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**NICST Internal Memo**

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From: J. McIntire

To: Bruce Guenther, Jim Butler, and Jack Xiong

Subject: VIIRS F1 FP-16 Part 2 Band to Point Static Electrical Crosstalk from the Cold Focal Planes

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References:

[1] ‘Relative Spectral Response Out-Of-Band and Band Point Crosstalk, FP-16 - VIIRS,’ TP154640-266\_A.

[2] ‘Sensor Performance Verification Plan (PVP) - VIIRS,’ PVP154640-101\_RevA-5.

[3] NICST\_REPORT\_09\_070, ‘Preliminary Analysis of Emissive Band, Band to Point Crosstalk from FP-16,’ J. McIntire, July 10, 2009.

[4] NICST\_REPORT\_09\_097, ‘Preliminary Analysis of Band to Point Crosstalk from FP-16,’ J. McIntire, August 7, 2009.

[5] NICST\_REPORT\_09\_125, ‘Updated Analysis of IB Crosstalk from FP-16,’ J. McIntire, October 1, 2009.

[6] ‘Performance Specification Sensor Specification,’ ps154640-101\_c.

[7] W054, ‘Flight 1 Relief from Crosstalk Requirements (SRV0631, SRV0632),’ L. Kneller and J. Essner, October 14, 2009.

[8] NICST\_MEMO\_08\_031, ‘Shutter Map Investigation for VIIRS EDU FP-15 and FP-16,’ J. McIntire, T. Schwarting, and C. Pan, September 10, 2008.

[9] NICST\_MEMO\_09\_001, ‘VIIRS EDU FP-16 Part 2 Band to Point, In Band Crosstalk Analysis for the Cold Focal Planes,’ J. McIntire, T. Schwarting, and C. Pan, January 9, 2010.

**1. Introduction**

The assessment of band to point static electrical crosstalk was performed during TV testing as part of FP-16 at Nominal plateau [1,2]. This work will focus on electrical crosstalk in the Cold Focal Plane Assemblies (CFPA), contained in Part 2 of FP-16. The test data used here is listed in Tables 1 and 2. Preliminary analysis of the electrical crosstalk has been reported [3,4,5].

The Spectral Measurement Assembly (SpMA) was used as the source for FP-16. The SpMA is a double monochrometer operating in subtractive mode. The slit is aligned such that only a single detector array is illuminated at a time. Two collects are taken for single gain bands; one with the default band substitution table and one with the M16A band substitution table. For the dual gain bands, a total of five collects were taken: two collects at low illumination in auto gain (one for each band substitution table), two collects at high illumination in auto gain (one for each band substitution table), and one collect at high illumination in fixed low gain (in the default band substitution table). The only dual gain band under consideration here is M13. The band substitution tables are given in Table 3. The SpMA is set to output at the specified band center wavelength for each sender band.

The static electrical crosstalk is assessed in this work versus the specification SRV0631. SRV0631 states that for all bands except the DNB, when the steady-state radiance on the senders is changed from 0 to LMAX, the corresponding change in signal on the receiver shall be less than or equal to the larger of 0.002 LTYP or 0.5 the measured NEdL of the receiver when the sender radiance is 0 [6]. As this requirement is relatively stringent, a wavier request has been made (W054) [7].

**2. Data Analysis**

The DN is first averaged over samples using three sigma rejection. In FP-16, there are 16 scans per collect. Due to the fact that FP-16 is a staring test, the background subtraction was obtained by use of a shutter on the SpMA. The shutter map is constructed via the method described in [8] with some minor modifications. Once the shutter order is determined, the shutter closed DN is subtracted from the shutter open DN, or

 (1)

where C, B, H, D, S, and G represent collect, band, HAM side, detector, subsample, and gain state, respectively. As this is staring test, the dn is then averaged over HAM side.

This test measures high gain to high gain, band to point crosstalk. The only exception is crosstalk from sender band M13 which is analyzed at high gain to high gain, auto low gain to high gain, and fixed low gain to high gain.

The dn is converted to radiance (L) by the equation

 (2)

where g is the radiometric gain, determined from RC-05 for the thermal bands and RC-02 for the SWIR bands (both nominal plateau).

The crosstalk is analyzed using the government standard crosstalk units [8]. The dn and L coefficients are defined as follows:

, (3)

 (4)

Here the sender signal is the sum of the dn (or L) in the illuminated band (all detectors and subsamples). As the slit was centered only on the one array of detectors (odd or even), the dn in the other array of detectors is small (except for the I bands). Occasionally, the dn in some detectors is negative; in these cases, the negative signal is not included in the sums.

The specification requires that the crosstalk, for a sender at LMAX, be evaluated against the larger of 0.002 LTYP or half the measured NEdL of the receiver when the sender radiance is 0 (σDARK) [6]. Both conditions are calculated (normalized to 0.002), or

 (5)

 (6)

where σDARK is the standard deviation of the shutter closed scans and dnMAX is the specified LMAX multiplied by the gain (note that the sum over dnMAX is only for the odd/even detectors depending on which array is directly illuminated). Now, the lesser of Equations (5) and (6) is the crosstalk specification coefficient (xtalkspec). Because they are both normalized, a receiver detector satisfies the requirement if |xtalkspec|≤0.002.

For the LWIR bands, we must also consider the problem of band substitution; if a sender band has been excluded from the reported data, then the shutter order cannot be determined directly. In these cases, the shutter order is reconstructed using telemetry data to count scans between collects (assuming the shutter order does not change phase between collects). The sender signal from the previous (or subsequent) collect is used. If any receiver band is not recorded, it is not reconstructed.

In addition, for the case when the slit was positioned over either I3 or M10, the sender signal is considered the sum of the signals in both I3 and M10 (minus any detectors with a negative response) [9]. This is due to the fact that they share a spectral bandpass and are next to each other on the SMWIR focal plane. However, in the text the band over which the slit is positioned will be referred to as the sender.

Lastly, all of the coefficients are averaged over collects at the same illumination level (for a given detector array), absent missing receiver data resulting from band substitution. For band M13, the auto low and fixed low gain collects are both treated separately.

**3 Analysis Results**

The full crosstalk coefficients tables (including ICdn, ICL, and xtalkspec) are available in spreadsheets upon request. Only the xtalkspec is reported in this memo. The legend in Table 4 indicates which crosstalk receivers fail the specification. In addition, this legend differentiates between negative (blue) and positive (yellow or red) crosstalk as well as provides some gradation (1X, 2X, 5X, and 10X the normalized specification of 0.002).

The xtalkspec values are listed in Tables 5 – 12 for the LWIR bands. The sender bands (odd or even detector arrays) are listed in the columns in focal plane order; the receiver band is listed in the rows for each detector and subsample. Some of the major pathways indicated by the tables are the result of optical contamination into nearest neighbors with overlapping bandpasses: M16A odd into I5, M16A even into M16B odd, and M16B odd into M16A even. The fact that the odd detectors in M16A are next to the even detectors of M16B on the focal plane accounts for greater contamination in these pathways than between the odd detector arrays from M16A and M16B (or between the even detector arrays for the same bands). As the I5 detectors are smaller and closer to the nearest neighbor (M16A odd), more contamination is observed into the non-adjacent detector array (odd) in I5. Negative crosstalk is observed from M15 into M14; the received crosstalk does not show an odd – even dependence. This is the probable result of electrical crosstalk. There are also pathways evident from M16A even into I5 (negative into odd and positive into even), particularly for subsample 2; a similar pattern is observed from M16B odd into I5. This pattern is the likely result of optical contamination into the nearer I5 detector array (even) and possible electrical crosstalk into the odd I5 detectors. In addition, there are also a number of more isolated crosstalk pathways into receiver bands I5 (senders M16B, M15, and M14) and M14 (senders I5 and M16A). The crosstalk into M14 from I5 and M16A tends to be negative, indicating electrical crosstalk.

The xtalkspec values for the SMWIR focal plane are listed in tables 13 – 40. Again, the sender bands (odd or even detectors arrays) are listed in the columns in focal plane order; the receiver band is listed in the rows for each detector and subsample. In the case of the SMWIR bands, the sender band M13 is also listed for auto and fixed low gain on the right side of each table (in the last two columns). There are a number of major pathways in the SMWIR focal plane that are attributable to optical contamination: M10 into I3, I3 into M10, I4 into M12, and M12 even into I4 odd. These bands are adjacent to each other on the focal plane and have overlapping bandpasses. In addition, M13 center wavelength is just outside the extended bandpass of M12. This possibly accounts for the observed pathways from M13 auto high gain (low number detectors) into M12. There is also a number of nearest neighbor positive crosstalk pathways observed, in which bands next to each other on the focal plane but without an overlapping bandpass exhibit crosstalk: M8 into M9 and M10 odd into M11 even. In addition, I4 odd sends negative crosstalk into four bands: M8, M9, M10, and M11.

In order to get sender band M13 into low gain, higher SpMA illumination was used. As a result, optical contamination sent from M13 in both auto low and fixed low gain was observed: M13 fixed low gain into M12, M13 even auto low gain into M12 odd, and M13 auto and fixed low into I4. As noted above, some overlap exists between the M13 and I4 bandpass and the center wavelength of M13 is just outside the extended bandpass of M12. In addition, when M13 auto low gain was the sender, the low number detectors in M12 received negative crosstalk (at the same time that some optical contamination was present in the odd detectors). Also, there are some isolated receivers in I3 when M13 odd is illuminated in auto low gain. Lastly, the crosstalk from M13 in fixed low gain tends to be greater than from M13 in auto low gain; as the illumination level is unchanged, this is likely an electronic effect.

**4. Summary**

* The major source of non-compliance with the specification is optical contamination in both SMWIR and LWIR focal planes.
* Negative electrical crosstalk is observed from M15 into M14, from M16A even and M16B odd into I5, from I4 odd into M8, M9, M10, and M11, and from M13 in auto low gain into M12 (low number detectors).
* Some nearest neighbor bands received positive crosstalk: M8 into M9 and M10 odd into M11 even. Note that no bandpass overlap is present in these cases.
* Isolated crosstalk pathways are evident in bands I5 (senders M16B, M15, and M14), M14 (senders I5 and M16A), and I3 (sender M13 in auto low gain).
* Crosstalk from M13 differs from auto low gain to fixed low gain.

**Acknowledgement**

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Table 1: VIIRS F1 FP-16 Part 2 SMWIR crosstalk data



Table 2: VIIRS F1 FP-16 Part 2 LWIR crosstalk data



Table 3: Band substitution tables



Table 4: Crosstalk legend



Table 5: Crosstalk into I5 subsample 1



Table 6: Crosstalk into I5 subsample 1



Table 7: Crosstalk into I5 subsample 2



Table 8: Crosstalk into I5 subsample 2



Table 9: Crosstalk into M16A



Table 10: Crosstalk into M16B



Table 11: Crosstalk into M15



Table 12: Crosstalk into M14



Table 13: Crosstalk into M8 (odd senders)



Table 14: Crosstalk into M8 (even senders)



Table 15: Crosstalk into M9 (odd senders)



Table 16: Crosstalk into M9 (even senders)



Table 17: Crosstalk into M11 (odd senders)



Table 18: Crosstalk into M11 (even senders)



Table 19: Crosstalk into M10 (odd senders)



Table 20: Crosstalk into M10 (even senders)



Table 21: Crosstalk into I3 subsample 1 (odd senders)



Table 22: Crosstalk into I3 subsample 1 (even senders)



Table 23: Crosstalk into I3 subsample 1 (odd senders)



Table 24: Crosstalk into I3 subsample 1 (even senders)



Table 25: Crosstalk into I3 subsample 2 (odd senders)



Table 26: Crosstalk into I3 subsample 2 (even senders)



Table 27: Crosstalk into I3 subsample 2 (odd senders)



Table 28: Crosstalk into I3 subsample 2 (even senders)



Table 29: Crosstalk into I4 subsample 1 (odd senders)



Table 30: Crosstalk into I4 subsample 1 (even senders)



Table 31: Crosstalk into I4 subsample 1 (odd senders)



Table 32: Crosstalk into I4 subsample 1 (odd senders)



Table 33: Crosstalk into I4 subsample 2 (odd senders)



Table 34: Crosstalk into I4 subsample 2 (even senders)



Table 35: Crosstalk into I4 subsample 2 (odd senders)



Table 36: Crosstalk into I4 subsample 2 (even senders)



Table 37: Crosstalk into M12 (odd senders)



Table 38: Crosstalk into M12 (even senders)



Table 39: Crosstalk into M13 (odd senders)



Table 40: Crosstalk into M13 (even senders)

