Development of “Optical Transmitter Module” for use in Quantum Communication

Introduction:

Quantum Key Distribution (QKD), an important solution under Quantum Communication, has gained much popularity in recent times due to rapid advancements in quantum computing and quantum algorithms that might pose a challenge to the security of the existing cryptographic methods. Lasers, Lithium Niobate based optical intensity modulators (IMs) and optical phase modulators (PMs) are integral parts of discrete variable QKD systems and test set-ups. There are often requirements for cascading multiple IMs and PMs to prepare quantum states for certain QKD protocols. However, assembling multiple such devices is often error-prone, tedious, and delicate. A module assembly consisting of laser and optical modulators and associated control circuitry can greatly simplify the design, offer convenience during the experiment, and reduce the system design and development cycle time.

Product Description:

The module assembly would have a narrow linewidth laser source, two IMs with bias controllers, two IM drivers, two PMs, two PM drivers, and an associated control circuit within an enclosure. The block diagram of the sub-system assembly is shown in Fig. 1. The collaborating partner also may suggest additional elements / features / interfaces for inclusion in the module.

Acronyms:

APC	Angle Polished Connector
CW	Continuous Wave
ER	Extinction Ratio
FC	Ferrule Connector
IM	Intensity Modulator
MBC	Modulator Bias Controller
NLW	Narrow Line-Width
PM	Phase Modulator
PMF	Polarisation Maintaining Fibre
RF	Radio Frequency
SMSR	Side Mode Suppression Ratio

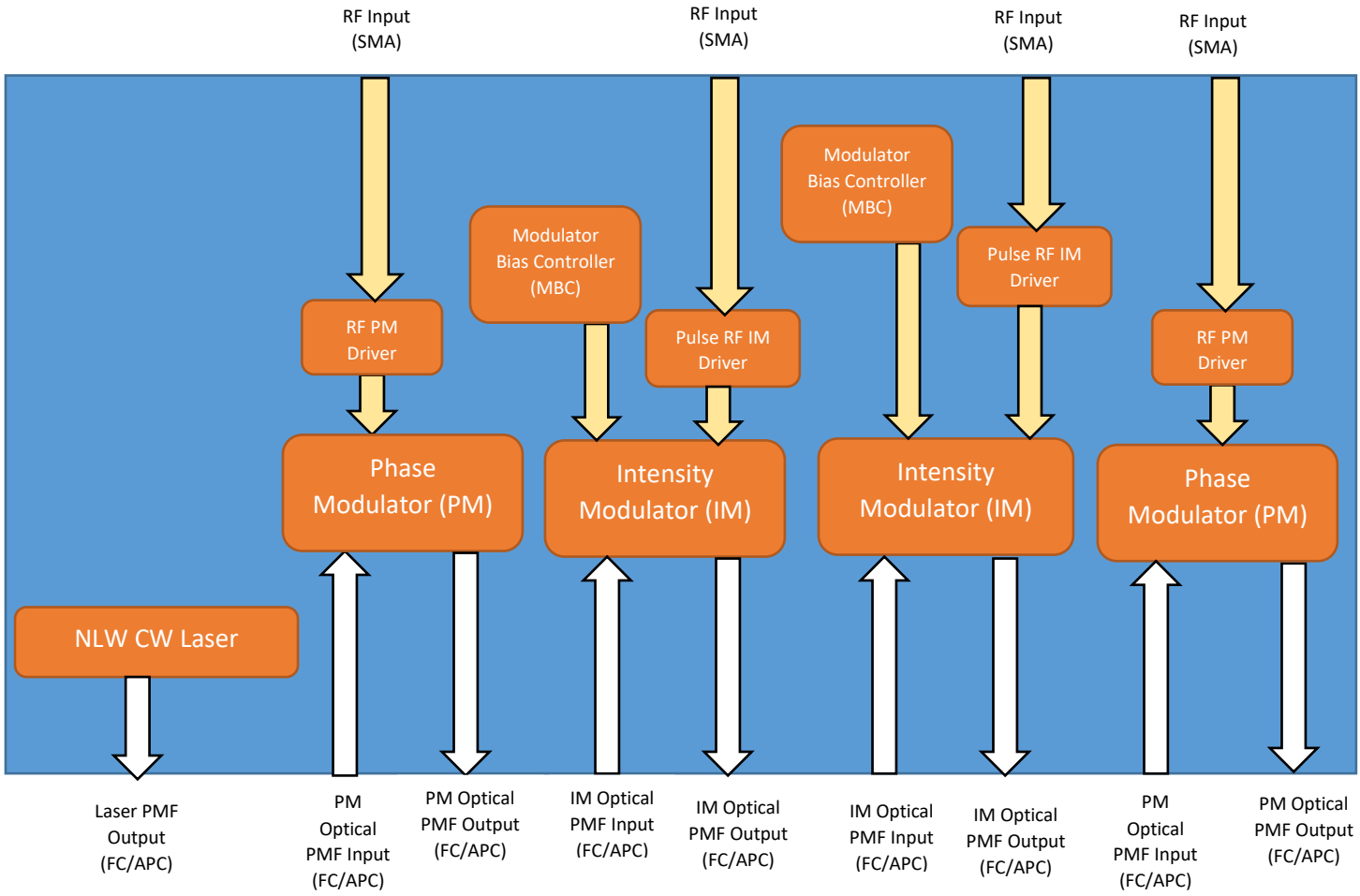

Fig. 1: Block diagram of the Optical Transmitter Module

Broad tentative Specifications (to be finalized by collaborating partner in discussion with C-DOT):

S.No.	Parameter	Specification
Narrow-line width (NLW) CW Laser		
1.	Laser Centre Wavelength	1550.12 nm
2.	Linewidth	< 5 KHz
3.	Side Mode Suppression Ratio (SMSR)	> 30 dB
4.	Polarisation Extinction Ratio	> 17 dB
5.	Output Optical Power	0 to +20 dBm
6.	Frequency Tuning Range	±10 GHz or better
7.	Frequency Tuning Resolution	5 MHz or better (Thermal control by software command)
8.	Fibre Type	PMF
9.	Optical Connector	FC/APC on the faceplate
Pulse RF IM (Intensity Modulator) Driver, Qty: 2		
1.	Pulse Repetition Frequency	≥ 1 Gbps
2.	Pulse Width	Min 100 ps
3.	Input Voltage (AC Coupled, 50 Ohm Termination, SMA Interface)	< 0.5 Vpp
4.	Bandwidth	20 GHz
5.	Gain (and any other) Adjustment	By software command
6.	RF Input Connector	SMA Female (50Ω termination) on the faceplate
Intensity Modulator (IM), Qty: 2		
1.	Operating Wavelength	C-Band (1530 nm – 1565 nm)
2.	Insertion Loss	< 4 dB
3.	Electro-Optical Bandwidth	Up to 20 GHz
4.	Extinction Ratio (ER)	≥ 40 dB
5.	Optical Return Loss	≥ 40 dB
6.	Optical Connector	FC/APC on faceplate (Input and output)
Modulator Bias Controller (MBC), Qty: 2		
1.	Bias Point of IM	Fixed @ NULL (with option to add programmable offset)
2.	Extinction Ratio (ER)	Min. 40 dB or better
3.	MBC Type	Ditherless or With dither tone The two MBCs must have suitablr biasing mechanism so that two intensity modulators can be used in cascade (i.e., the optical output of one IM given to the second IM input) without degrading the extinction ratio or other parameters

RF PM (Phase Modulator) Driver, Qty: 2		
1.	Pulse Repetition Frequency	≥ 1 Gbps
2.	Pulse Width	Min 900 ps
3.	Input Voltage (AC Coupled, 50 Ohm Termination, SMA Interface)	< 0.5 Vpp
4.	Bandwidth	20 GHz
5.	Gain Adjustment	By software command
6.	RF Input Connector	SMA Female (50Ω termination) on the faceplate
Phase Modulator (PM), Qty: 2		
1.	Operating Wavelength	C-Band (1530 nm – 1565 nm)
2.	Insertion Loss	< 3 dB
3.	Electro-Optical Bandwidth	Up to 20 GHz
4.	Optical Return Loss	≥ 40 dB
5.	Optical Connector	FC/APC on faceplate (Input and Output)
General Specifications		
1.	Mechanical Dimension	19” rack-mountable with maximum 2U height
2.	Supply Input	Single phase AC 230V 50/60 Hz or DC operated with suitable AC to DC adapter
3.	Operating Temperature Range	0°C to 50°C
4.	User Control Interface	USB/Ethernet port with GUI supported in Windows 10 or higher for alarms, performance monitoring and configuration

Note:

1. The final specifications need to be finalized in consultation with C-DOT
2. Appropriate Laser drive and control electronics should be incorporated in the module to ensure consistent performance of the laser diode such as smooth tunability of the wavelength.
3. The collaborating partner(s) should have suitable theoretical and practical experience, appropriately skilled resources and facilities for undertaking development of such module.
4. The collaborating partner(s) need to share the details of major components used in the design of the Optical Transmitter Module.
5. The collaborating partner(s) need to prepare a detailed test plan and ensure that the Optical Transmitter Module is thoroughly tested for various parameters like extinction ratio, wavelength stability etc. The detailed plan and timelines in which few tested modules can be provided to C-DOT need to be provided in the proposal.
6. Complete details of the developed module need to be shared with C-DOT.