A COTS RF/Optical Software Defined Radio for the Integrated Radio and Optical Communications Test Bed

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Outline

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- Transmitter Architecture Overview
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- Optical Testing Results
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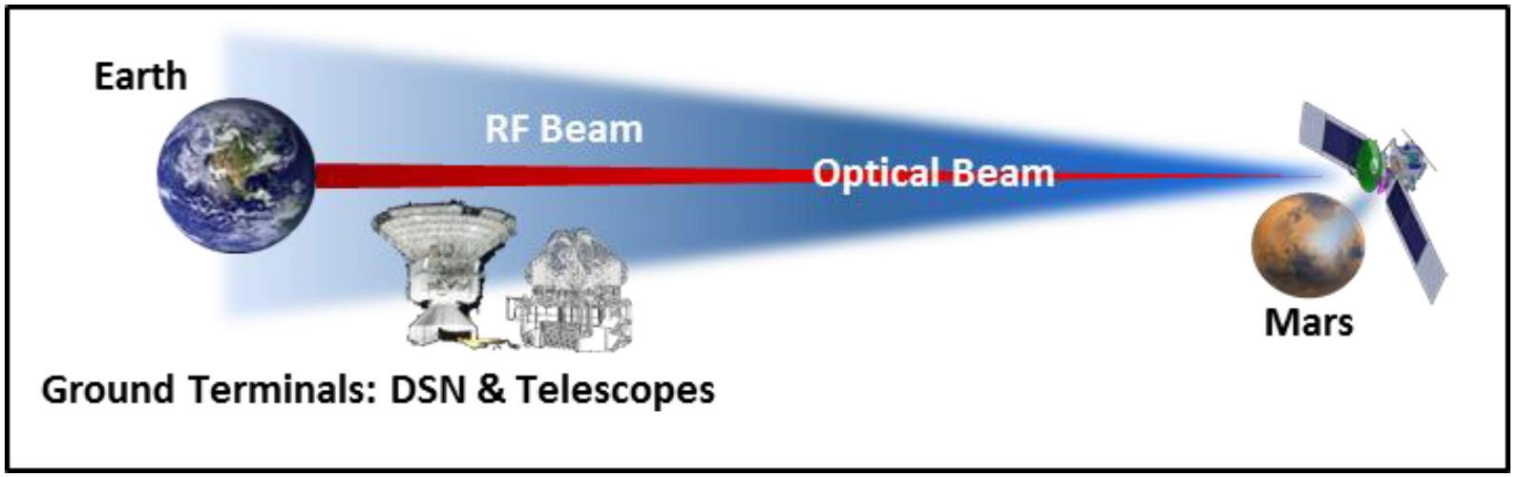
RF/Optical Transmitter and Optical Receiver

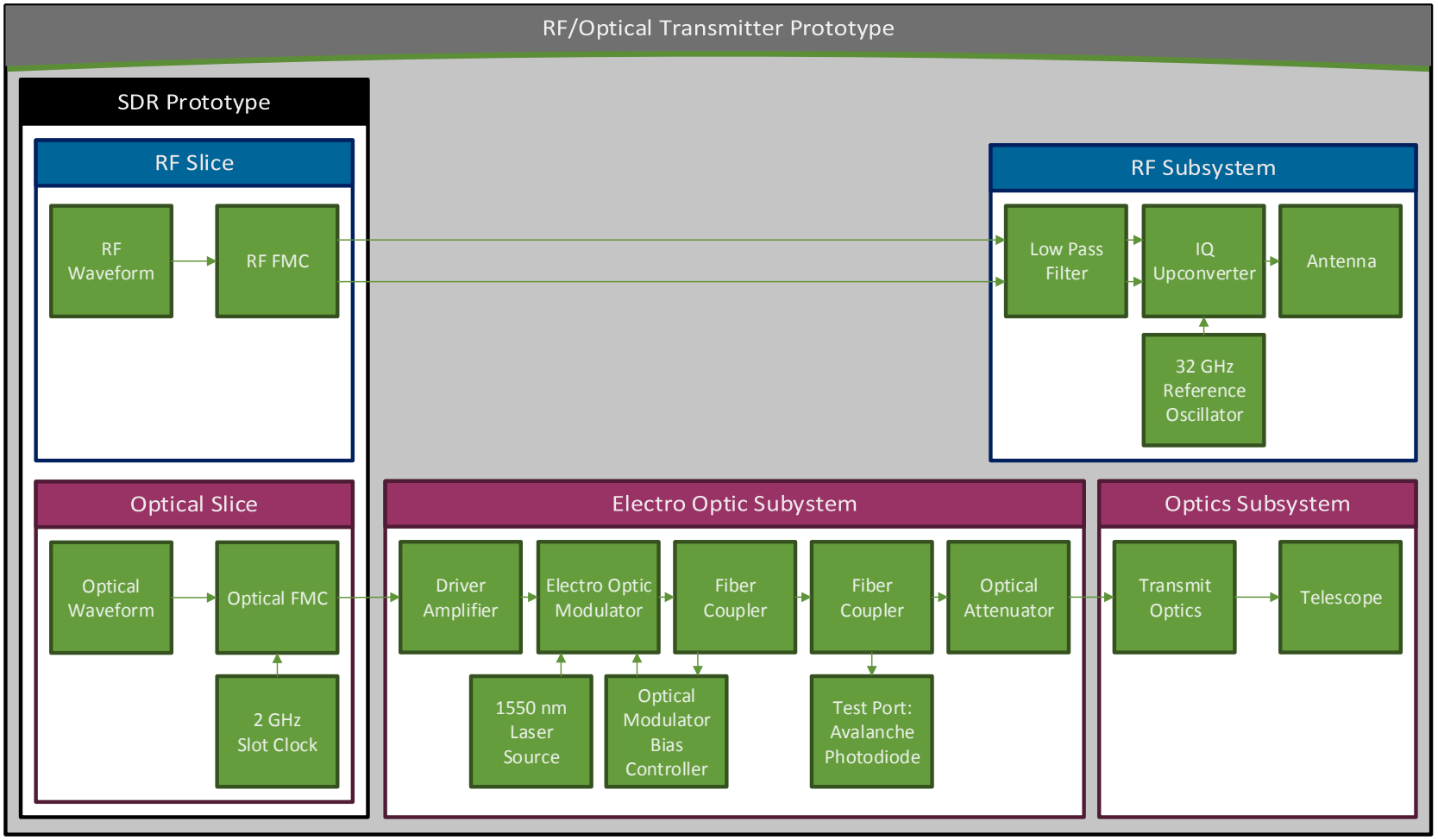
Integrated Radio and Optical Communications Project (iROC) Overview

Description:

- Technology development program for integration of RF and optical deep space communication systems.
- Key areas of development include:
  - RF antenna + optical telescope = teletenna
  - Beaconless (open loop) optical pointing
  - RF/Optical software defined radio

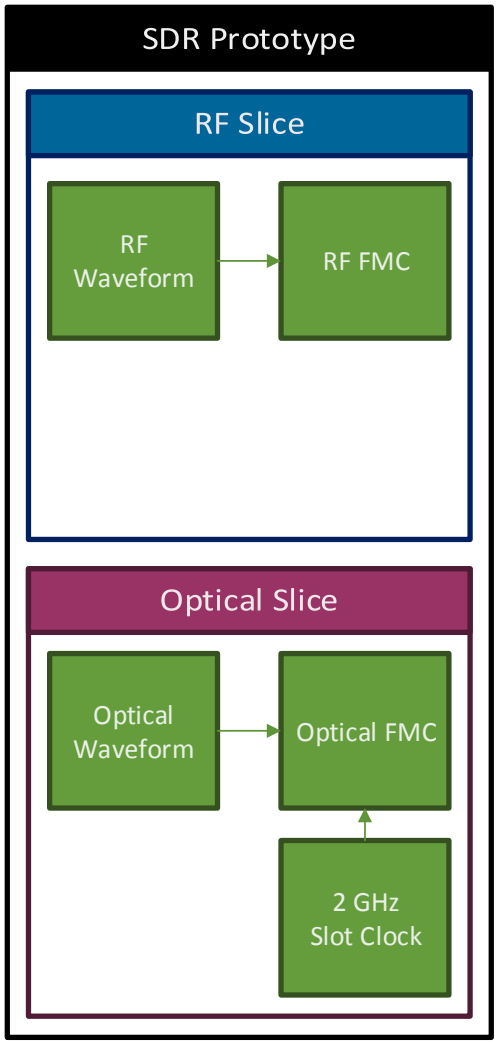


Transmitter Architecture Overview



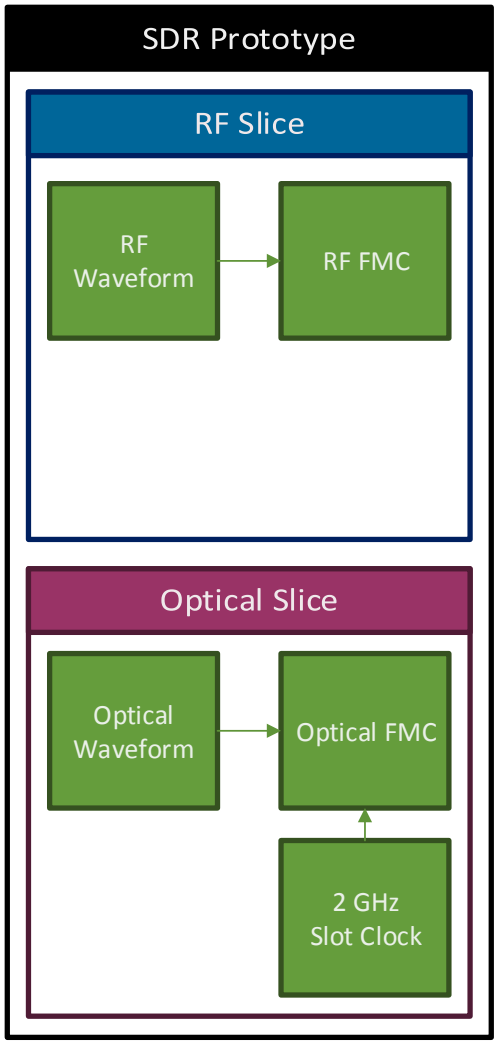
The transmitter includes: Software Defined Radio (SDR) Prototype, the RF Subsystem, The Electro Optic Subsystem, and the Optics Subsystem

Software Defined Radio Prototype



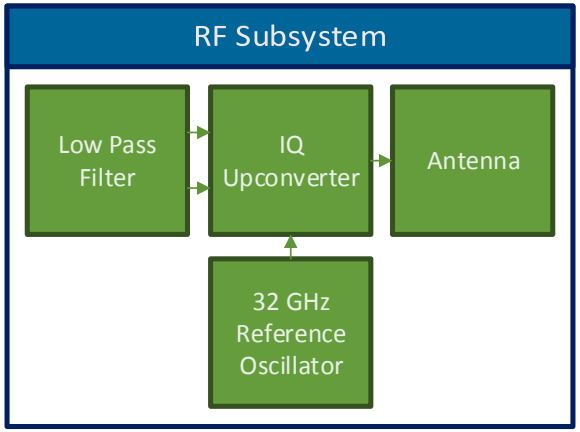
RF and Optical waveforms are integrated onto one Xilinx field programmable gate array (FPGA) development board.

RF Slice



- RF Waveform: Offset quadrature phase shift keying (QPSK)
- Symbol rate: 46.08 MSps
- RF FPGA Mezzanine Card (FMC): Contains a digital to analog converter (DAC) and oscillator at 737.28 MHz which is used to drive the RF waveform.

RF Subsystem



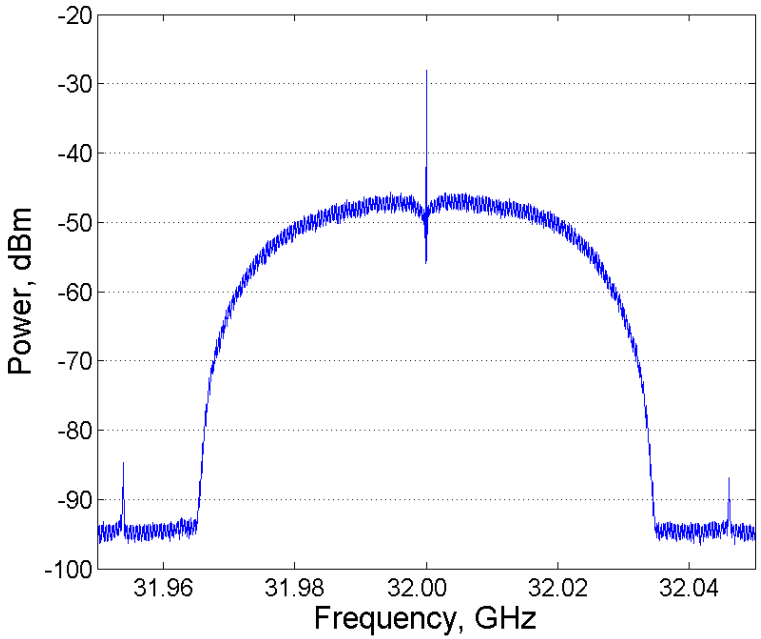
The RF subsystem interfaces to the DAC from the SDR, filters, mixes, and upconverts the I/Q signals from baseband to RF.

Components

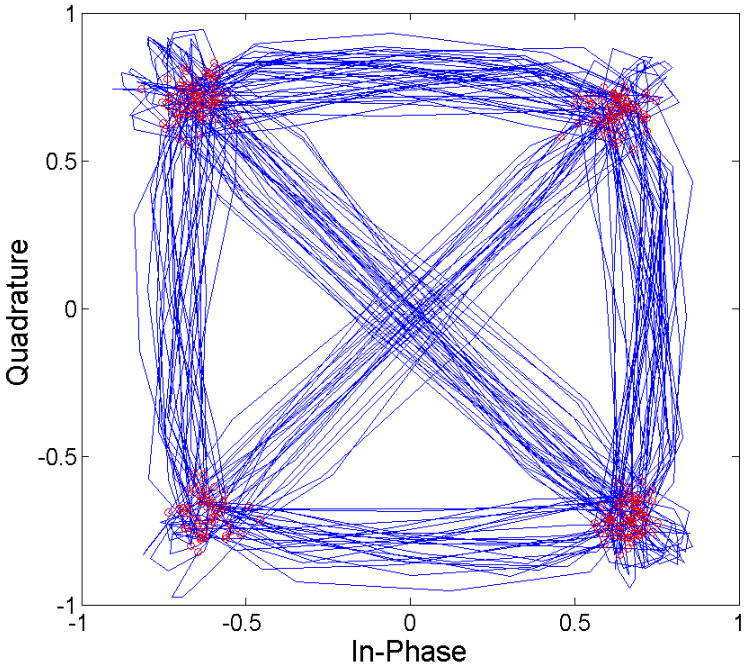
- Low pass filter
- I/Q upconverter
- 32 GHz reference oscillator

RF Testing Results

Transmit Signal Spectrum

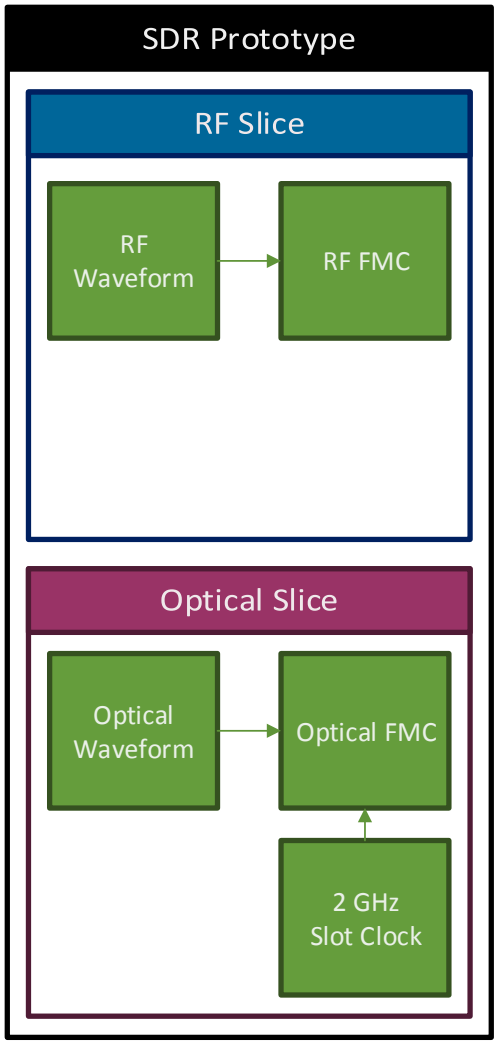


Constellation Diagram



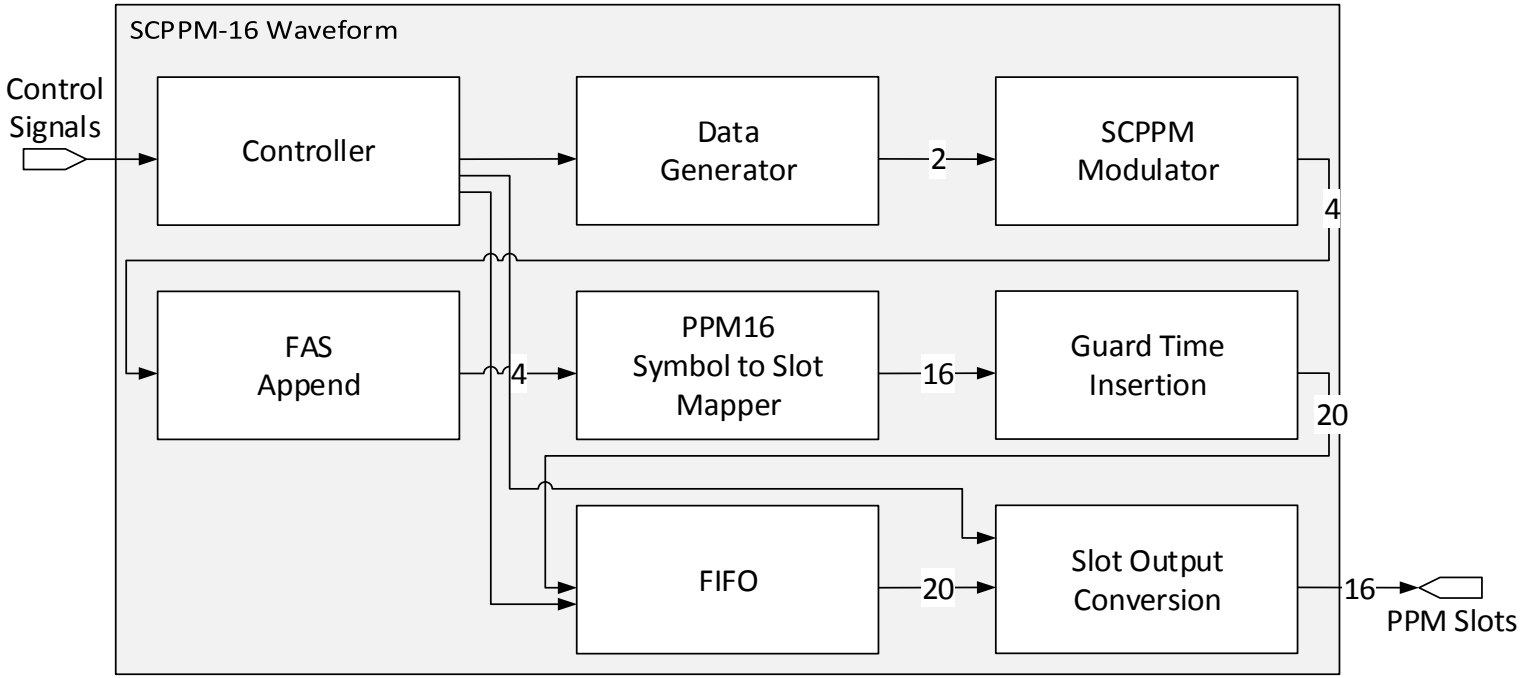
Description	Value	Units
Error Vector Magnitude	11.105	%rms
Phase Error	6.520	Deg

Optical Slice



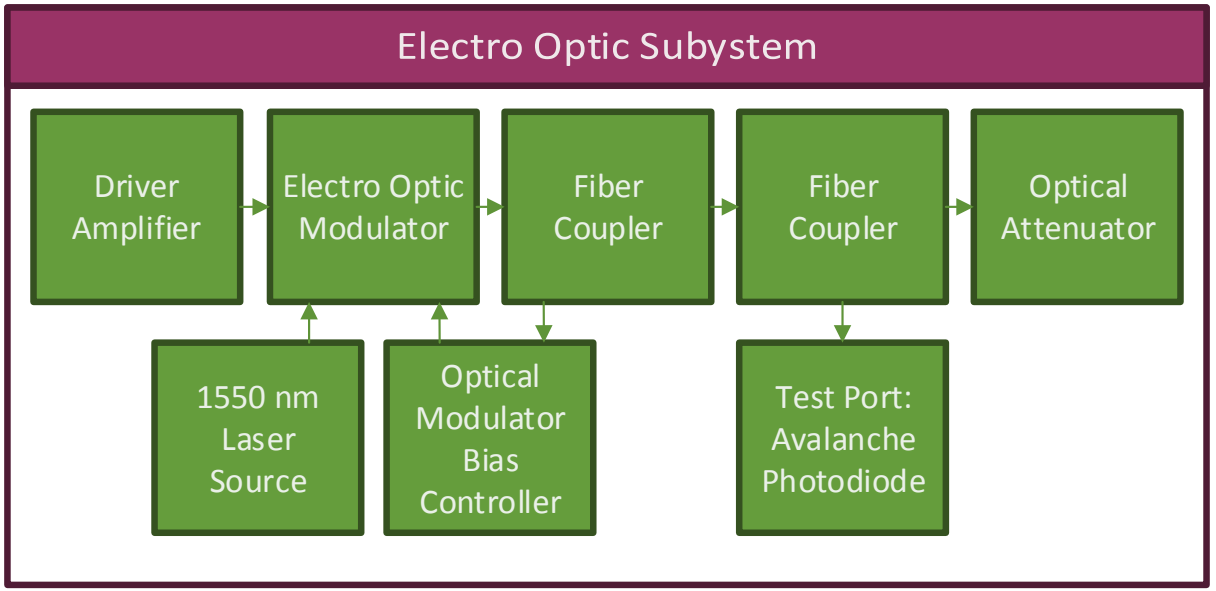
- Optical Waveform: SCPPM-16 (serially concatenated pulse position modulation), rate ½ code
- Data rate: 200 Mbps
- Optical FPGA Mezzanine Card (FMC): Performs 16 to 1 parallel to serial conversion and divides the 2 GHz (0.5 ns) slot clock by 16 to drive the waveform.

Optical SCPPM Waveform



- SCPPM-16 (serially concatenated pulse position modulation), rate ½ code
- 4 slots inter symbol guard time
- 16 symbol frame acquisition sequence between code words

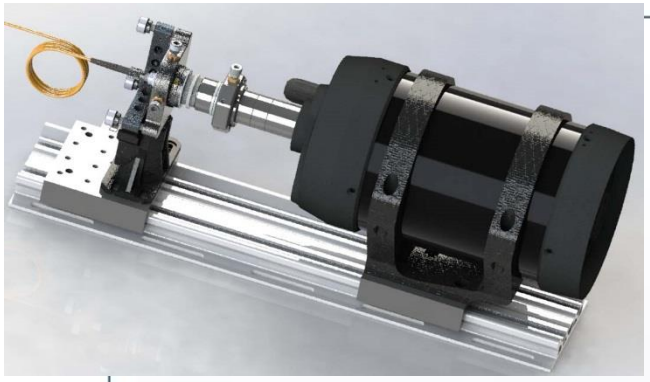
Electro Optic Subsystem



Components

- Driver amplifier
- Lithium niobate electro optic modulator
  - 20 dB extinction ratio
  - >40 dB extinction ratio
- Bias controller
- 1550 nm laser source
- Optical attenuator

Optics Subsystem



A series of axicon lenses maximizes the transmitted power by directing nearly all of the laser power around the secondary reflector.

Optical Testing Results

Specified Electro Optic Modulator Extinction Ratio	Code Words Processed	Code Word Errors	K_s (photons/ signal slot)	K_b (photons/ slot)	Average PMT Current (μA)
20 dB	43,900	14	3.6	0.037	0.91
>40 dB	43,900	4	4.3	0.0025	0.93

Configuration:

- Modulation: SCPPM-16, rate ½
- Slot clock: 20 MHz (50 ns)
- Data rate: 2 Mbps
- Receiver post processing system

Conclusions

- RF and Optical COTS prototype was designed and tested in a laboratory
- Future work includes porting the design to a platform designed for space

Acknowledgements

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