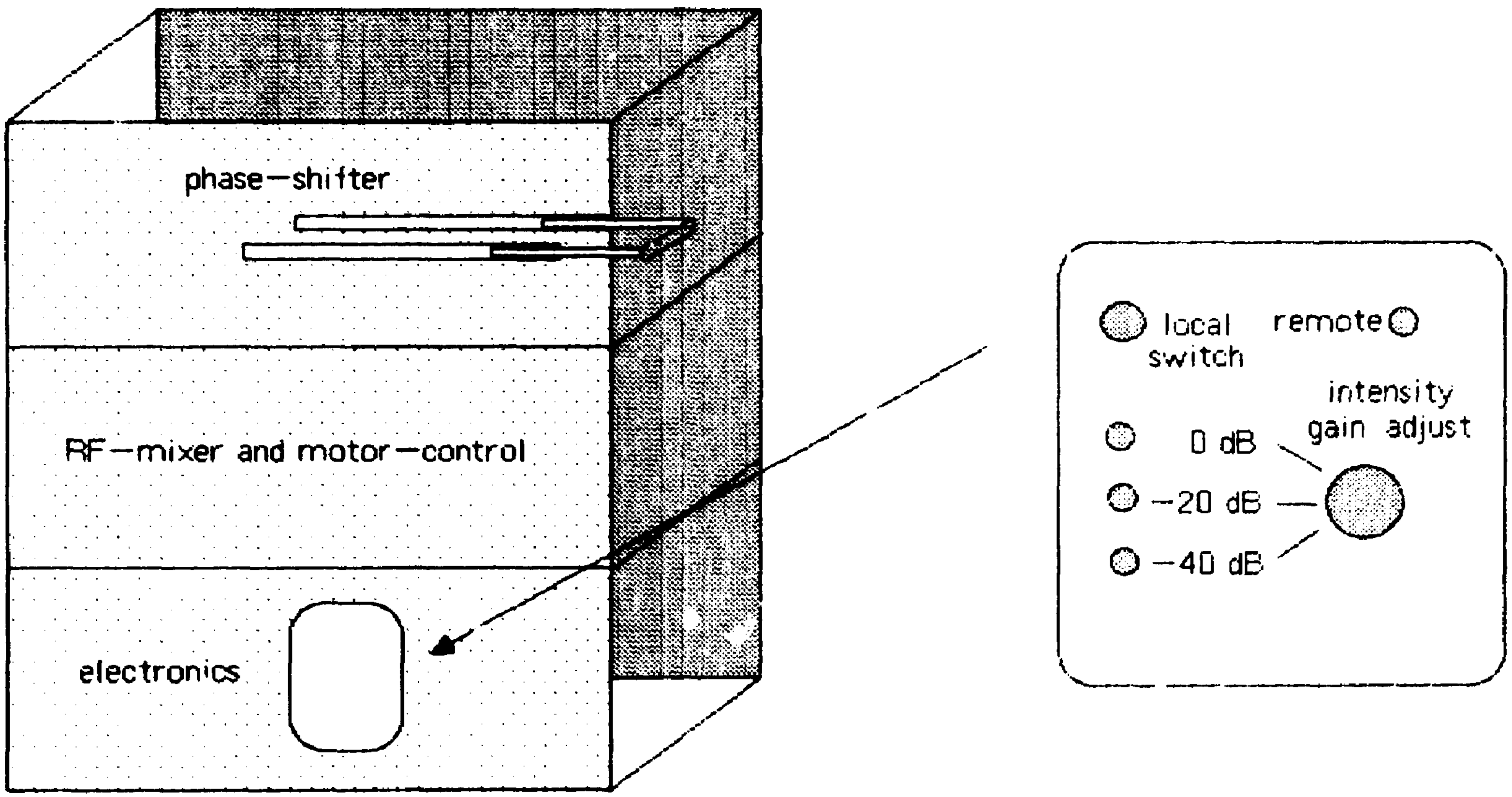
Mechanical details.

Some mechanical problems can be expected, since no advice was available as to the choice of flange couplings. We agreed to use our own system, and tried to be helpful by sending our drawings at a very early stage.

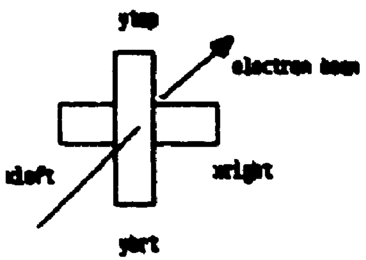
List of connectors:

j1. Ytop input (2856 Mc, low power)
j2 Ybot input (2856 Mc, low power)
j3 Xleft input (2856 Mc, low power)
j4 Xright input (2856 Mc, low power)
j5 RF reference signal (1 mW, 2856Mc)
j6 Motor Control for x and y (+24 V)
j7 Yshift output (y—position—signal, 50Ω)
j8 Xshift output (X—position signal, 50Ω)
j9 gate input (TTL ,important)
j10 Squelch or muting voltage input (not needed when using the gate,0—1V)
j11 intensity gain control inputs (0,—20,—40dB;+24V))
j12 Intensity status outputs (not needed,closing contacts)
j13 Cal switch inputs (x/y,+24 V)
j14 Ytop intensity output (50Ω,1V)
j15 Ybot intensity output (50Ω,1V)
j16 Xleft intensity output (50Ω,1V)
j17 Xright intensity output (50Ω,1V)
j18 110V input

Front view of monitor 27-11-1984/T.Sluijk



view of travelling-wave-monitor 27-11-1984/T.Sluyk



connector layout on waveguides