Memorandum

To: File ALMA EDM No. FEND-40.02.06.13-002-A-REP

From: John Effland
Kamaljeet Saini
Dave Schmitt

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Revisions:

2006-02-15	jee	Initial
2006-03-01	jee	Updated data in Figure 3
2006-03-02	jee	Updates and comments from Saini: Removed spec, added percent
2006-03-03	kss	Updated discussion section, added numbers for other bands
2006-03-07	jee	Updated Fig 3 using Saini's comments

Subject: Warm IF Cable Contributions to Overall Cartridge and FE IF System Phase Change with Temperature

1. Summary

This memo compares phase drift contributed by the cables connecting the warm IF amplifiers in the Warm Cartridge Assembly (WCA) to the Front end IF Subsystem.

Figure 4 and Table 3 show that for Band 6, cables with phase changes less than 100 PPM are acceptable for use between the 300K plate, the warm IF amps, and the WCA harness plate. Acceptable cable phase changes for other bands are also shown in Table 3.

2. Introduction

Initial analysis by D. Urbain and subsequent study by K. Saini[1] indicates that the overall Front End (FE) phase changes with temperature in excess of project specifications of 0.5°/C. Saini calculates the phase change is about 2.5°/C near the operating temperature of 20C.

Part of this overall FE phase change results from the cables connecting the warm IF amps to the 300K baseplate and to the WCA harness plate. This memo compares their contribution relative to the overall predicted phase change of the Front End IF Subsystem.

3. Discussion

The existing warm IF cable used in the Band 6 cartridge is Haverhill[2] EasyBend II which is a flexible cable with conventional PTFE-based dielectric. As shown in Saini's analysis, PTFE-based dielectrics have large phase change characteristics near 20C and consequently other types of cables are being considered to replace the EasyBend II.

[1] http://edm.alma.cl/forums/alma/dispatch.cgi/iptfedocs/docProfile/101593/d20051130173716/No

Vendors under consideration for providing phase-stable Warm IF cables for the Band 6 Cartridge are listed in Table 1.

Table 1: Cables and Phase Change Specs

Vendor	Phase change (PPM/C near 20C)
PTFE	175[3]
Storm Products 421-298	50[4]
Times Microwave AE30595X	2.5[5]
Volex FMCA-AS-XXXT-Q1	10[6]

It has been difficult to convince these vendors to provide measured data on phase change with temperature for their cables, but Times Microwave has measured data shown in Figure 1 and Figure 2.

Figure 1 shows the characteristic hysteresis in phase change with temperature, and the relevant phase change used in this report was obtained from the vendor's specified phase change.

Figure 2 also shows phase change with temperature, and indicates what happens when the cable is not temperature-cycled a sufficient number of times. The hysteresis curves don't close on themselves because changes to the dielectric and physical length haven't stabilized[7].

Table 2 lists the lengths of all warm IF cables in the Front End. Note that the IF cables on the WCA that connect to the Warm IF Amp are only 18% of the total cable length in the Front End, and their contribution to the overall phase drift is even less because that figure excludes the significant drift contribution from the IF switch.

Figure 3 identifies the subsystems whose phase drift is analyzed in this report. The cables changed are those in the Warm Cartridge Assembly while all other cables are assumed to be Times Phasetrack 210. Phase drift from the LO subsystem is excluded from this analysis.

Table 2: Length of Warm IF Cables in Front End

Cable	Length
300K Baseplate to Warm IF Amp Input	17.8 cm (7")
Warm IF Amp Output to WCA Connector Plate	27.3 cm (10.75")
Harness plate to IF switch (Times Phasetrack 210)	177.8 cm (70")
IF switch to FE Bulkhead (Times Phasetrack 210)	71.1 cm (28")

Figure 4 is a graph of the phase change of Front End IF Subsystem defined in Figure 3 when different cables are used to connect the warm IF amps.

The cartridge is required to maintain 0.5 degrees[8] phase over 300 s (5 minutes). The receiver cabin temperature can change 2 C over an hour, which translates to 0.17 C over 5 minutes.

With STORM cables in the WCA, the drift is 1.9 degrees phase change per C, *i.e.* 0.32 degrees of phase for 0.17 C temperature change over 5 minutes, leaving 0.18 degrees for the rest of the cold cartridge. With Times or Volex cables, the phase change is about 1.6 degrees phase change per C, *i.e.* 0.27 degrees of phase for 0.17 C temperature change over 5 minutes, leaving 0.23 degrees for the rest of the cold cartridge. Similar calculations are shown in Table 3, for other ALMA bands.

[2] Haverhill Cable and Manufacturing, Corp. 179-181 Ferry Road, Haverhill, MA 01835
[3] From Saini's spreadsheet
[4] Storm Products phase change spec from Saini's spreadsheet
[5] Specified Times Microwave phase change spec. Figure 1 shows typical data of 1.7 °/C near 20C
[6] \\cvfiler\cv-cdl-sis\Cartridge\WarmIFcables\Volex QuoteFMCA-AS-120T-Q1_B.pdf.
[7] "Current Innovations in Phase Stable Coaxial Cable Design," Times Microwave Systems, written in *Microwave Product Digest*, July 2003.
[8] The 0.5 º specification is for the Band 6 cartridge. The corresponding numbers for other bands are as follows: 0.24º (Band 3), 0.36 º (Band 4), 0.79 º (Band 7), 1.1 º (Band 8), and 1.7 º (Band 9).

Table 3: Suggested phase stability of IF cables in the WCA for various bands				
Band designation	Phase drift specification (degrees) over 300 s	Suggested phase stability of IF cable used in the WCA (PPM per degree Celsius)	Total phase drift (degrees) in IF cabling per degree C	Total phase drift (degrees) in IF cabling over 300 s worst case with existing environmental (2 K per hour) specifications
3	0.25	2.5	1.5	0.250
4	0.36	50	1.9	0.317
6	0.50	100	2.25	0.375
7	0.79	175	3.25	0.542
8	1.10	175	3.25	0.542
9	1.70	175	3.25	0.542

Based on the above, it is felt that cables with phase changes less than 100 PPM per degree C temperature change are needed for connecting the Warm IF amps for Band 6, while 175 PPM per degree C would suffice for bands 7, 8 and 9. Even more than that would probably be okay, particularly for Bands 8 and 9. However for Band 3 and 4, a requirement of specialty phase stable IF cables is indicated. Given that Band 3 is used as a calibrator for higher bands, this requirement becomes even more important for that case.

The FE IPT is working with the IF switch vendor to improve the stability of that subsystem, so as to reduce the total IF phase change from 1.5 degrees phase per K to 1.0 degrees phase change per K for the case where Times Phasetrack 210 cable is used everywhere. That would free up some of the phase drift budget for the Band 3 cold cartridge.

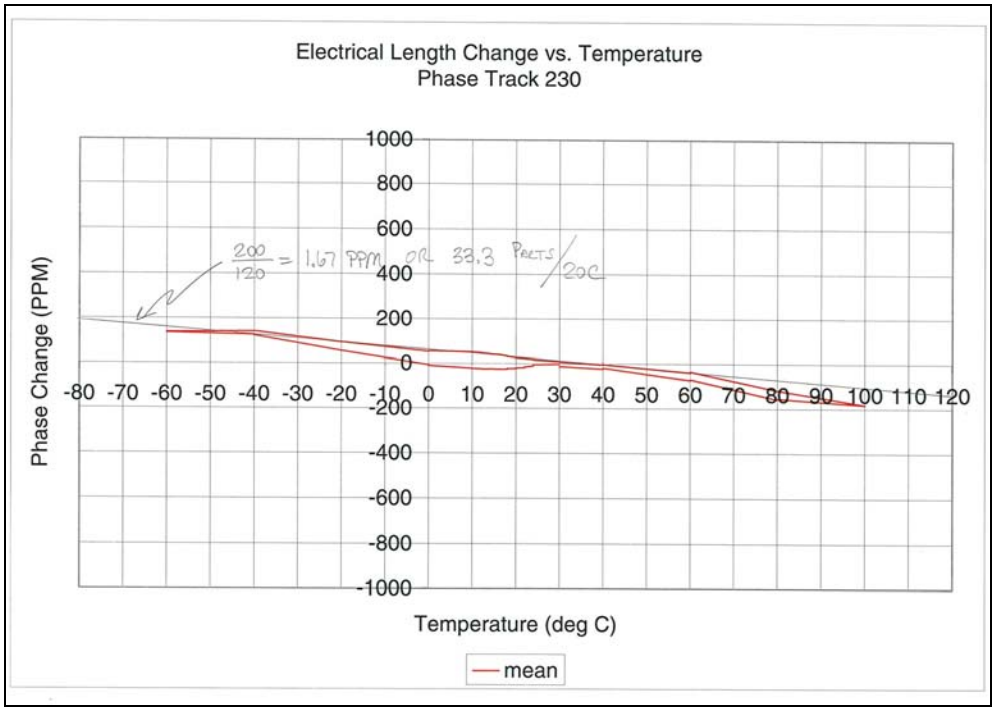

Figure 1: Measured Phase Change with Temperature for Times Microwave Phase Track 230 Cable

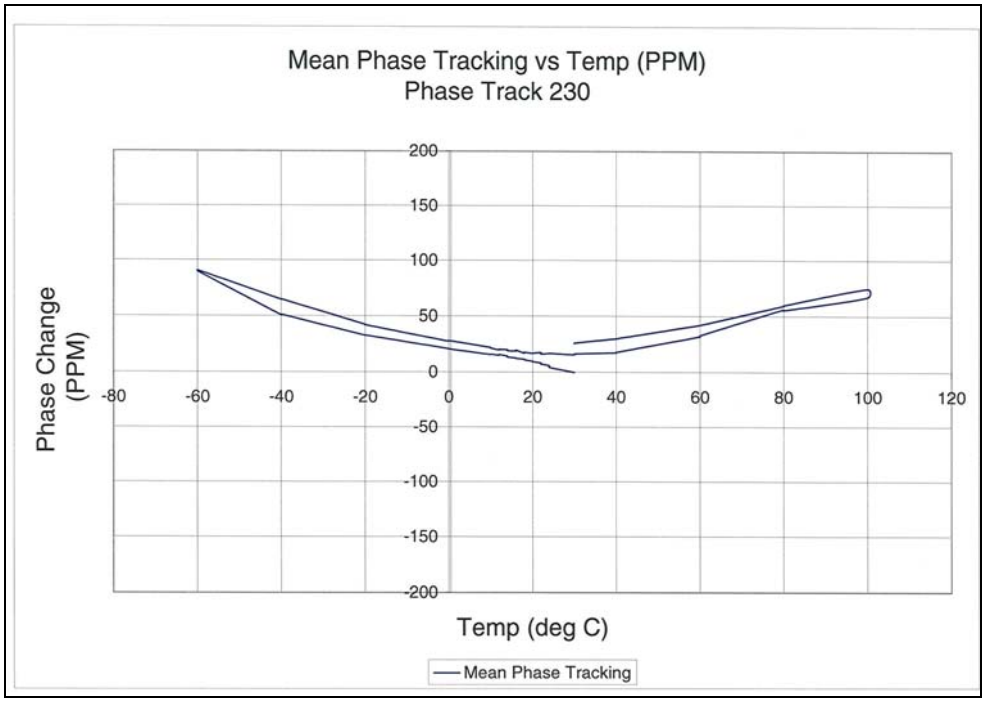

Figure 2: Phase Track 230 Prior to Temperature Cycling

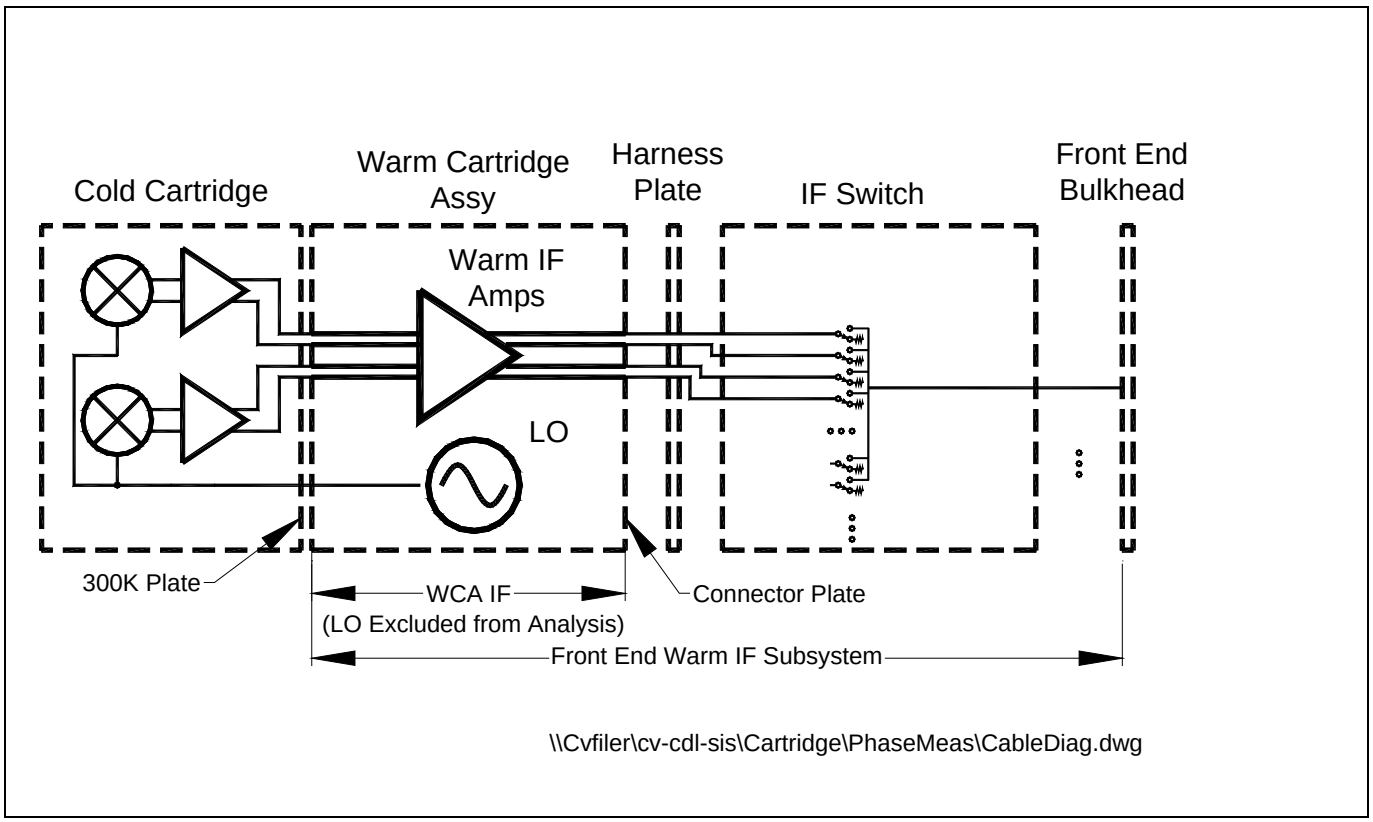

Figure 3: Phase drift of just the "Front End Warm IF Subsystem" is analyzed in this report by changing the cables in the "WCA IF" section

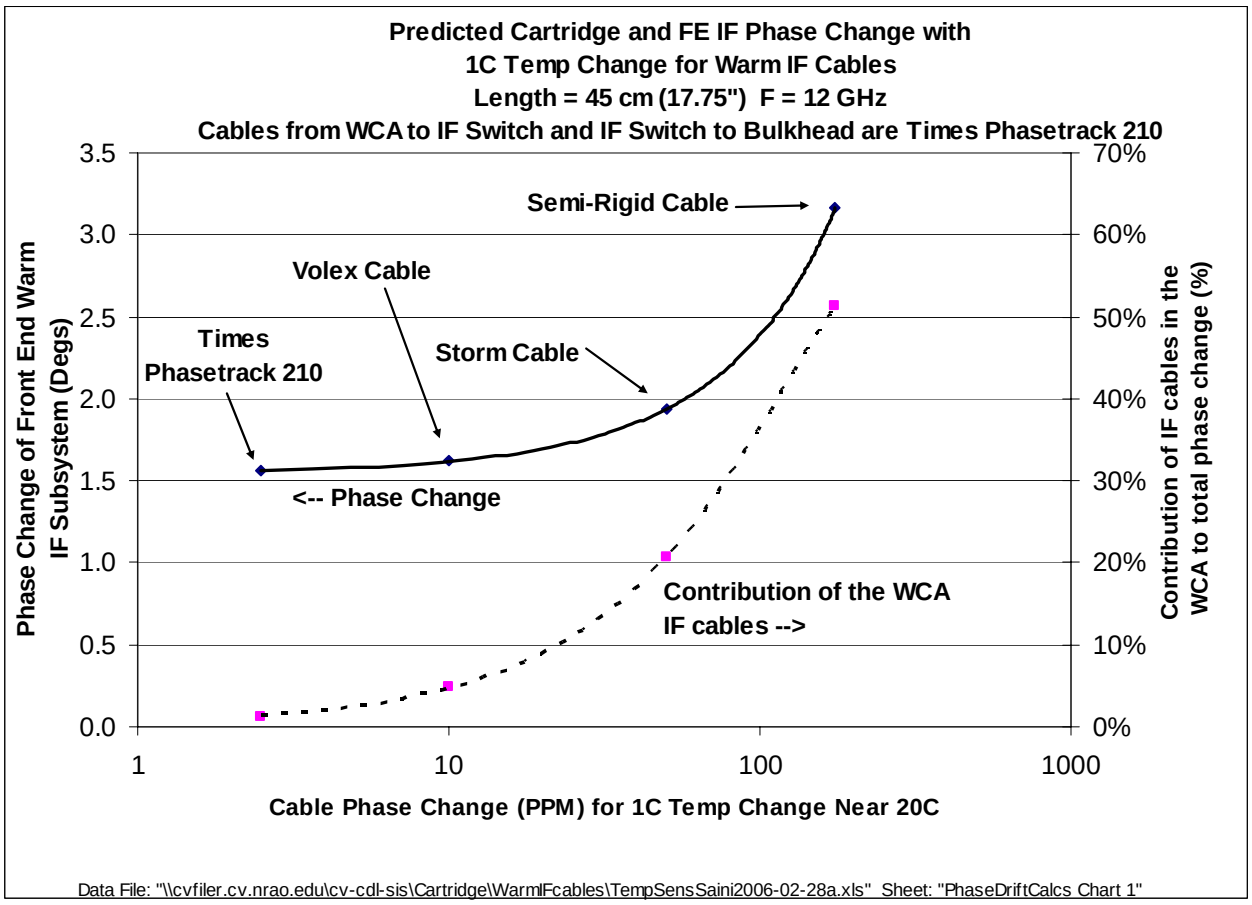

Figure 4: Phase Change of the Front End IF Subsystem for 1C change in temperature.