**NICST\_MEMO\_10\_020**

**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 VisNIR Focal Plane

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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\_097, ‘Preliminary Analysis of Band to Point Crosstalk from FP-16,’ J. McIntire, August 7, 2009.

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

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

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

[7] NICST\_MEMO\_10\_018, “VIIRS F1 FP-16 Part 2 Band to Point Static Electrical Crosstalk from the Cold Focal Planes,” J. McIntire, June 23, 2010.

[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 VisNIR focal plane assembly, contained in Part 1 of FP-16. The test data used is listed in Table 1. Preliminary analysis of the electrical crosstalk has been reported [3,4].

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 band is illuminated at a time. The SpMA is set to output at the specified band center wavelength for each sender band.

For each collect, one of two band substitution tables are loaded; these tables define which bands are reported. The VisNIR bands reported for each band substitution table are given in Table 2. Two collects are taken for single gain bands; one with the default band substitution table and one with the M16A band substitution table loaded. 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 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 [5]. As this requirement is relatively stringent, relief from this specification in the form of a wavier (W054) was accepted [6].

**2. Data Analysis**

The majority of data analysis methodology follows from [7]. 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 band to point crosstalk from high gain, auto low gain, and fixed low gain senders.

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 [9]. 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) [5]. 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 I2 or M7, the sender signal is considered the sum of the signals in both I2 and M7 [2]. This is due to the fact that they share a spectral bandpass and are next to each other on the VisNIR focal plane (note that the signal in the band not directly illuminated is generally significant). 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 within a UAID, absent missing receiver data resulting from band substitution. For the dual gain bands, the auto low and fixed low gain collects are both treated separately.

**3 Analysis Results**

The full crosstalk coefficient tables (including ICdn, ICL, and xtalkspec) are available in spreadsheets upon request. Only the xtalkspec is reported in this memo. The legend in Table 3 lists the color scheme used to indicate which crosstalk receivers fail the specification. 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). In this section, the crosstalk pathways which exceed the specification will be described.

The xtalkspec values are listed in Tables 4 – 18 for the VisNIR bands when the sender is in high gain. The sender bands are listed in the columns in focal plane order; the receiver band is listed in the rows for each detector and subsample. Optical contamination is observed between I2 and M7; these bands have a common bandpass and are adjacent to each other on the focal plane. The I bands are common senders of crosstalk: I1 sends to I2 and M5 while I2 sends to I1 SS1, M2, M5, and M6. These pathways are not characterized by optical spillover (illumination inside the bandpass of the receiver). The crosstalk from I1 tends to be between 1X and 3X the specification into I2 and M5; the crosstalk from I2 into I1 SS2, M2, and M6 is in general around 1X – 2X the requirement. However, the crosstalk from I2 into M5 is between 3X and 6X the requirement. The remaining major crosstalk senders are nearest neighbor bands: M7 into M5, M5 into M7 (low numbered detectors), and M4 into M3 (low numbered detectors). These pathways into low numbered detectors may indicate a slight tilt in alignment relative to the focal plane which would result in higher contamination for adjacent bands low numbered detectors.

Tables 19 – 33 list the xtalkspec values for the VisNIR bands when the sender is in auto low gain. All sender detectors for this portion of the test had transitioned to low gain; in addition, all receiver detectors were in high gain. Optical contamination is evident between I2 and M7 and from M5 into I1; for these bands, the illumination was inside the bandpass of the receiver. Nearest neighbor crosstalk accounts for the majority of the observed pathways. Minor crosstalk pathways (at about 1X the specification) include: M1 into M2 lower numbered detectors, M3 into M4, and M3 into I1 SS1. The more significant pathways are as follows (along with the relative non-compliances to the specification): M4 into M2 (between 2X and 4X), M4 into M3 (between 2X and 6X), M5 into M7 (2X), and M5 into M6 (3X). None of these pairs has overlapping bandpasses; however, due to the higher intensity required to transition the dual gain bands to low gain, optical OOB contamination would be higher than in auto high gain. Other significant crosstalk pathways observed were M5 into I2 SS1 (between 1X and 3X), M3 into I2 SS1 (1X), and M1 into M6 (negative 1X).

The xtalkspec values are listed in Tables 34 – 48 for the VisNIR bands when the sender is in fixed low gain. Note that every dual gain band is in low gain. Optical contamination is observed between I2 and M7 and from M5 into I1; for these bands, the illumination is within the bandpass of the receiver. Again, nearest neighbor crosstalk accounts for the majority of the crosstalk pathways observed (along with the relative non-compliances to the specification): M1 and M4 into M2 low numbered detectors (1X), M3 into M4 lower numbered detectors (2X), M4 into M3 (between 1X and 3X), M5 into M7 (between 1X and 3X), M7 into M5 lower numbered detectors (1X), and M5 into M6 (between 2X and 4X). While none of these band pairs have an overlapping bandpass, the higher intensity illumination may lead to optical OOB contamination. The remaining pathways are crosstalk into the I bands: M1 into I1 SS2 and I2 (1X), and M4 into I1 SS2 and I2 SS2 (1X). Note that the M1 crosstalk into I2 SS1 is negative and the crosstalk into I2 SS2 is positive.

It should be noted that there are some differences in the observed crosstalk pathways between auto low gain and fixed low gain modes for high illumination collects. The two modes are best compared in the single gain receivers (I1, I2, and M6). For M6, crosstalk is observed from M5 in both modes, but negative (or electrical) crosstalk is observed from M1 in auto low gain mode only. For the I bands, M3 and M5 are senders in auto low gain (especially for SS1), while M1 and M4 (and M5 for I1 only) are senders in fixed low gain mode.

**4. Summary**

* The major pathways of crosstalk are between nearest neighbors on the focal plane (without overlapping bandpasses).
* The I bands are also frequent senders and receivers of crosstalk.
* Crosstalk from the dual gain bands is different between auto low gain and fixed low gain modes.
* Optical contamination is evident between I2 and M7 as well as from M5 into I1. These pathways are characterized by illumination inside the bandpass of the receiver band.

**Acknowledgement**

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Table 1: VIIRS F1 FP-16 Part 1 VisNIR crosstalk data



Table 2: Band substitution tables



Table 3: Crosstalk legend



Table 4: Crosstalk into M1 (auto high gain)



Table 5: Crosstalk into M2 (auto high gain)



Table 6: Crosstalk into M4 (auto high gain)



Table 7: Crosstalk into M3 (auto high gain)



Table 8: Crosstalk into I1 subsample 1 (auto high gain)



Table 9: Crosstalk into I1 subsample 1 (auto high gain)



Table 10: Crosstalk into I1 subsample 2 (auto high gain)



Table 11: Crosstalk into I1 subsample 2 (auto high gain)



Table 12: Crosstalk into I2 subsample 1 (auto high gain)



Table 13: Crosstalk into I2 subsample 1 (auto high gain)



Table 14: Crosstalk into I2 subsample 2 (auto high gain)



Table 15: Crosstalk into I2 subsample 2 (auto high gain)



Table 16: Crosstalk into M7 (auto high gain)



Table 17: Crosstalk into M5 (auto high gain)



Table 18: Crosstalk into M6 (auto high gain)



Table 19: Crosstalk into M1 (auto low gain)



Table 20: Crosstalk into M2 (auto low gain)



Table 21: Crosstalk into M4 (auto low gain)



Table 22: Crosstalk into M3 (auto low gain)



Table 23: Crosstalk into I1 subsample 1 (auto low gain)



Table 24: Crosstalk into I1 subsample 1 (auto low gain)



Table 25: Crosstalk into I1 subsample 2 (auto low gain)



Table 26: Crosstalk into I1 subsample 2 (auto low gain)



Table 27: Crosstalk into I2 subsample 1 (auto low gain)



Table 28: Crosstalk into I2 subsample 1 (auto low gain)



Table 29: Crosstalk into I2 subsample 2 (auto low gain)



Table 30: Crosstalk into I2 subsample 2 (auto low gain)



Table 31: Crosstalk into M7 (auto low gain)



Table 32: Crosstalk into M5 (auto low gain)



Table 33: Crosstalk into M6 (auto low gain)



Table 34: Crosstalk into M1 (fixed low gain)



Table 35: Crosstalk into M2 (fixed low gain)



Table 36: Crosstalk into M4 (fixed low gain)



Table 37: Crosstalk into M3 (fixed low gain)



Table 38: Crosstalk into I1 subsample 1 (fixed low gain)



Table 39: Crosstalk into I1 subsample 1 (fixed low gain)



Table 40: Crosstalk into I1 subsample 2 (fixed low gain)



Table 41: Crosstalk into I1 subsample 2 (fixed low gain)



Table 42: Crosstalk into I2 subsample 1 (fixed low gain)



Table 43: Crosstalk into I2 subsample 1 (fixed low gain)



Table 44: Crosstalk into I2 subsample 2 (fixed low gain)



Table 45: Crosstalk into I2 subsample 2 (fixed low gain)



Table 46: Crosstalk into M7 (fixed low gain)



Table 47: Crosstalk into M5 (fixed low gain)



Table 48: Crosstalk into M6 (fixed low gain)

