I^2C settings for APV operation at cold temperatures – measurements on a TOB module

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1. Introduction

This note gives recommendations for optimum APV bias register I^2C settings for TOB modules, resulting from studies on a 4 APV TOB module (type 3.4.12.12(OB_L12P.4U)). Details of the measuring technique will not be repeated here, since the method used was essentially identical to that used for TIB module studies, previously described in a note [1], where an explanation of the origins of the power consumption dependence on temperature can also be found. The TIB results and some additional information can also be found in Powerpoint form [2].

Recommended values for CMS operation at -10° C

Table 1 lists recommended APV25 I^2C bias current settings for a range of TOB hybrid temperatures. The performance and power consumption dependence on I^2C bias register settings is sufficiently weak that a single set of parameters can be used to cover a reasonable temperature span, at least ±5° and probably more. The values for the -10° column in table 1 are recommended for CMS operation, and are identical (as expected) to those previously specified for the TIB [1]

Cautionary note

While values for VPSP, ISHA and VFS are listed in table 1, these parameters should be considered as variables. VPSP sets the analogue baseline level and should always be 'tuned' to position this appropriately. The values for the pulse shape tuning parameters ISHA and VFS listed in table 1 were found appropriate for the particular APV on the TOB module used for this test.

2. Details of results and discussion

Table 1 summarises the results of the measurements on the 4 APV25 chip TOB module. The measurements are taken from the APV chip designated #5 in figure 1. The hybrid surface temperature was monitored in the centre between the two pairs of APVs.

The lowest temperature used for this module was -15^o. At lower temperatures problems were encountered with operating this module. Nevertheless -15^o is still 5^o below the nominal CMS operating temperature and is sufficient for the purposes of this study.

The method used was identical to that used for the previous TIB module study [1]. The standard parameters were used at $+30^o$ and the I^2C bias current parameters were adjusted to achieve a similar module power consumption at the lower temperature settings. This was done before the pulse shape was tuned. Since a lower value of ISHA (the shaper bias current) was required at lower temperatures, the final measured values for module power (after pulse shape tuning) show a small decrease in module power with decreasing temperature. The total module power measurements are similar, though slightly higher, to those measured for the TIB module, but within the expected +/- 10% estimated tolerance [3]. The module power consumption figures will be dominated by the APVs, but also include APVMUX, PLL and DCU chip contributions.

The I^2C bias current settings chosen for $+20^o$, $+10^o$ and 0^o are similar, but not identical, to those found appropriate for the TIB module [1], but in practice the same values could have been chosen without significantly affecting the results. The -10^o values are identical to those for the TIB module allowing a standard identical set of parameters to be specified for both TIB and TOB modules at the CMS operating temperature.

2.1. ISHA, VFS and VPSP

The values for ISHA and VFS in table 1 are those chosen to achieve a peak mode pulse shape close to the ideal, as can be seen in figure 2. This tuning is done "by eye". The pulse shapes were acquired by averaging the internal calibration response for one group of 16 channels. The deconvolution response corresponding to the same tuned parameters is also shown. It was not found necessary to alter the value of VFS. **Note that the optimum choices of ISHA and VFS depend on sensor capacitance and that the values here are for one chip on a particular TOB module**. For other module types different values will be required, and there will likely be some module to module and chip to chip variation within module types.

For these studies the movement in the analogue baseline with temperature was found to be relatively small and so VPSP was left approximately constant at 44, corresponding approximately to a baseline position of 25% of the digital header range. The APV power consumption does depend on the position of the analogue baseline, see [1]

2.2. Pulse height spectra

The peak and deconvolution mode pulse height spectra in figures 3 and 4, obtained using a beta source, show gain and signal/noise increases with reducing temperature, similar to those observed for the TIB module [1].

3. Conclusions

Table 1 lists recommended values for TOB module operation in the +30° to -15° temperature range, and the values for –10 ° are those recommended for initial operation in CMS. The results are very similar to those for the previous TIB module studied, and the –10° values are identical.

The results presented here are for one chip on a TOB module, for which appropriate values for the ISHA, VFS and VPSP parameters were chosen. Some chip to chip and module to module variation in the optimum values for these parameters is to be expected, and significant differences between different module types (different sensor dimensions and hence capacitance) are to be expected.

4. References

[1] http://www.hep.ph.ic.ac.uk/~dmray/pdffiles/cold_APV_params.pdf

[2] http://www.hep.ph.ic.ac.uk/~dmray/pptfiles/APVcold.ppt

[3] http://www.hep.ph.ic.ac.uk/~dmray/pdffiles/APV25 Power Consumption.pdf

Table 1. Recommended APV25 bias parameter values (decimal) for TOB module operation at different hybrid temperatures. The values for the -10° column are those recommended for CMS operation.
* Note that values for VPSP, ISHA and VFS have been chosen for the particular APV on the **T0B** module studied. The optimum values for these parameters will vary from chip to chip and also depend on module type. See text for further discussion.

	Hybrid Temperature °C (± ~2°)					
	+ 30°	+ 20°	+10°	0°	**-10°**	-15°
IPRE	98	94	92	89	**85**	85
IPCASC	52	50	49	47	**45**	45
IPSF	34	33	32	31	**30**	30
ISSF	34	33	32	31	**30**	30
IPSP	55	53	52	50	**48**	48
IMUXIN	34	33	32	31	**30**	30
VFP	30	30	30	30	**30**	30
VPSP*	44*	44*	44*	44*	43*	44*
ISHA*	80*	75*	65*	58*	50*	50*
VFS*	50*	50*	50*	50*	50*	50*
relative test pulse amp. for ICAL = 60 (normalised to + 30° value)	1.00	1.04	1.07	1.11	1.15	1.18
I125 [mA/module]	211	209	209	207	202	205
I250 total [mA/module]	532	531	527	523	524	522
I250 (analog bias OFF) [mA/module]	300	302	301	300	300	301
power [mW/module]	1594	1589	1580	1566	1562	1561

Figure 1. Diagram of module showing Peltier cooling and Pt100 temperature measuring points.

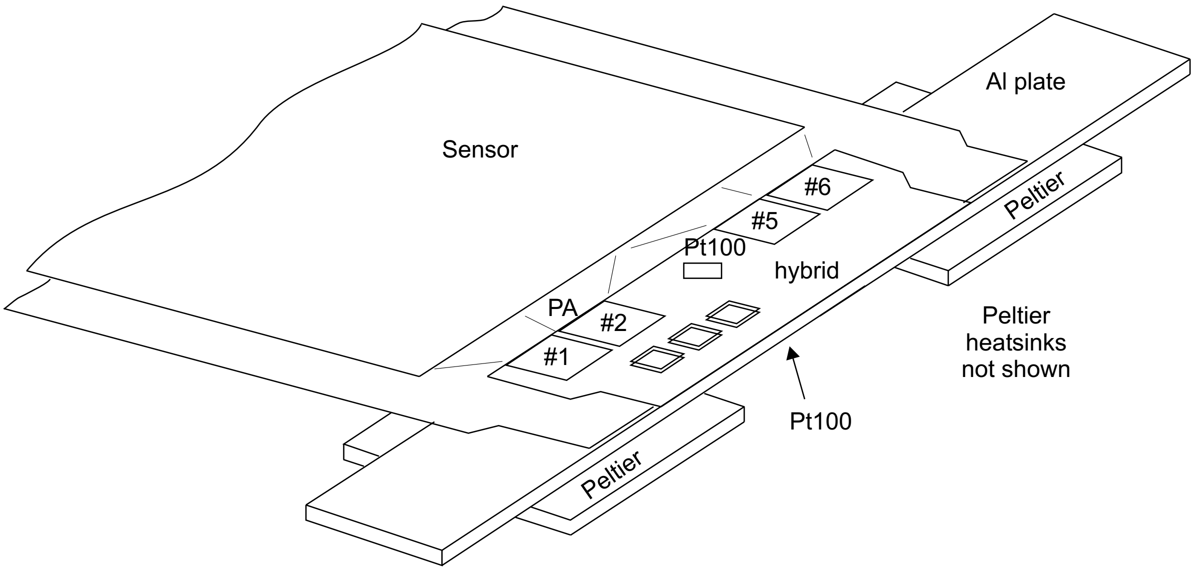

Figure 2. TOB module peak and deconvolution mode pulse shapes obtained after tuning the ISHA parameter at different hybrid temperatures. The pulse shapes shown are the average of 16 channels corresponding to one calibrate input. ICAL = 60, VFS = 50 in all cases. Measured peak mode pulse shape is shown in red, ideal 50 ns CR-RC pulse shape in green, deconvolution mode pulse shape in blue.

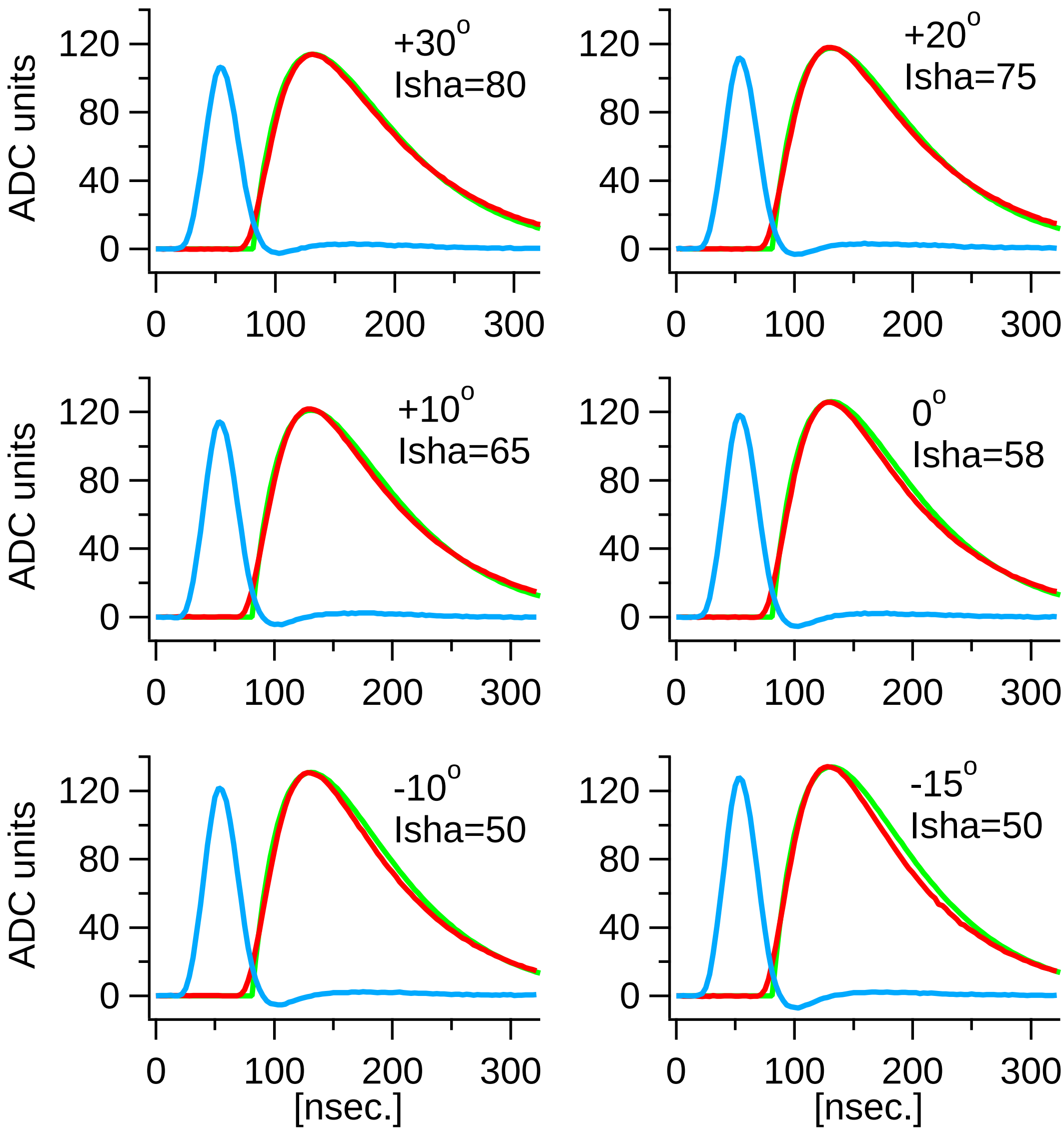

Figure 3. TOB module peak mode beta source pulse height spectra for different module temperatures. Strip signal included if neighbouring strip signals < 3 x noise. Sensor HT = 250 V.

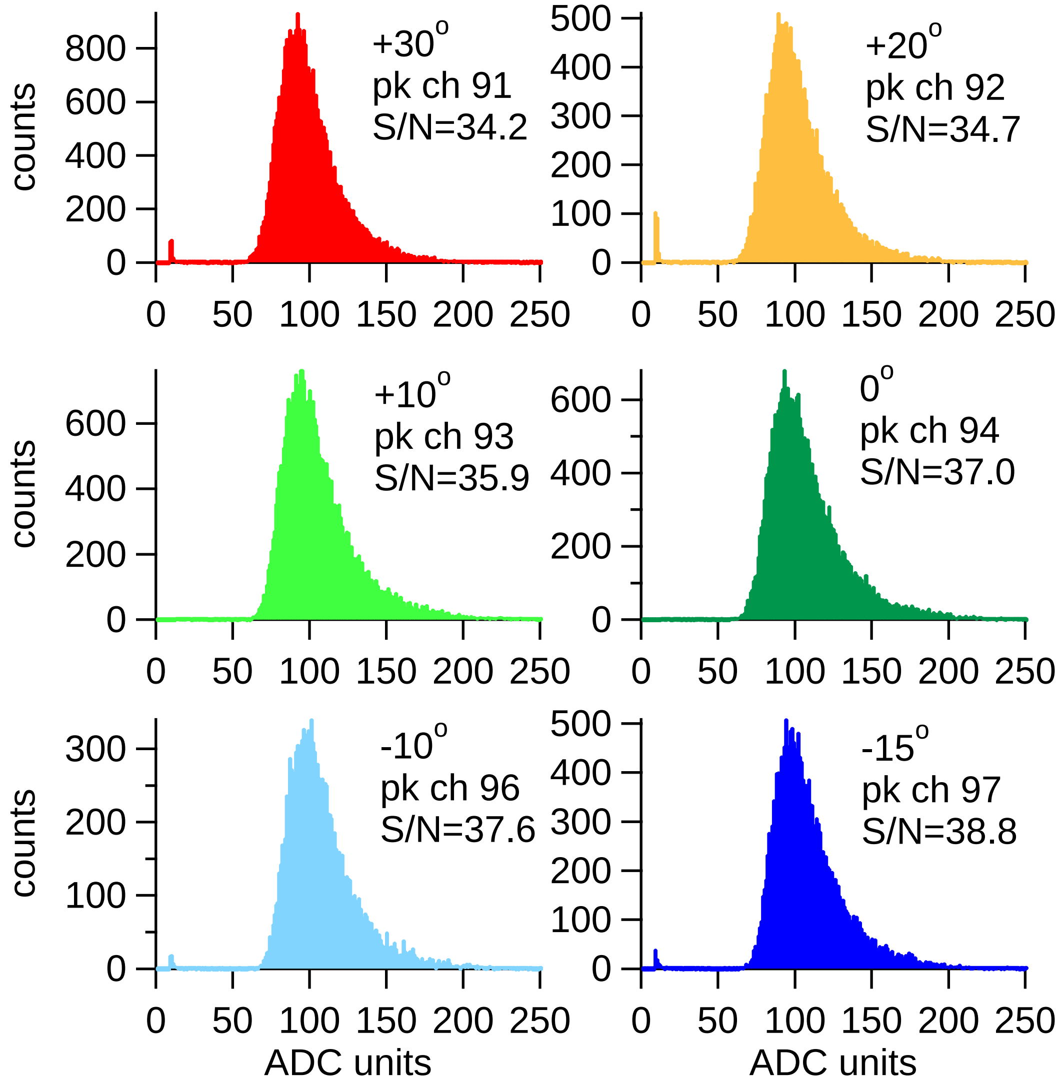

Figure 4. TOB module deconvolution mode beta source pulse height spectra for different module temperatures. Strip signal included if neighbouring strip signals < 3 x noise. Sensor HT = 250 V.