PERFORMANCE AND PROGRESS OF THE DARESBURY PHOTON BEAM TUNGSTEN VANE MONITOR SYSTEM

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Abstract

The tungsten vane monitors (TVMs) on the SRS at Daresbury are used operationally to monitor the photon beam position and angle on user beamlines. On many of these lines the TVM output is used to perform automatic feedback correction and it is therefore crucial to optimise the TVM precision and stability. Recent changes to TVM bias voltages and amplifier gain are reported which have improved the signal-to-noise ratio and the stability of the calibration. A new procedure, mapping out the vane currents as a function of beam position in two dimensions, has proved a powerful technique for the diagnosis of TVM misalignment and shadowing. Investigation of the stability of the TVM output as a function of the SRS electron beam current are also discussed.

1 PRESENT STATUS

Vertical photon beam monitors are installed on all VUV and X-ray beamlines of the SRS. Additional monitors are planned for installation later this year on two beamlines (5 and 9) with one being a combined vertical/horizontal unit. A new beamline (5 D), with commissioning starting in 1998, will also incorporate 2 photon beam position monitors.

Presently 6 beamlines (2, 3, 5U, 8, 9 and 16) are regularly stabilised with a local vertical feedback system with 3 more beamlines (1, 6 and 7) to follow shortly. The feedback system [1] corrects mainly the drift caused by the thermal cycling of the machine (i.e. day-to-day refill) with a correction every 30 s. All the vertical feedback loops are local using a 3 magnet corrector bump. This means that angle and position cannot be corrected independently. The configuration and design of the TVMs have been reported elsewhere [2].

The control of the TVM system, which had its own dedicated system, has recently been converted to the PC NT/Visual Basic operator interface [3].

2 BIAS AND AMPLIFIER GAIN

The ADC are located some distance from the log-ratio amplifiers and consequently there is a certain amount of noise pickup in the transmission line from amplifier to ADC stage. The log-ratio amplifiers have been operated with a fixed gain and the output sensitivity was adjusted via the TVM bias voltage to achieve a given linear range with a maximum sensitivity so as to achieve a satisfactory signal-to-noise ratio [2]. The amplifier gain on beamlines with low sensitivity has recently been increased by a factor of 10 which allowed a change to an improved bias configuration. All beamlines are now configured with a positive block bias and a negative vane bias, typically -9V on vanes and + 18V for the block bias. This reduces cross-talk between vanes and block. The RMS noise seen by the ADC from the transmission line as well as other contributions is now typically 1 µm equivalent or less, measured with a constant current source input to the log-ratio amplifier at 1Hz, shown in Figure 1 for the beamline 8 TVM.

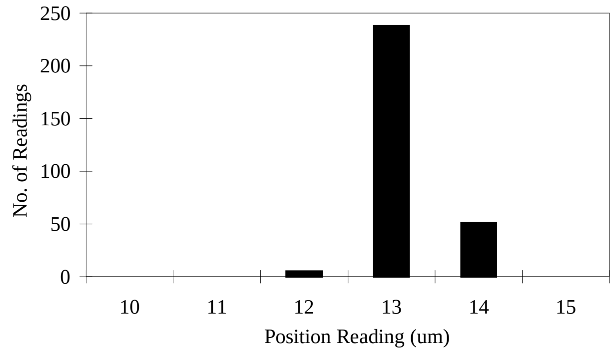

Figure 1: TVM noise equivalent on beamline 8

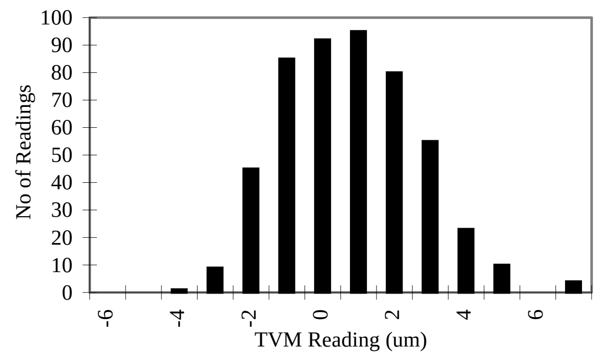

Figure 2: Beam Movement at TVM beamline 8

The beam position stability of beamline 8 TVM, located about 22 m from the tangent point, is shown in Figure 2 taken with local servo active and multibunch beam current 170mA, giving an RMS of 2.5 µm. The data were taken over a period of 10 minutes at 1 Hz. A test on the stability of the calibration factors during November

1995 has shown a variation in the calibration factors of up to about 10%.

3 HORIZONTAL SENSITIVITY

The investigation of the dependence of TVM output on beam position in the horizontal plane was prompted by low vane currents in one TVM and large changes in calibration factors in another. The TVMs have a translation stage only in the vertical direction and horizontal bumps had to be applied to quantify the sensitivity of the monitors to horizontal beam movement. The procedure involves the application of a series of horizontal 3 magnet corrector bumps and the recording of the log-ratio and vane current response over a ± 500 μm TVM position range.

Figure 3 shows the TVM log-ratio response from beamline 9. The TVM in this case was partly shadowed (probably an aperture) and thus a strong dependence of the calibration factor on the horizontal beam position was observed.

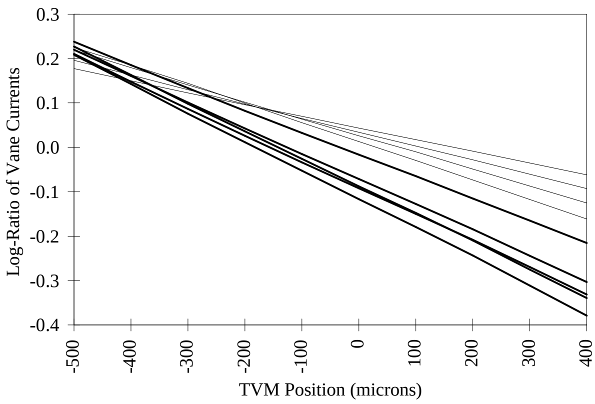

Figure 3: Sensitivity of beamline 9 calibration: (from top) -2 to + 2 mm horizontal bump in 0.5 mm steps before position adjustment.

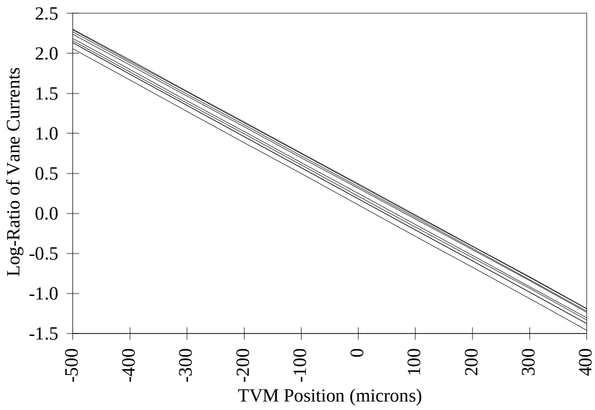

Figure 4: Sensitivity of beamline 9 calibration, bump settings as in Fig 3, after position adjustment.

The horizontal TVM position in the beamline was subsequently adjusted and the measurements were repeated. The response after the modification is shown in Figure 4. All the photon monitors have since been investigated and only 2 beamlines (1 and 9) have shown a significant sensitivity to horizontal movement over the range shown in Figs. 3 and 4. The sensitivity on beamline 1 was due to a large discrepancy between surveyed and actual beam position. The monitor problems on these beamlines have now been rectified.

Figure 4 shows a series of nearly parallel lines. It should be noted that while variations in the gradient of these lines are ascribed to TVM non-linearity or mis-alignment/shadowing phenomena, the offset of each line is not necessarily related to TVM behaviour. In particular, field and alignment errors in the horizontal steering magnets used in the bumps give rise to a vertical component equivalent to a small field change on vertical steering magnets. Thus magnet field shape or alignment errors are expected to cause a small offset between the curves at each bump setting, the magnitude of which should be proportional to the bump amplitude used. Figure 5 shows the offset as a function of bump size for TVM 6; here the offset is defined as the TVM reading at the TVM encoder zero position (i.e. nominal beam height) for each bump setting.

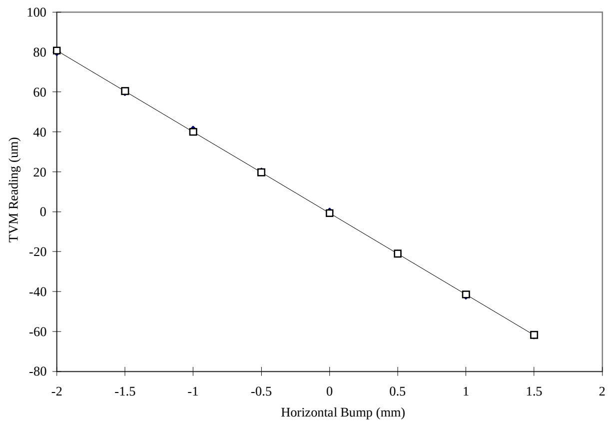

Figure 5: TVM 6 reading as a function of applied horizontal bump

A linear fit to the data-points provides a good description of the offset behaviour with a maximum deviation from linearity of less than 1 μm. This is consistent with recent studies of magnetic "crosstalk" effects due to field/alignment errors [4]. Only a non-linear dependence of the offset on applied horizontal bump amplitudes indicates a possible TVM (rather than magnet alignment) problem.

4 CURRENT DEPENDENCE

To test the dynamic range of the TVM position output, the SRS beam current was reduced with the aid of the beam collimators and the apparent position change on the TVMs observed. The current dependence of the TVM output on most beamlines is very small, however 3 beamlines (1, 8 and 9) have in the past shown a change in TVM position output of up to several hundred µm. For beamlines 1 and 9 this was related to horizontal shadowing of the TVM blades while on beamline 8 a buckled bellows liner caused a vertical shadow. Figure 6 and 7 show the present current dependence of the position output.

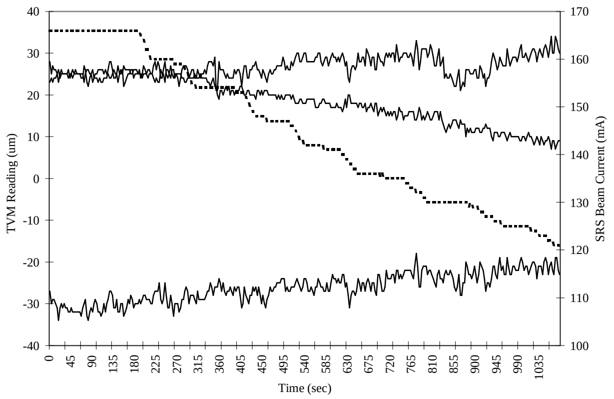

Figure 6: Current dependence of TVM position reading**,** from top(right): 1,8 and 9 after modification. Dashed line indicates beam current

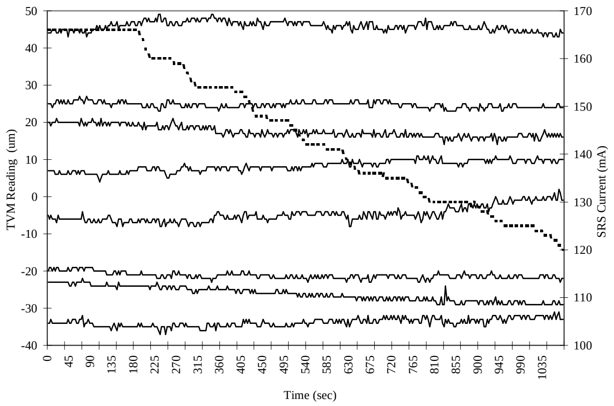

Figure 7: Current dependence of TVM position reading**,** from top(right): beamlines 4, 6, 5, 3, 1, 2, 13 and 7. Dashed line indicates beam current

It is difficult to separate current dependent effects from real beam motion and such measurements are therefore usually carried out at a time when the the beam drift due to thermally induced movement is small [5] but the current still large enough to give a reasonable range of current. Beamlines 8, 9 and 16 TVMs, shown in Figure 6, show a change in reading between 10 - 15 µm, however they are located furthest away from their respective tangent points. All other beamlines show around a 5 µm change in TVM reading. Looking at the data in Figs. 6 and 7 there is no correlation between the step changes in beam current and the TVM reading and so the changes in the TVM readings are likely to be real beam motion. There will also be some remaining thermally induced beam drift over the time the experiment took to complete. Thus assuming that some of the position drift in Figure 6 and 7 is real beam movement the current dependence of the TVMs is negligible.

5 SUMMARY

Recent changes in gain and bias that have been introduced have reduced noise and improved stability. Horizontal shadowing problems have been identified through mapping of the TVM response and consequently rectified. The current dependence of the TVMs is negligible. The operation so far of 6 local vertical servo loops is working well. The introduction of second TVMs on some beamlines in the near future will provide information about beam position and angle and offer the possibility of a servo correction of angle and position on these beamlines.

REFERENCES

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