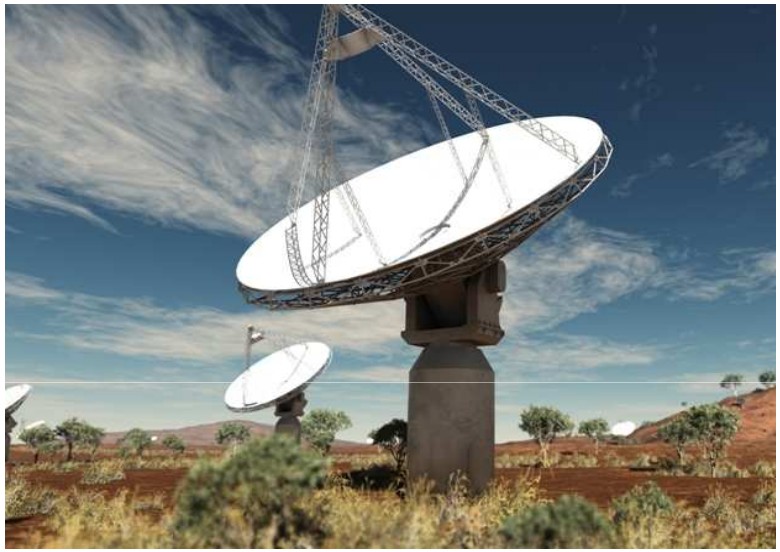
PAF Signal Transport
Australian SKA Pathfinder
STaN CoDR

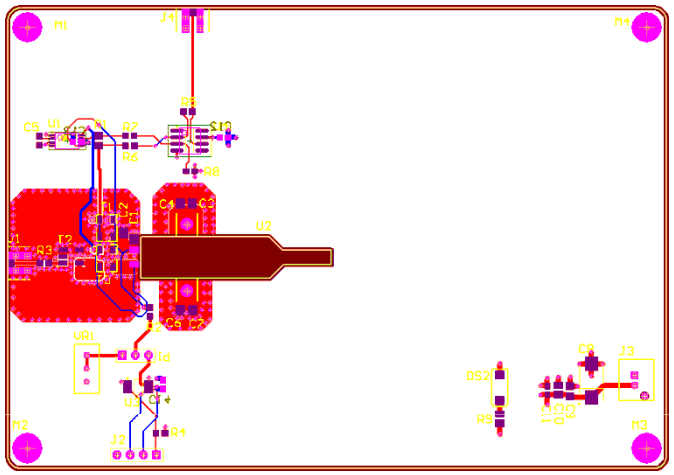
Ron Beresford 27June 2011

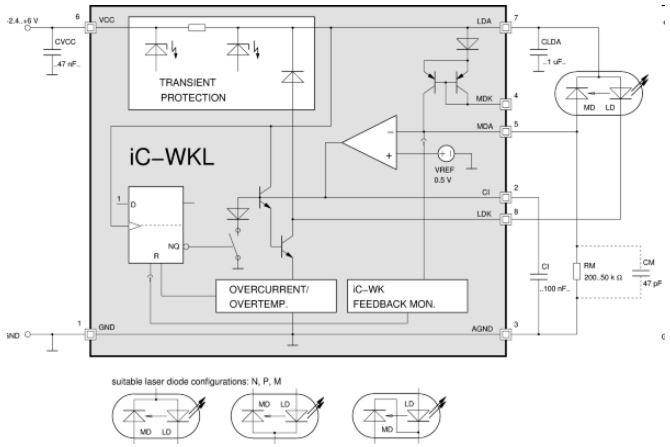
1 Advantages of RF over Fibre for PAF's



- Simpler Antenna…cheaper
- No high speed digital ….No self RFI
- Less power at antenna
- Less cooling requirement
- Galvanic Isolation/Lightning
- Less electronics hence reduced maintenance at antenna

2 Early Test Card



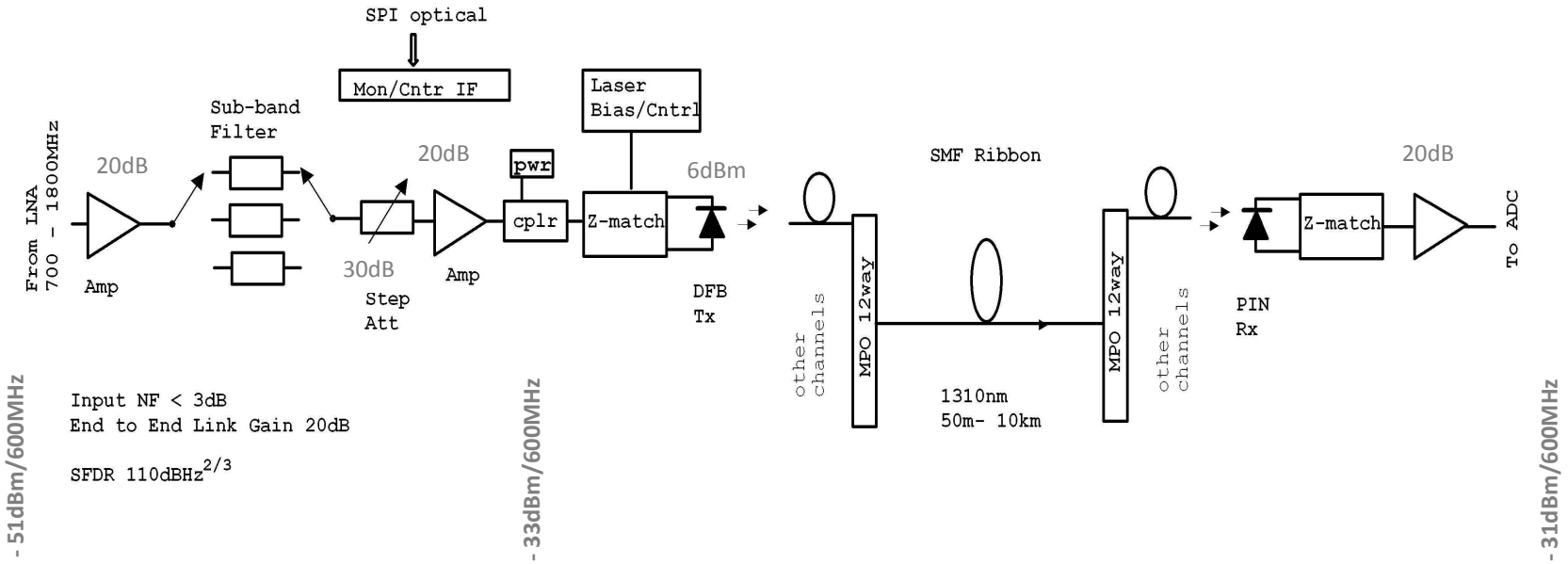


Model 1933F/R/W CATV Coaxial DFB Laser Diode

1310nm, Wide Bandwidth 5MHz – 4000MHz

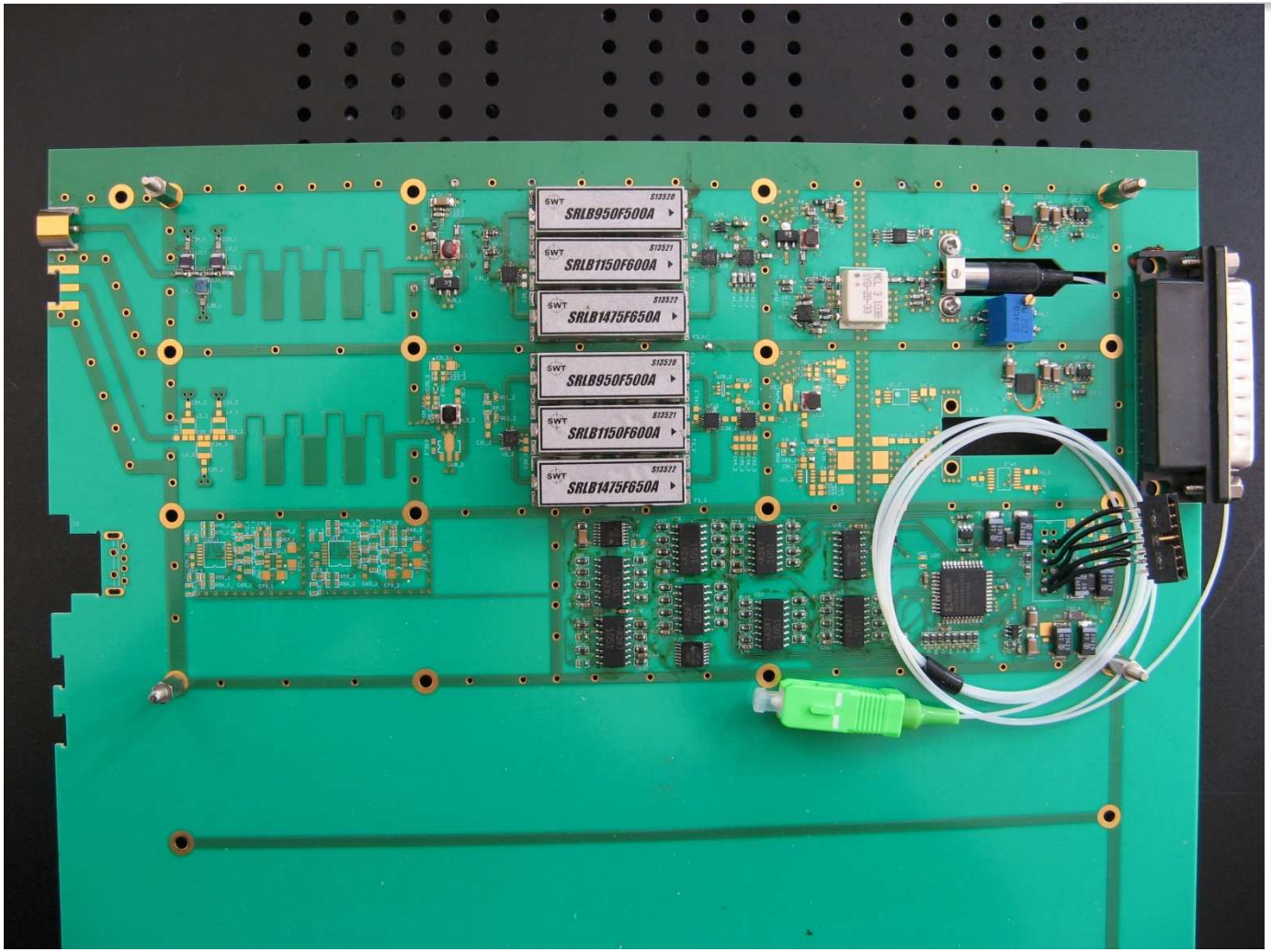
Emcore's Model 1933 DFB lasers offer a low cost solution for linear fiberoptic links. These components can be cooled with external thermo-electric coolers for high stability, or run without TEC's to reduce power consumption. The DFB laser builds upon Ortel's long history of high performance, leading edge designs in CATV, wireless, and high speed digital applications. The laser diode devices are packaged in a compact hermetic assembly together with monitor photodiode and isolator, for flexible integration into various transmitter configurations.

3 RFoF Single Channel PAF

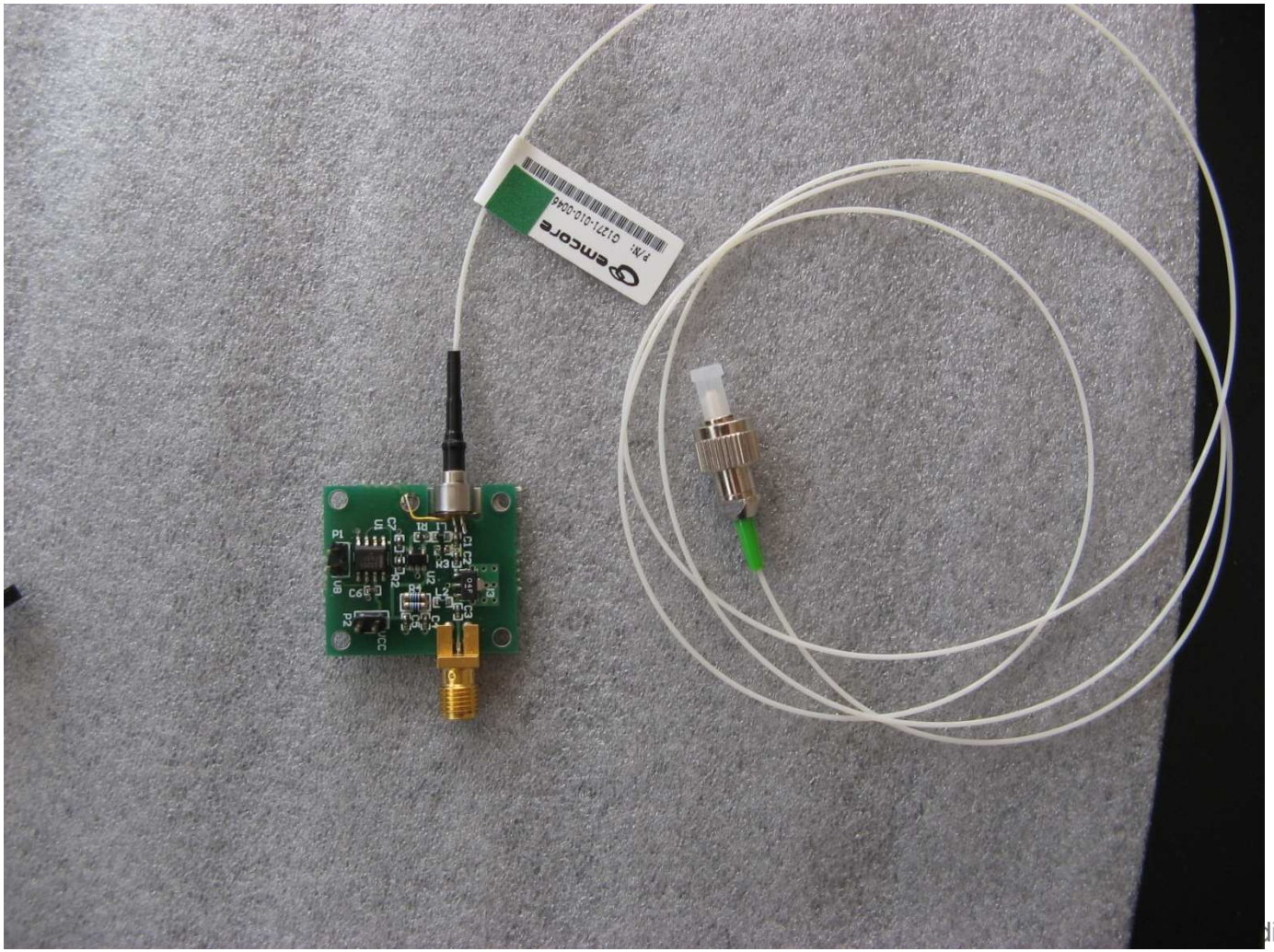


All analog antenna remoting out to 10km!

4 Prototypes for PAF- 2ch



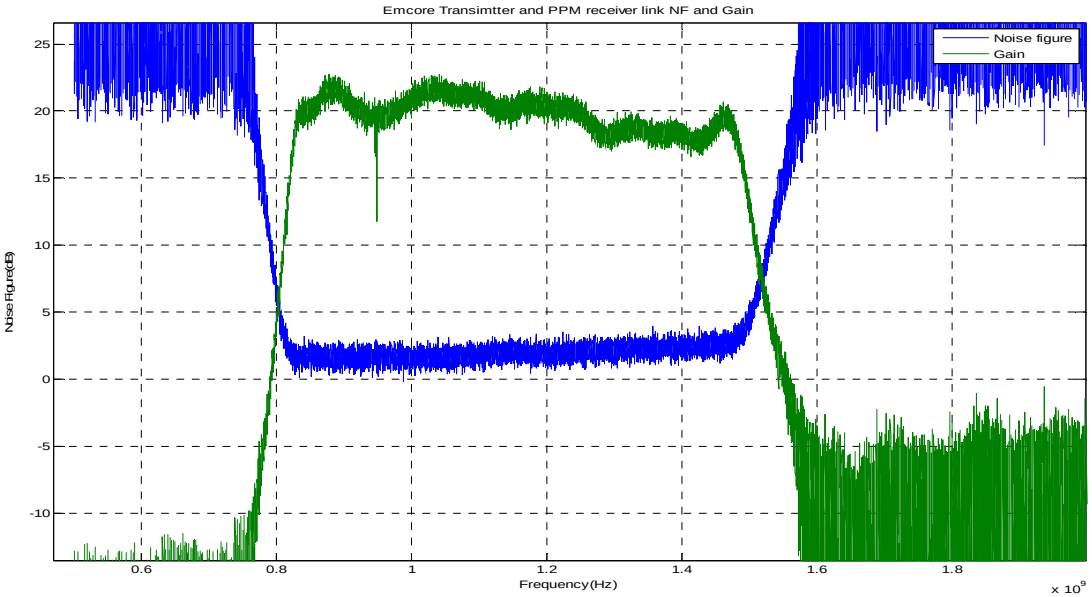
5 RFoF Rx Daughter card DSP mothercard



dio telescope

6 Noise Figure and Gain at 10km

Fibre distance /band	Optical power@receiver	Band 1 (700-1200MHz)		Band 2 (850 to 1450MHz)		Band 3 (1150 to 1800MHz)	
		Gain	Noise Figure	Gain	Noise Figure	Gain	Noise Figure
5m	2.8dBm	25.28	1.60	24.41	1.79	24.18	2.4
1km	1.0dBm	20.98	1.69	20.14	1.86	19.65	2.54
10km	-0.1dBm	20.84	1.63	20.05	1.92	19.56	2.56



NF and Gain
10km link

7 Achieved Specifications

Lengths up to 10km have been tested with SMF bare spool.

- SFDR 110dBHz $^{2/3}$ [approximately 50dB SFDR in a 500MHz wide band]
- Intrinsic link loss better than 30dB [good DFB slope efficiency 0.3W/A]
- Link input NF better than 3dB [excellent less front end gain needed, low RIN]
- Link Gain >20dB achieved
- Band flatness +/- 1dB
- P1 compression -20dBm at input.
- IP2 +6dBm at input
- IP3 -12.8dBm at input
- *Performance with Ribbon SMF to be done*
- *Currently looking at connector techniques. TBD performance?*

8 Achieved Stability Specifications

- Amplitude Stability of better than **0.05dB** achieved with worst case fibre flexing. Mechanical simulation of drive axis.

  Sensitive cross-correlation integrating spectrometer used.

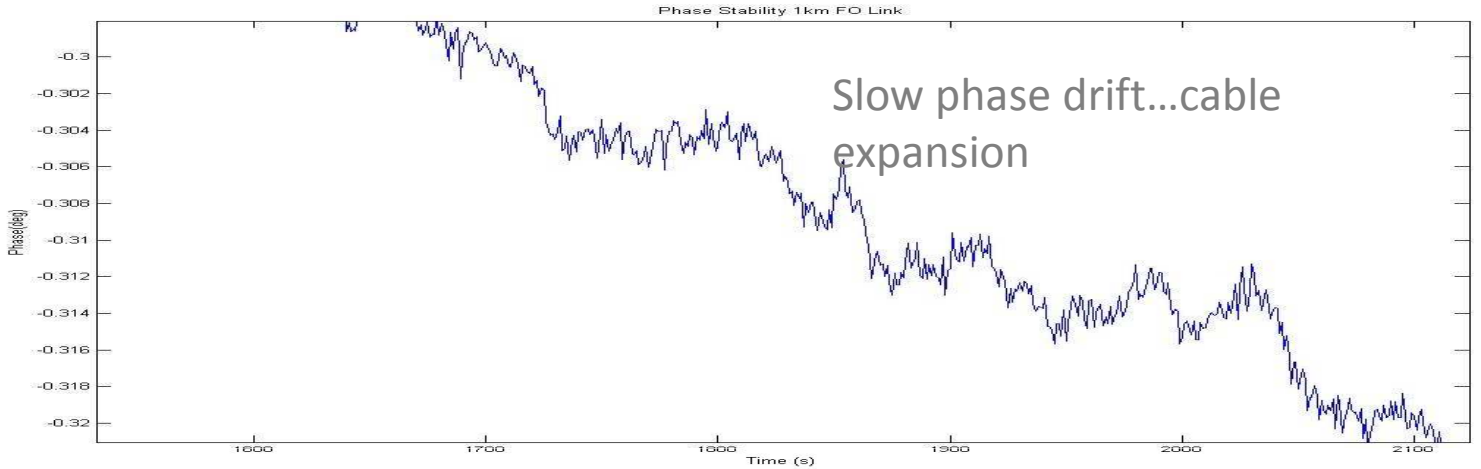
PAF specification

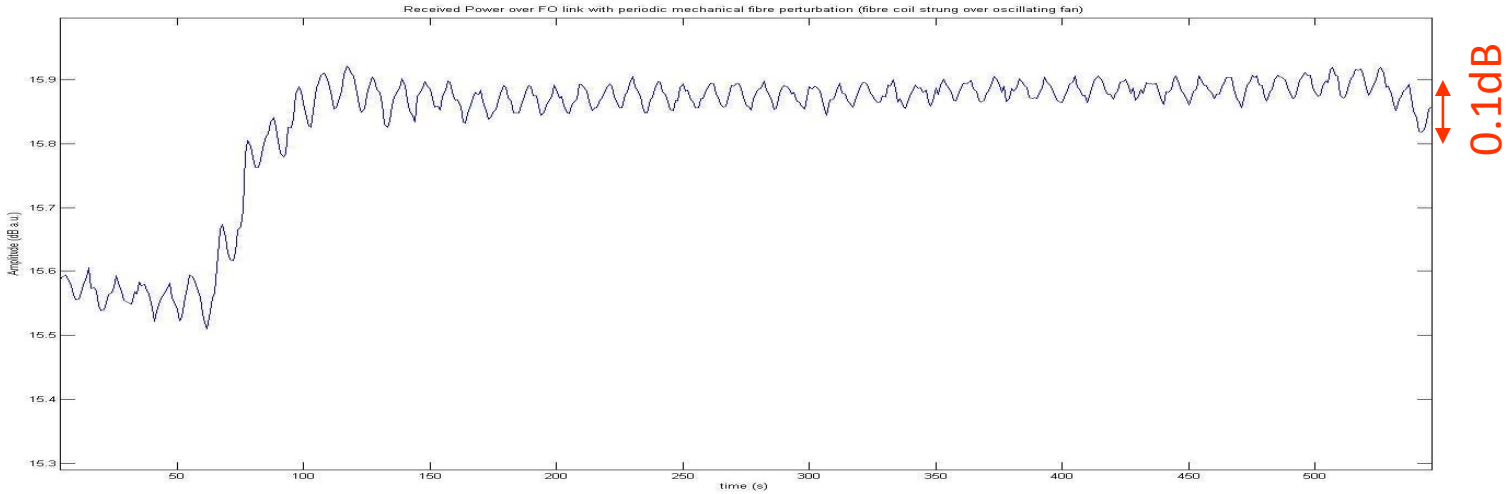
< 1.4 dB and < 10deg avg over any 1 sec period

< 0.013dB and < 0.16deg avg over any 60sec period

- Phase Stability dominated by fibre **7ppm/C** only.
- Round Trip Phase measurement desirable.

9 Stability Measurements (excellent!)





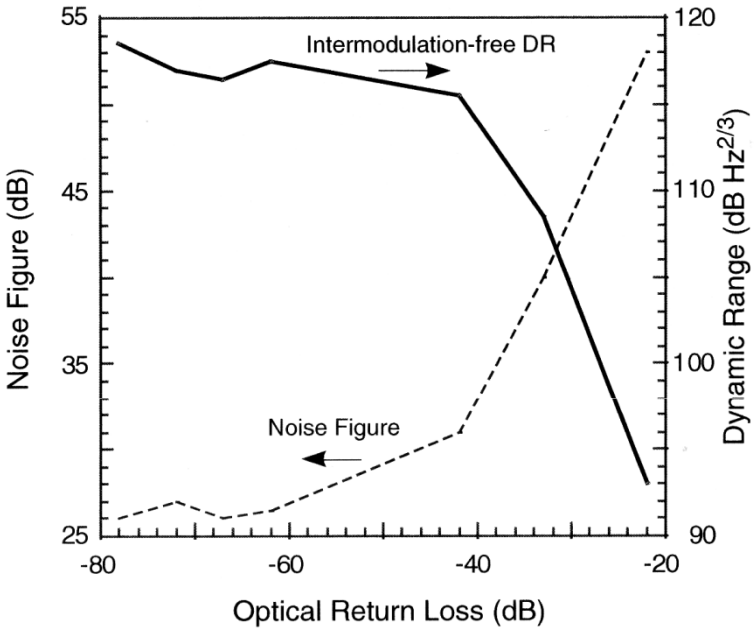
10 Cost Estimate per RFoF channel.

Item	Cost ea USD based on QTY 1000
DFB 1310nm Laser/isolator cw connector	$99
PIN Diode cw connector	$60
MPO connector at PAF	$20/per fibre core
Bias Control	$3
RF Gain Blocks	$8
Other discrete parts	$5
PCB Tx and Rx	$15
Sub-Octave Filtering and Switching	$50
TOTAL	**$260**

Current Cost $260 per RFoF channel using HQ DFBs.
Could be as low as $180 with VCSELs but would require continued R&D effort.

11 DNR as function of ORL (thanks Cox et al)

Link design tradeoffs



APPLICATIONS

- Patch cords and Fan-Out assemblies
- ATM & DWDM high speed communication systems
- Multimedia
- CATV and Video
- Data and Telecommunication Networks
- Industrial

SPECIFICATIONS

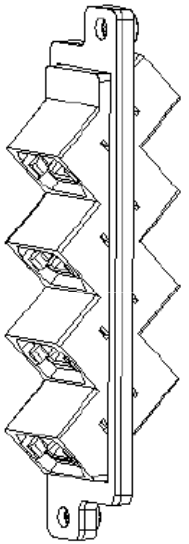
	MULTIMODE 0° PC	SINGLE MODE 0° PC	SINGLE MODE 8° APC	UNITS	TEST CONDITIONS
Insertion Loss (IL)	typ. 0.35	typ. 0.25 max. 0.75	typ. 0.35 max. 0.75	dB	IEC61300-3-4; λ= 1300/1550nm
Return Loss (FL)	typ. 30	min. 40	min. 60*	dB	IEC61300-3-6; λ= 1300/1550nm
Repeatability of IL	max. ±0.2			dB	Over service life
Service life	1000 mate/demate cycles				
Operating temperature	-40/+85**			°C	
Storage temperature	-40/+90**			°C	

* Measured with high precision reflectometer
** May be further limited by cable specifications

12 OPTICAL CONNECTORS

MOLEX

MTP*/MPO
Connectors and Adapters



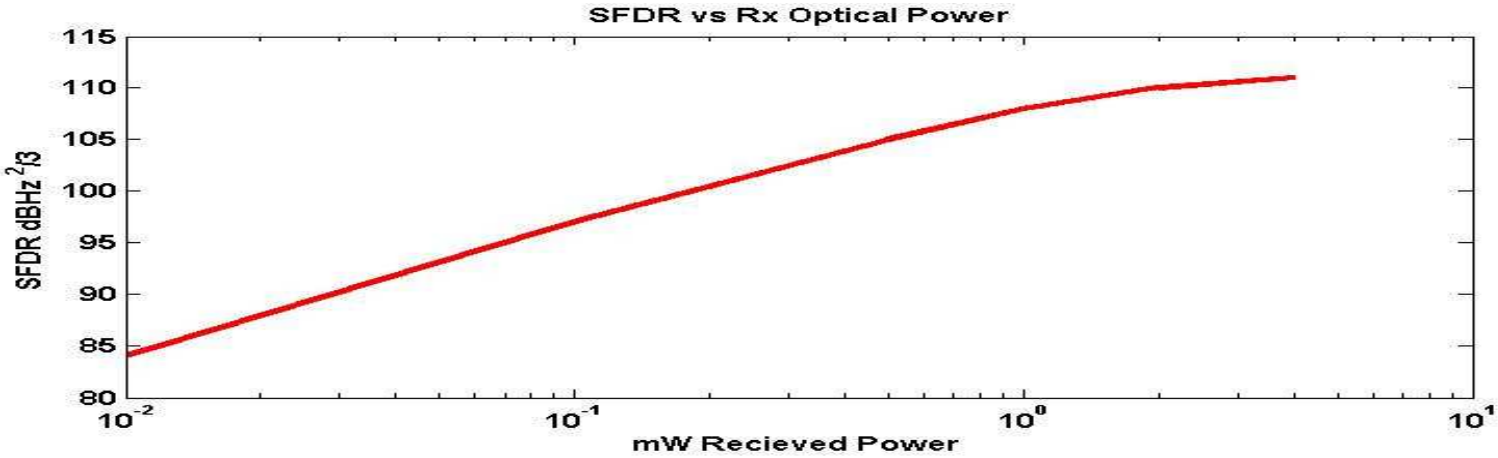
APC

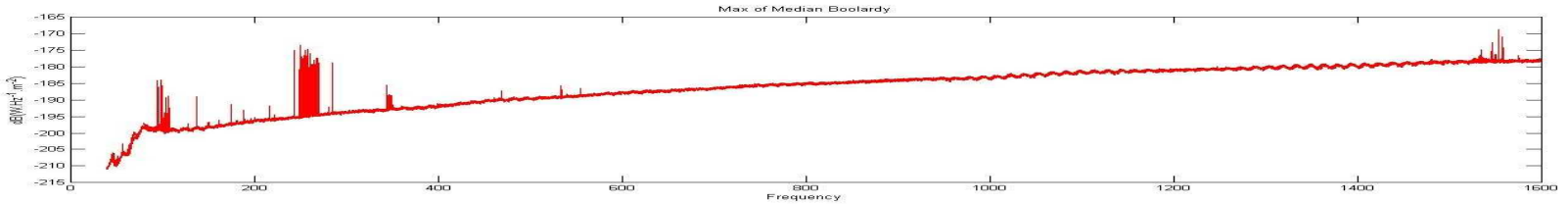
available →

PERFORMANCE AND SPECIFICATIONS

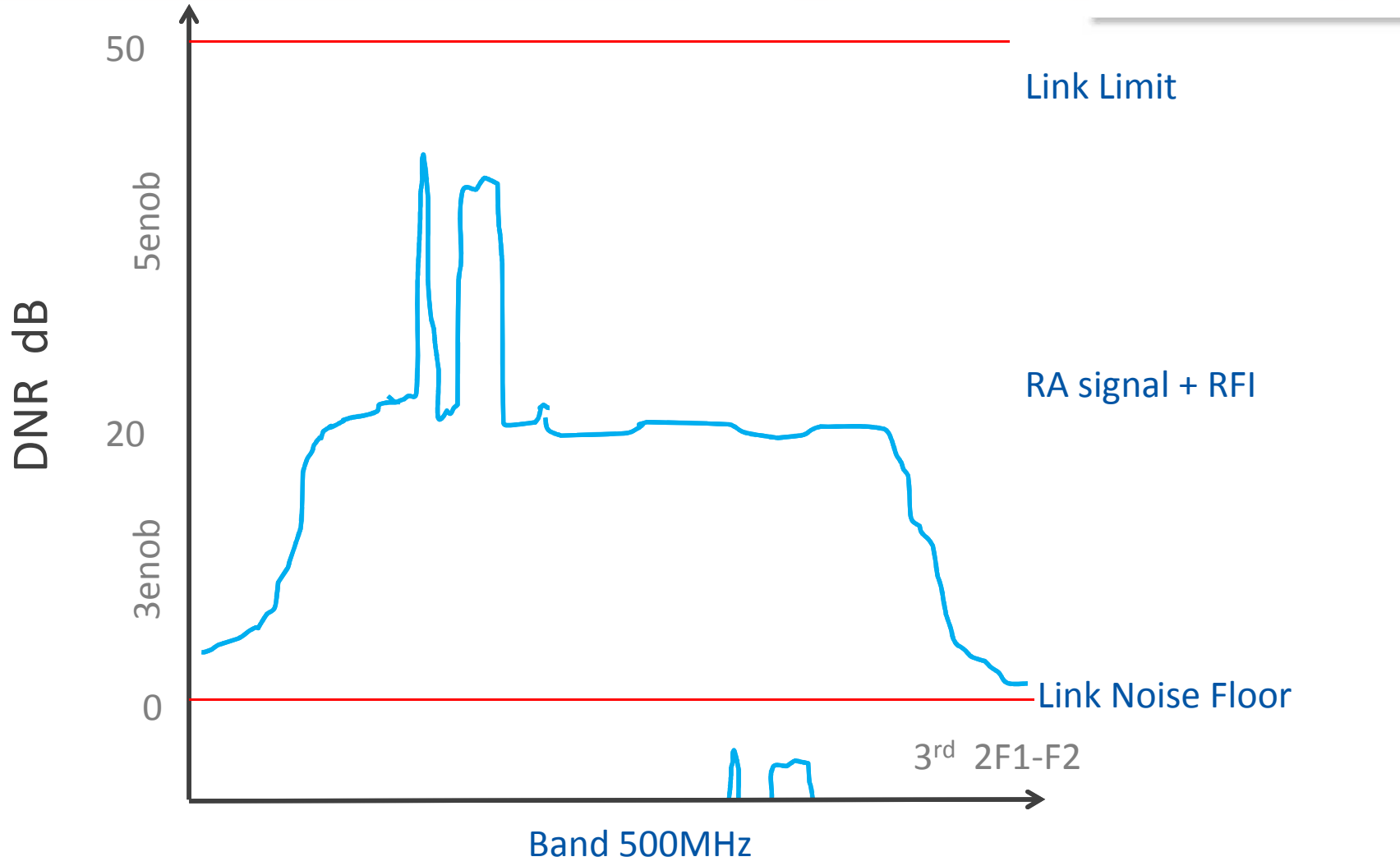
Characteristics	Units	Typical	Maximum At Test
Insertion Loss 4, 8 or 12: 9/125 Singlemode Fiber 62.5/125µm Multimode Fiber 50/125µm Singlemode Fiber	 ~dB ~dB ~dB	 .3 .3 .3	 .75 .75 .75
Insertion Loss 8 Fiber Low Loss Ferrule 9/125 Singlemode Fiber	 ~dB	 .15	 .5
Insertion Loss 24 Fiber Ferrule 9/125 Singlemode Fiber 62.5/125µm Multimode Fiber 50/125µm Singlemode Fiber	 ~dB ~dB ~dB	 .4 .4 .4	 1.0 1.0 1.0
Return Loss: Singlemode	~dB	55	< 50
Cable Assembly Length	M	1 to 10	2000
Temperature Range	°C		+70

13 Maintaining SFDR





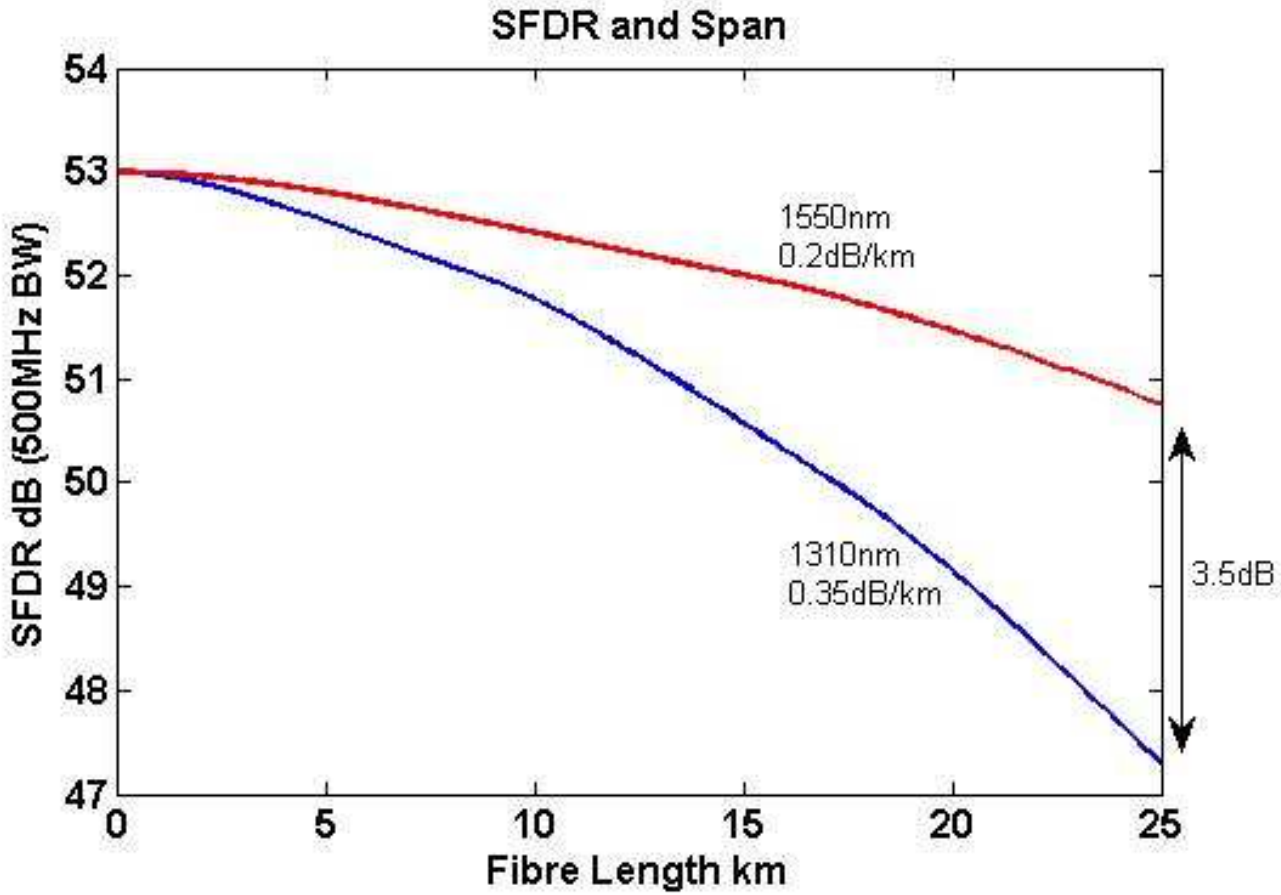
14 SFDR Important



15 SFDR Notes

- RFI that is strong will generate new in-band spectra
- Stationary RFI that is weak will show after integration
- Outrigger antennas will fringe wash RFI
- Less requirement for highest SFDR at 25km?
- Fits nicely with RFoF characteristics.
- 50dB SFDR over 500MHz BW good fit with 8b ADCs
- Actual SFDR dependent on real RFI measurements.
- Core site selection consideration.

16 Phase1 25km Span with RF



17 1550nm is an option

DATASHEET| MARCH 3, 2010

Model 1955F/R/W Coaxial DFB Laser Diode

1550nm CWDM, 5 MHz – 4000 MHz

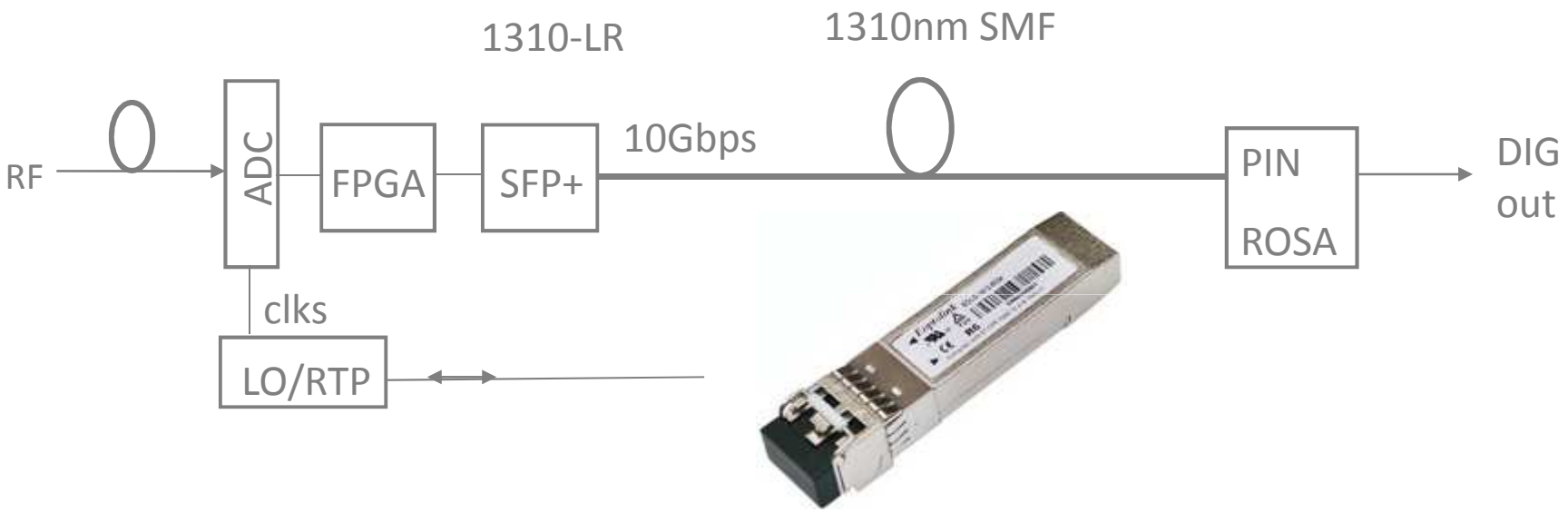
Emcore's Model 1955 DFB lasers offer a low cost solution for linear fiberoptic links. These components can be cooled with external thermo-electric coolers for high stability, or run without TEC's to reduce power consumption. The DFB laser builds upon Ortel's long history of high performance, leading edge designs in CATV, wireless, and high speed

- **High slope efficiency up to 0.3mW/mA**
- **Monitor photodiode**

Enhanced Linearity	-	-	-57	
Composite Triple Beat (79 channels)	-	-	-65	dBc
CWDM Wavelength	1470, 1490, 1510, 1530, 1550, 1570, 1590, 1610			nm
Optical Return Loss	45	-	-	dB

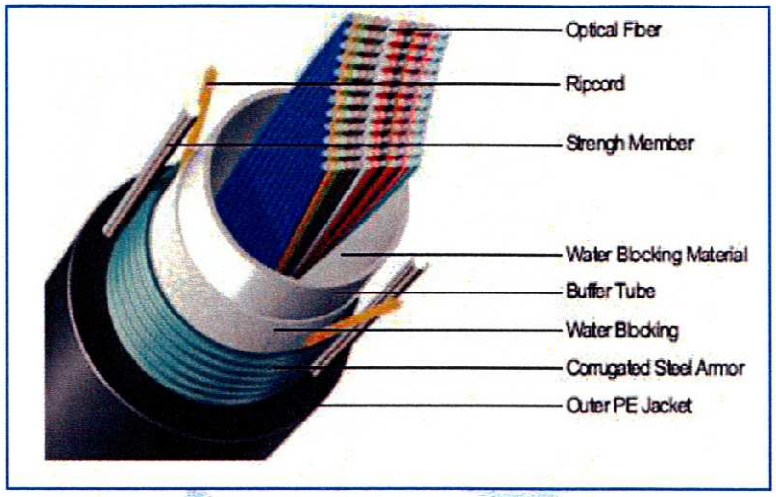
CWDM would require Dispersion Shifted Fibre and compensation
Reduce fibre core count

18 Current ASKAP BETA



- Current 188e PAF uses 192 x SFP+ 1310LR at < $200/10km link
- Could be easily extended to 40km for same cost 1550ER
- Can be easily upgraded to 80km EML-APD CWDM 1550ZR (< $1800 ea)
- Too much antenna hardware...EMC issue.

19 Ribbon Fibre Cable



Several Manufacturers.

Cost ~ $4.30/m in qty [216 core]

$4300 /km

$430000 / 100km

Mechanical Characteristics:

Storage Temperature : -40 to + 70℃ / Operating Temperature : -40 to + 70℃

Fiber Count	LSC Part Number	Nominal* Outer diameter		Nominal* Weight		Maximum Tensile Load Short Term		Maximum Tensile Load Long Term		Crush Load Short Term		Crush Load Long Term		Minimum Bend Radius Loaded		Minimum Bend Radius Installed	
		[mm]	[inch]	[kg/km]	[lb/1000 ft]	[N]	[lb]	[N]	[lb]	[N/cm]	[lb/inch]	[N/cm]	[lb/inch]	[cm]	[inch]	[cm]	[inch]
96	CR-NJB□E/B□□-096	13.8	0.54	166	111	2,700	125	1,000	46	440	251	220	125	27.6	10.87	13.8	5.43
216	CR-NJB□E/B□□-216	16.3	0.64	244	164	2,700	125	1,000	46	440	251	220	125	32.6	12.83	16.3	6.42
432	CR-NJB□E/B□□-432	20.0	0.79	333	224	2,700	125	1,000	46	440	251	220	125	40.0	15.75	20.0	7.87

END

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