Preliminary Design for 3 Simultaneous Local Oscillators, GLT Project

filename – 3LO-system
version – 2023.01.26
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Requirements for 3-LO Subsystem

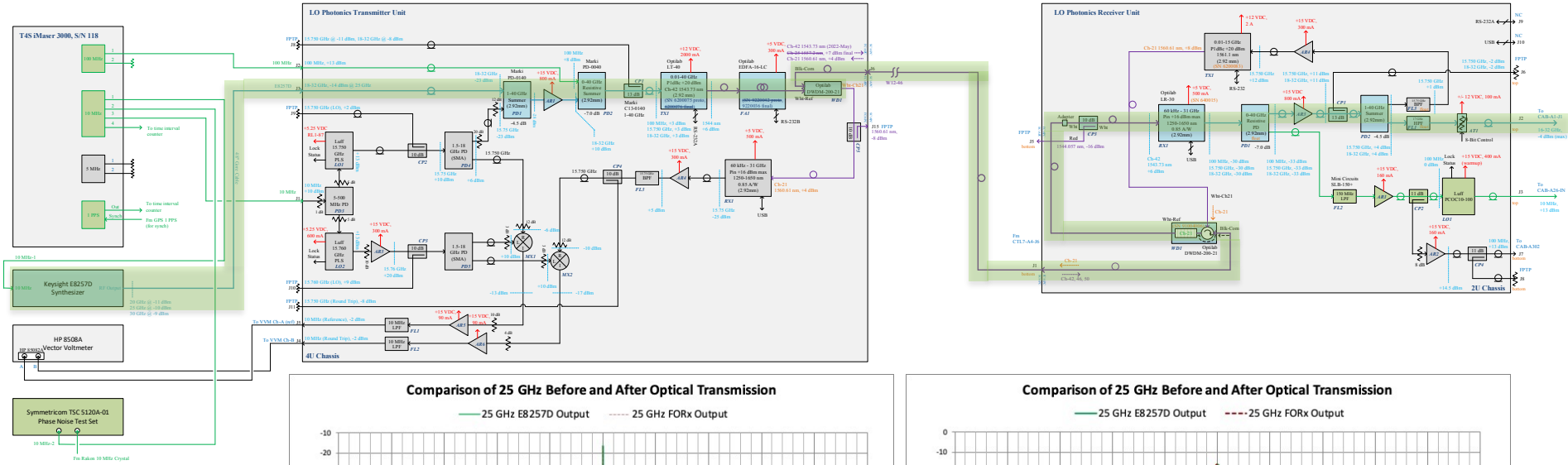
- Provide 3 simultaneous phase coherent LOs for:
  - 86 GHz Receiver with LO = 73.500 to 88.500 GHz (TBR)
  - Corresponds to f_{synth} = 18.367 125 to 22.117 125 GHz
  - 230 GHz receiver with LO = 220.500 to 265.500 GHz (TBR)
  - Corresponds to f_{synth} = 18.367 125 to 22.117 125 GHz (TBR)
  - 345 GHz receiver with LO = 280.500 to 367.500 GHz (TBR)
  - Corresponds to f_{synth} = 23.367 125 to 30.617 125 GHz

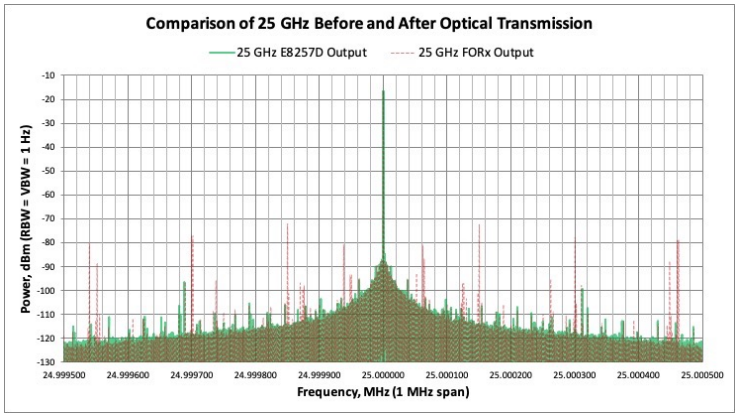
  and potentially 690 (requires deletion of one of the above receivers)

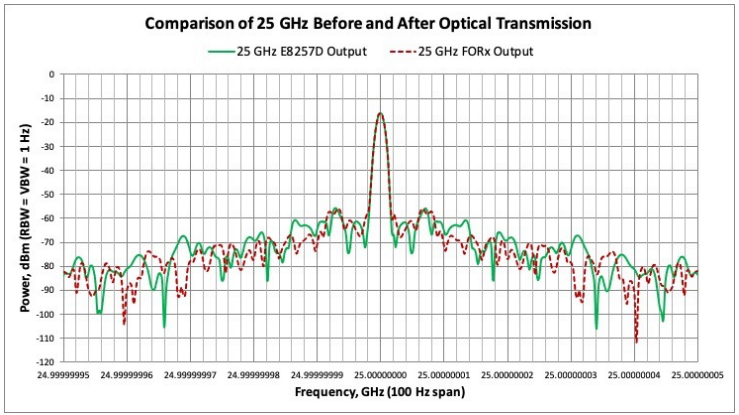
  - 690 GHz receiver with LO = 610.200 to 712.008 GHz (TBR)
  - Corresponds to f_{synth} = 16.942 125* to 19.770 125 GHz
- Phase noise performance better than or equal to current system

*slightly below 17 – 34 GHz filter in current hardware

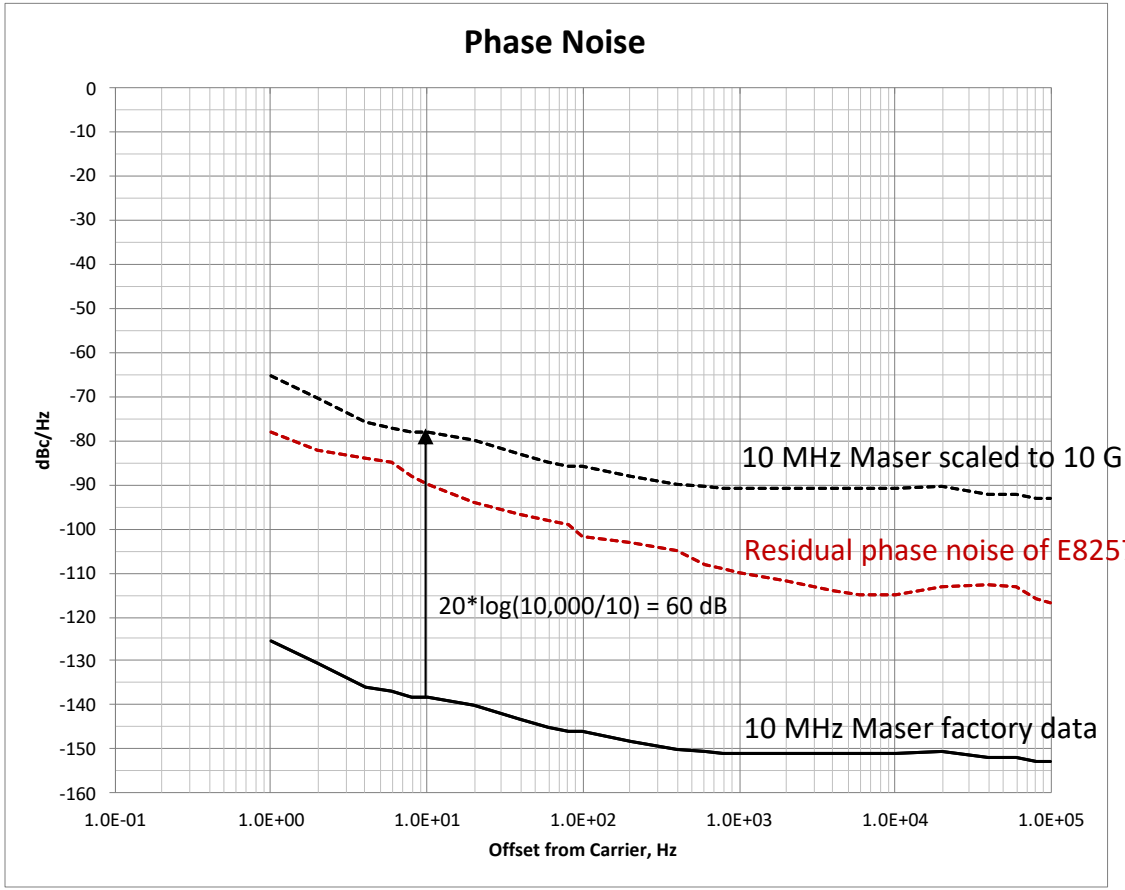
LO Subsystem, Existing Hardware Configuration



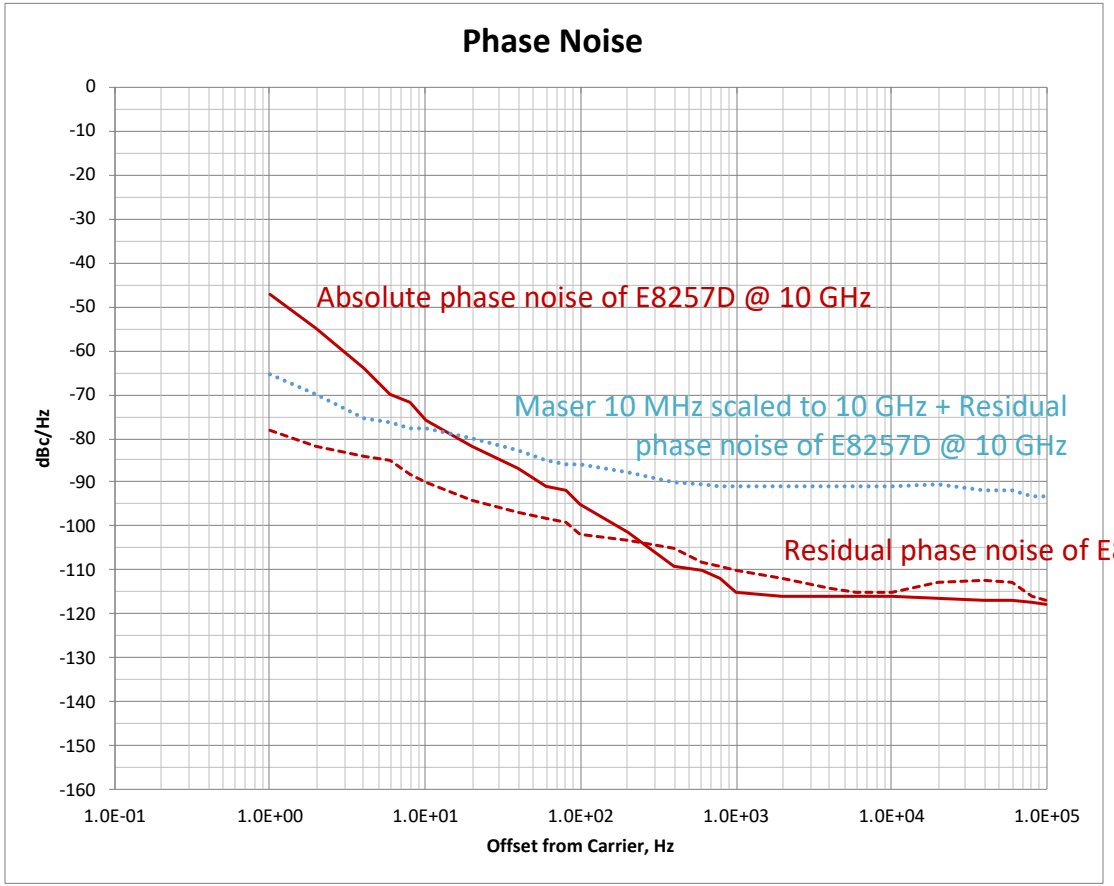




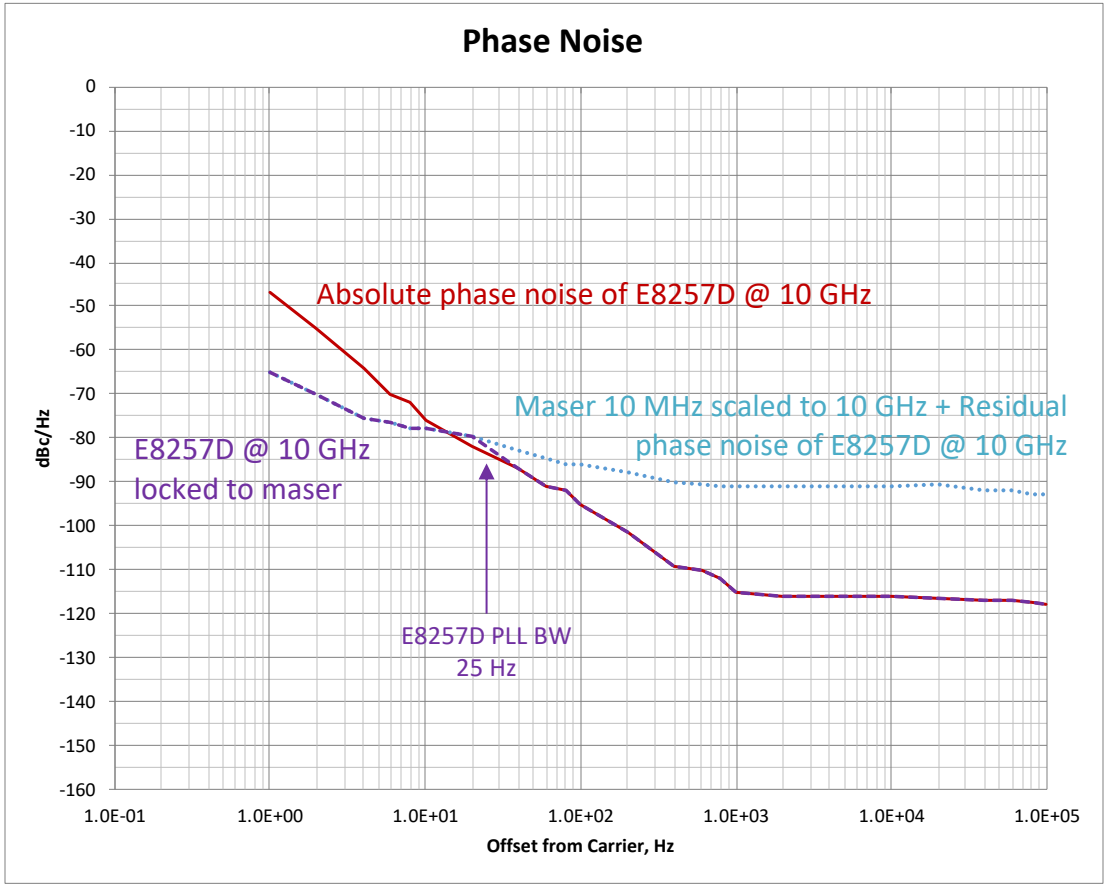
Estimated Phase Noise Performance



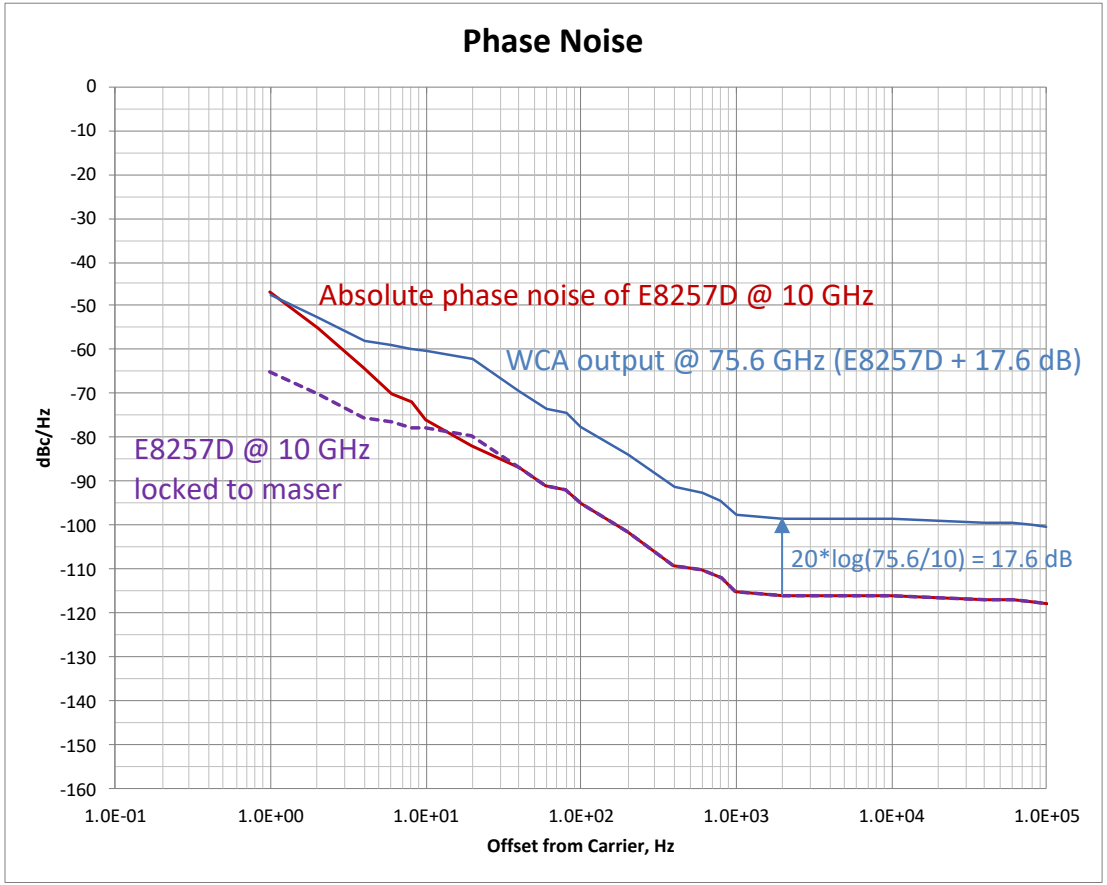
Estimated Phase Noise Performance



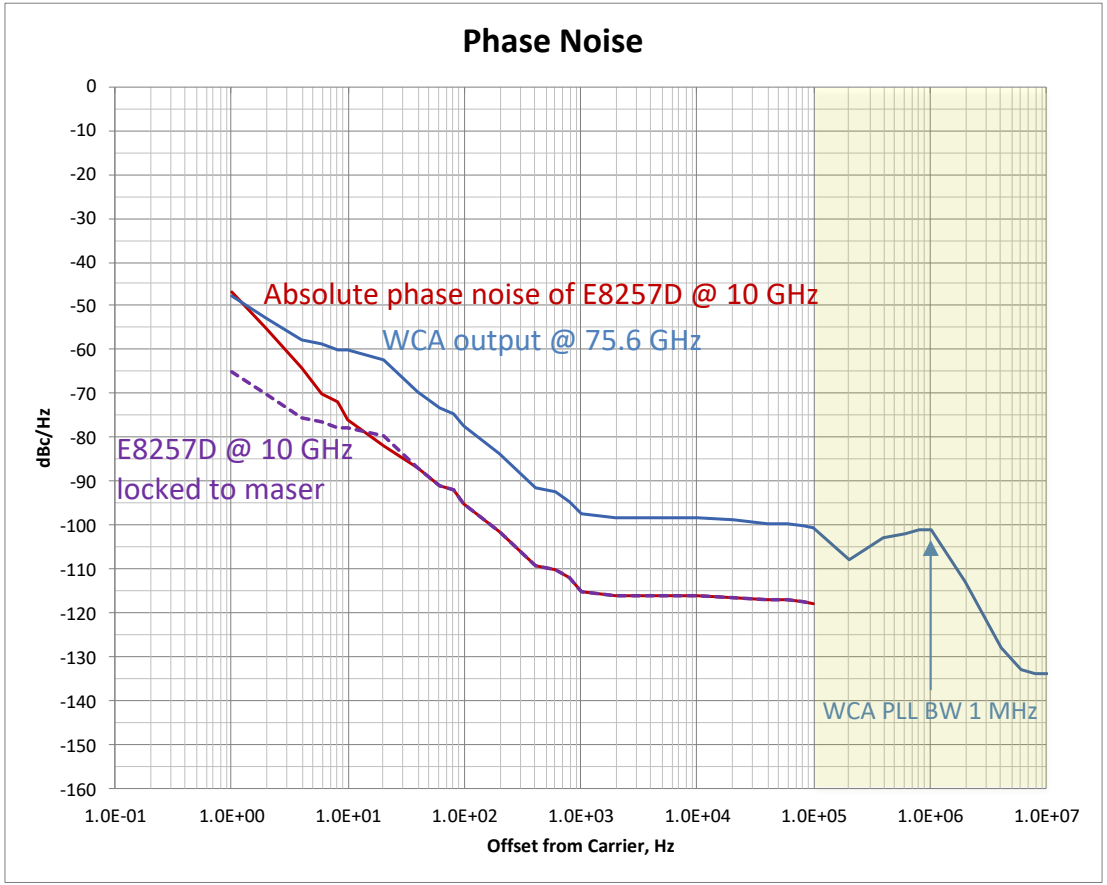
Estimated Phase Noise Performance



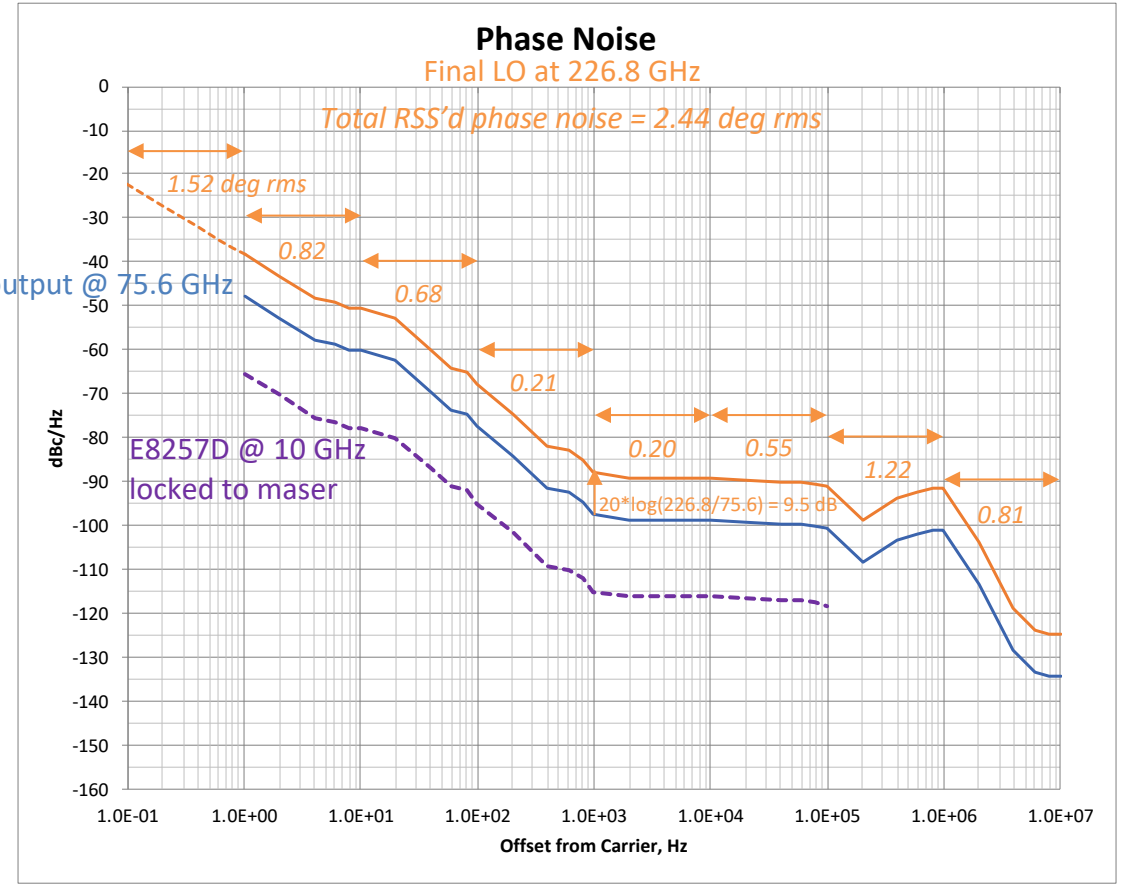
Estimated Phase Noise Performance



Estimated Phase Noise Performance



Estimated Phase Noise Performance



7.2.8 Effect of Phase Errors TMS 3rd Edition, pg 277

Rapidly varying phase errors, such as those resulting from noise in LO circuits, cause a loss in signal amplitude and hence in sensitivity. They may also cause errors in the visibility phase, but the effect is small, since fast variations in the visibility phase are substantially reduced by the visibility averaging. To determine the loss in sensitivity, the signals from two antennas can be represented by $V_m e^{\phi_m(t)}$ and $V_n e^{\phi_n(t)}$ at the correlator inputs, where the ϕ terms are the phase errors for antennas m and n. The correlator output is

$$r = \langle V_m e^{\phi_m(t)} V_n^* e^{\phi_n(t)} \rangle \,, \tag{7.32}$$

where the angle brackets represent the expectation. Then if $\Delta\phi = [\phi_m(t) - \phi_n(t)]$ is the phase error, we have

$$r = V_m V_n^* [\langle \cos \Delta\phi \rangle + j \langle \sin \Delta\phi \rangle] \,. \tag{7.33}$$

If the probability distribution of $\Delta\phi$ is an even function with zero mean, which is frequently the case, the time average of the sine term has an expectation of zero. Then, by using the first two terms of the series expression for a cosine, we obtain a result in terms of the rms phase error, $\Delta\phi_{\text{rms}}$:

$$r \simeq [1 - \tfrac{1}{2} \Delta\phi_{\text{rms}}^2] \,. \tag{7.34}$$

The cosine approximation is accurate to 1% for values of $\Delta\phi_{\text{rms}}$ less than $\sim 37°$. A reduction in sensitivity of 1% occurs for $\Delta\phi_{\text{rms}} = 8.1°$.

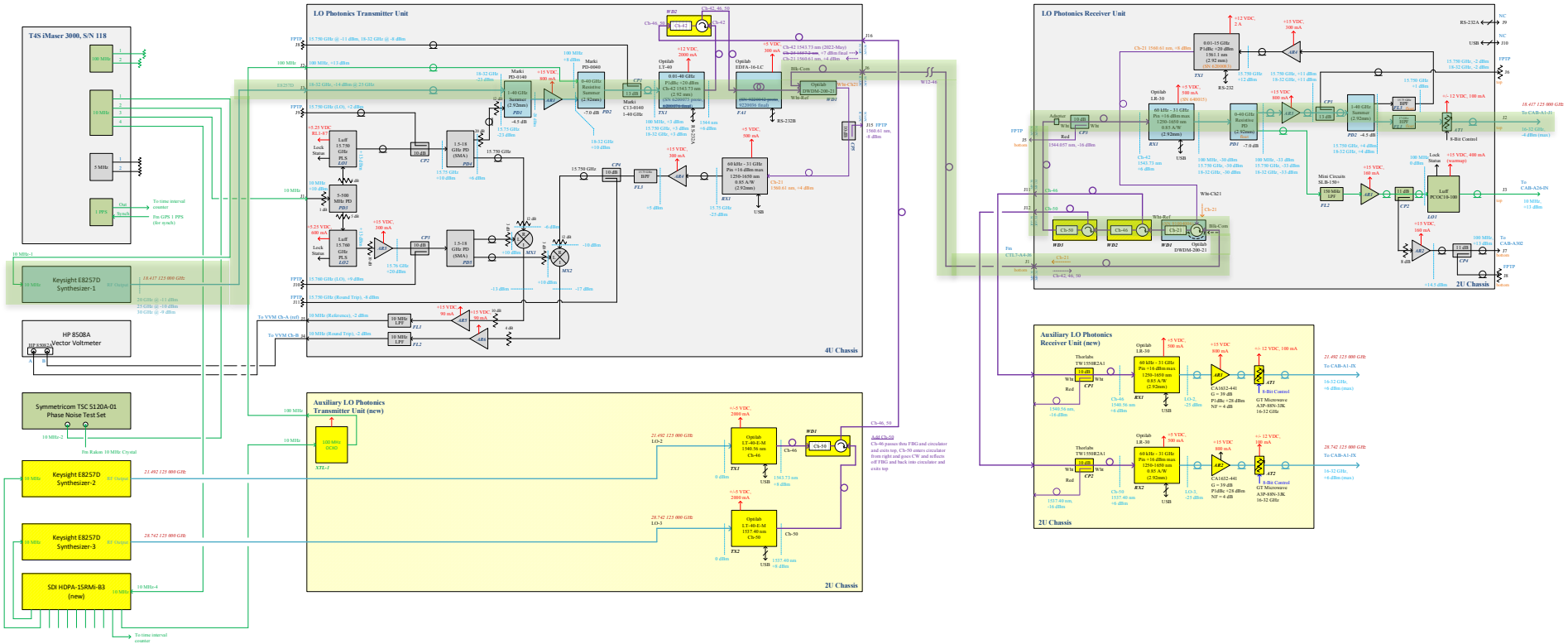
Assume our actual phase noise is a factor of 2 worse than calculated: 2.44 → 5.0 deg rms

$\Delta\phi_{\text{rms}}$ = 7.1 deg rms
r ~ [1 - 0.5*0.12^2]
= 0.992 (0.8% loss)

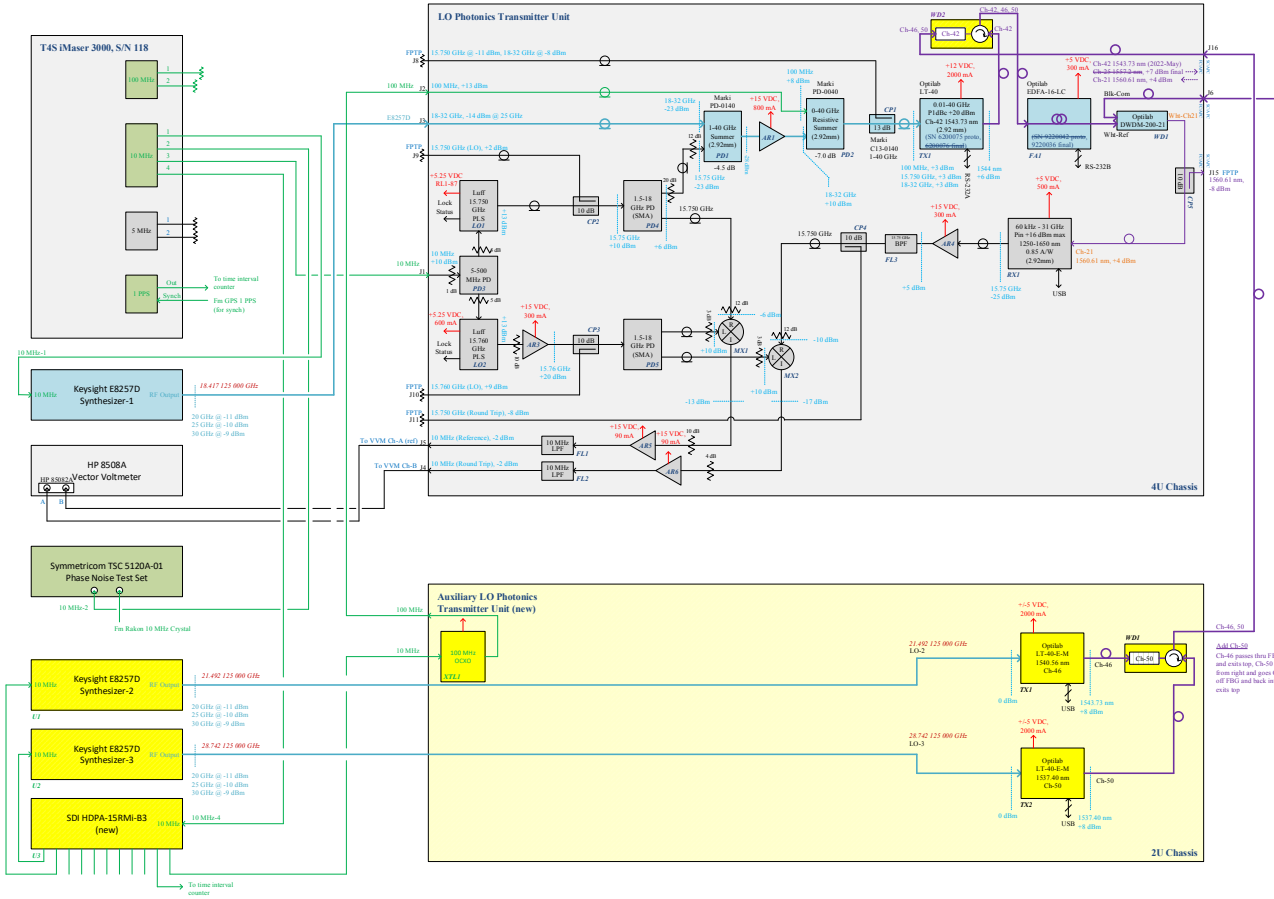
5.0 & 10 deg rms → 11.18 deg
r ~ [1 - 0.5*0.195^2]
= 0.981 (1.9% loss)

5.0 & 20 deg rms → 20.62 deg
r ~ [1 - 0.5*0.360^2]
= 0.935 (6.5% loss)

3-LO Subsystem Transmitter, *Version-1*



3-LO Subsystem Transmitter Cost, *Version-1*



U1	Keysight	E8257D, 540, UNX	$60,000
U2	Keysight	E8257D, 540, UNX	$60,000
U3	Spectral Dynamics	HDPA-15RMi-B3	$5,000
Wx	Gore	RF Cables, High Quality	$1,500
			$126,500

Aux Photonics Transmitter Unit:

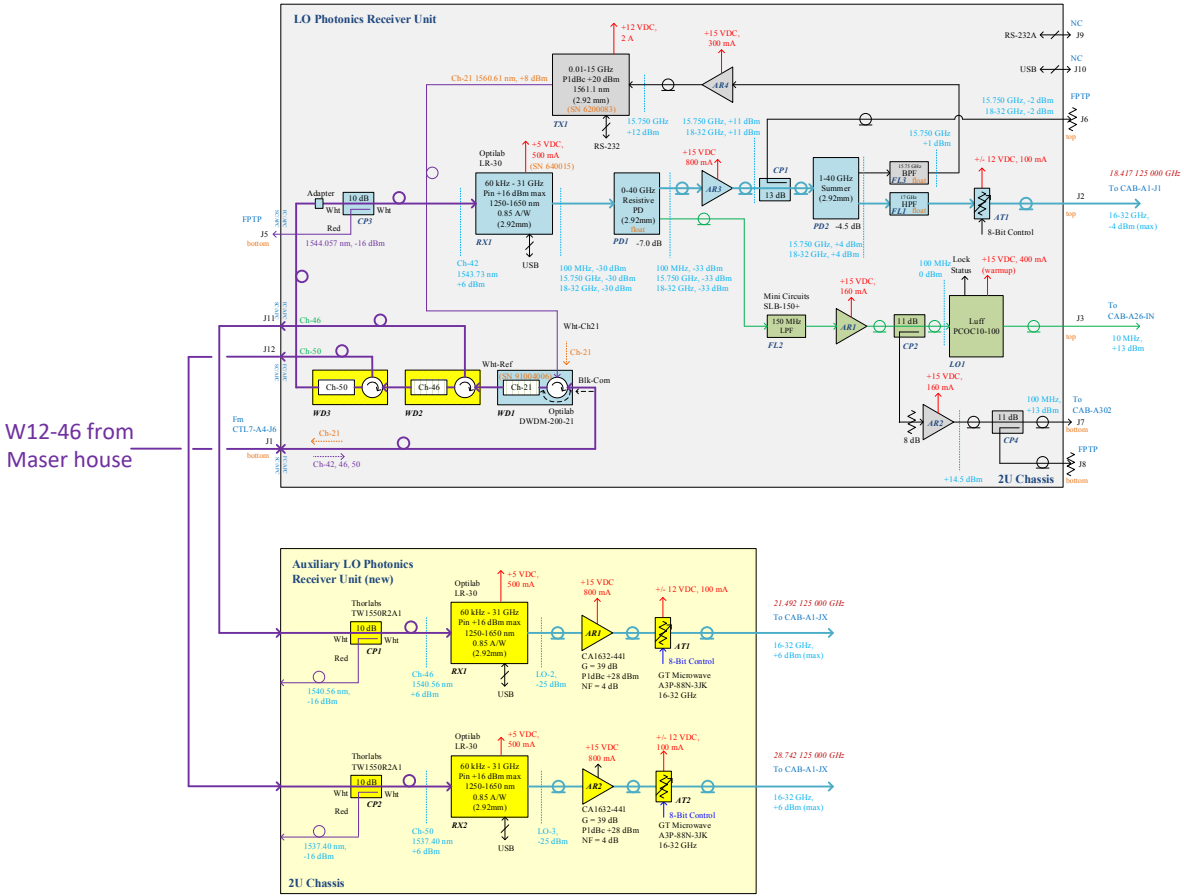
XTL1	TBD	100 to 10 MHz Crystal	$2000
TX1	Optilab	LT-40-E-M, Ch-46	$7000
TX2	Optilab	LT-40-E-M, Ch-50	$7000
WD1	Optilab	DWDM-200-50	$500
-	Misc	Optical Components	$500
-	Par-Metal	2U EMI Chassis	$300
-	Labor	Fabrication	$500
-	Daitron	Low Noise DC PS	$500
-	Misc	Thermal Management	$200
-	Advantech	Monitor & Control	$500
			$19,000

Additional Parts for Photonics Transmitter Unit:

WD2	Optilab	DWDM-200-42	$500
Misc	Optical parts		$300
			$800

Subtotal for Tx $146.3k USD

3-LO Subsystem Receiver Cost, *Version-1*



Aux Photonics Receiver Unit:

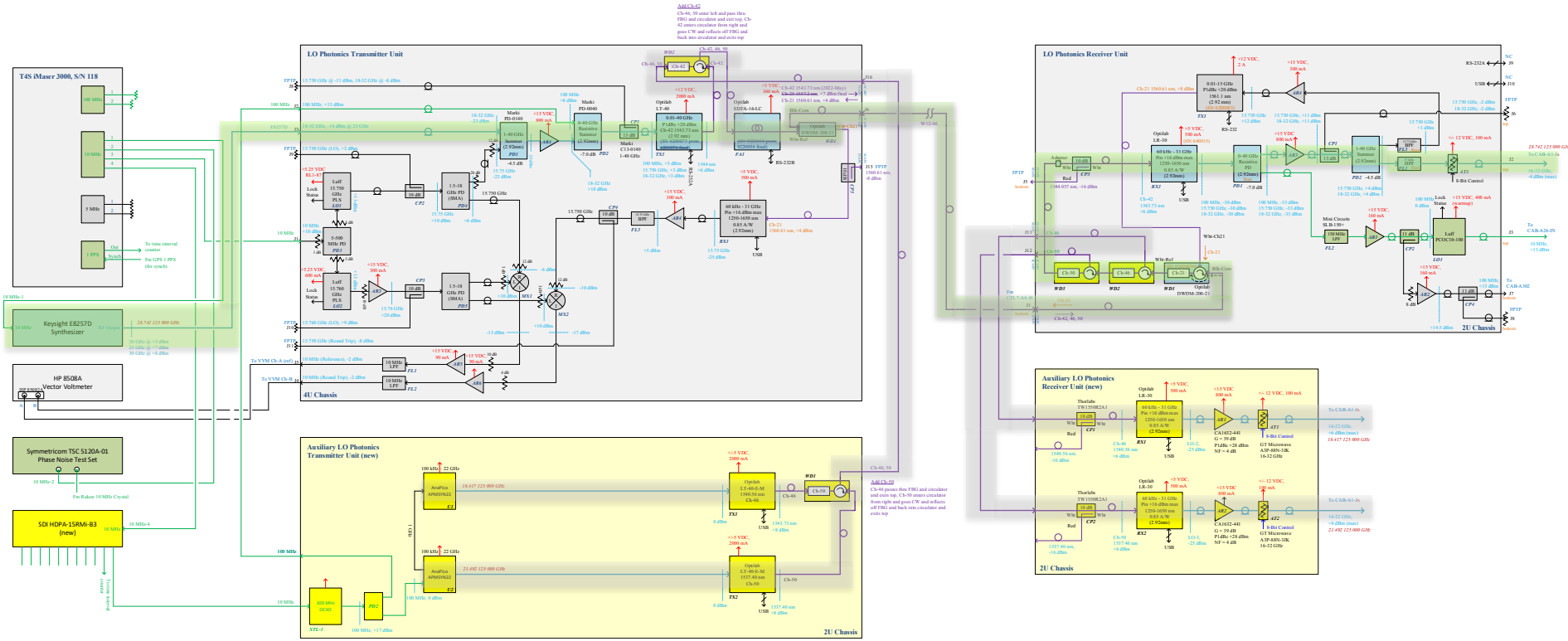
CP1	General Photonics	10/90 Optical Coupler	$900
CP2	General Photonics	10/90 Optical Coupler	$900
RX1	Optilab	LRC-40x	$2700
RX2	Optilab	LRC-40x	$2700
AR1	Ciao Wireless	CA1632-441	$2500
AR2	Ciao Wireless	CA1632-441	$2500
AT1	GT Microwave	A3P-88N-3JK	$2500
AT2	GT Microwave	A3P-88N-3JK	$2500
-	Misc-1	Optical Components	$500
-	Misc-2	RF Components	$500
-	Misc-3	Thermal Management	$200
-	Par-Metal	4U EMI Chassis	$300
-	Labor	Fabrication	$500
-	Daitron	Low Noise DC PS	$500
-	Advantech	Monitor & Control	$500
			$20,200

Additional Parts for Photonics Receiver Unit:

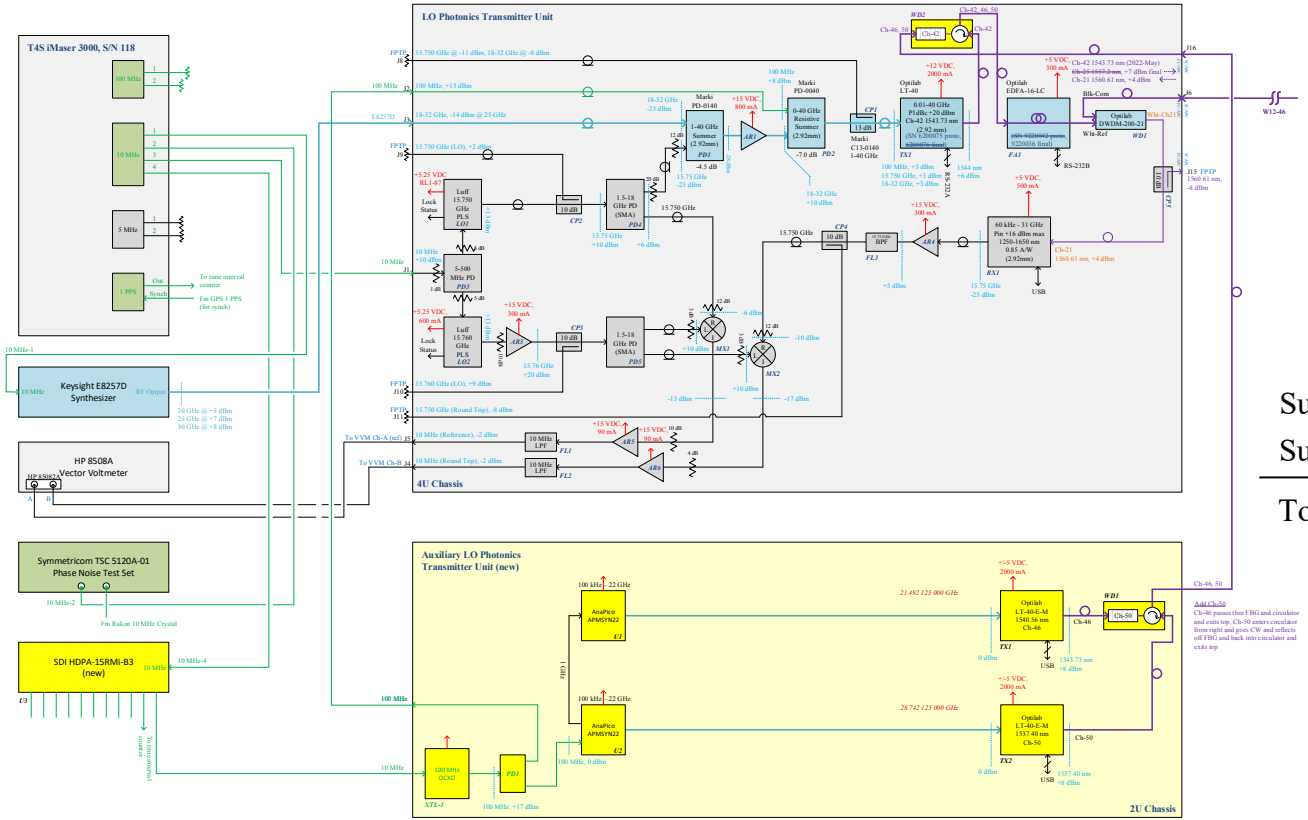
WD2	Optilab	DWDM-200-46	$500
WD3	Optilab	DWDM-200-50	$500
Misc	Optical parts		$300
			$1300

Subtotal for Tx	$146.3k USD
Subtotal for Rx	$ 21.5k USD
Total for Tx & Rx	$167.8k USD

LO Subsystem, Augmented to Support 3 LOs, *Version-1*



3-LO Subsystem Transmitter Cost, *Version-2*



U3	Spectral Dynamics	HDPA-15RMi-B3	$5,000
Aux Photonics Transmitter Unit:			
XTL1	TBD	100 to 10 MHz Crystal	$2000
PD2	Mini-Circuits	TBD	$100
U1	AnaPico	100 kHz – 22 GHz synth	$1500
U2	AnaPico	100 kHz – 22 GHz synth	$1500
TX1	Optilab	LT-40-E-M, Ch-46	$7000
TX2	Optilab	LT-40-E-M, Ch-50	$7000
WD1	Optilab	DWDM-200-50	$500
-	Misc	Optical Components	$500
-	Par-Metal	2U EMI Chassis	$300
-	Labor	Fabrication	$500
-	Daitron	Low Noise DC PS	$500
-	Misc	Thermal Management	$200
-	Advantech	Monitor & Control	$500
			$49600
Additional Parts for Photonics Transmitter Unit:			
WD2	Optilab	DWDM-200-42	$500
Misc	Optical parts		$300
			$800

Subtotal for Tx	$ 55.4k USD
Subtotal for Rx	$ 21.5k USD
Total for Tx & Rx	$ 76.9k USD