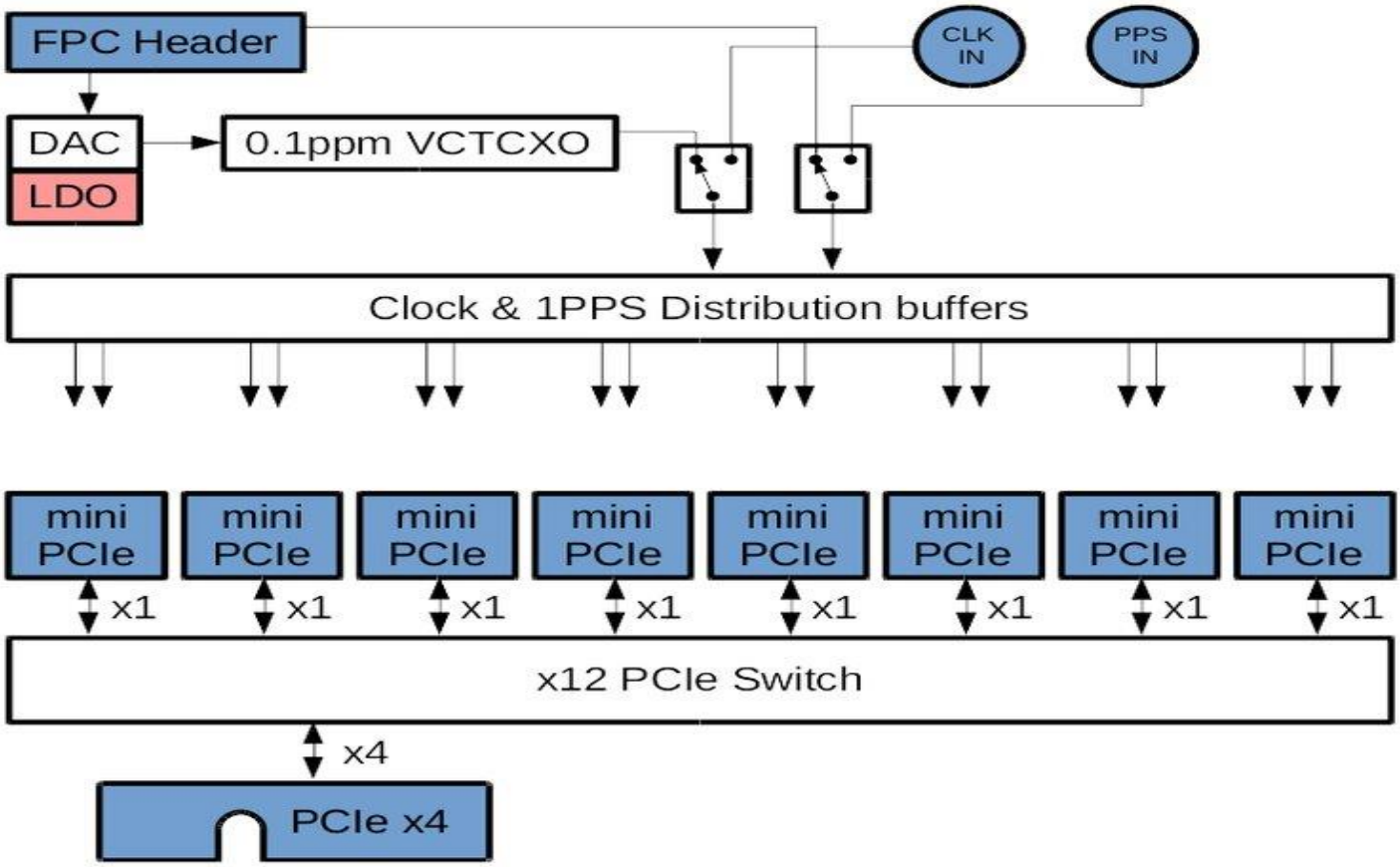
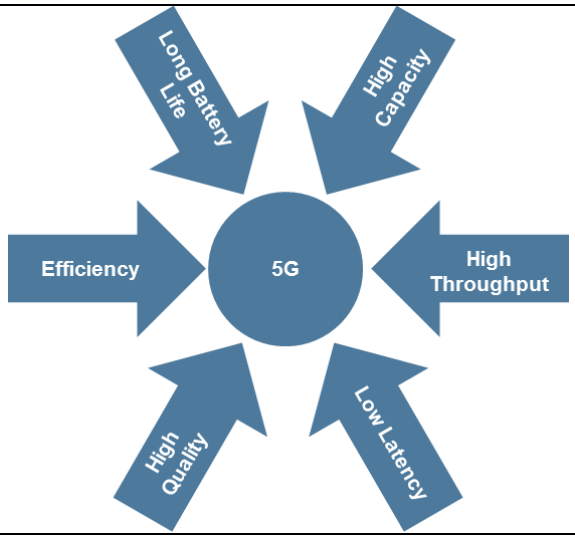


5G MASSIVE MIMO LAB features:

- **Complete Full-Duplex System with 16 TX and 16 RX channels**
- **Frequency Range of 50 MHz to 3.8 GHz**
- **ASIC architecture with LNA, PA, I/Q Mixers, Synthesizers, RX/TX Filters and RX/TX Gain Control**
- **Linux GnuRadio interface**
- **On-board GPS disciplined oscillator**
- **Low latency PCIE interface**



The next generation of wireless networks need to provide enhanced data rates for mobile broadband applications along with low latency and reliability for machine and vehicular communication. Spectrum in conventional cellular frequency bands of 500MHz to 4 GHz is crowded and exorbitantly expensive. For optimum utilization and mass deployment, there are many challenges which need to be addressed such as development of new algorithms, technologies and air interfaces along with energy efficiency and channel models.

The Amitec 5G MASSIVE MIMO LAB is a software programmable hardware transceiver which allows limitless research and development along with laboratory experiments to be performed on a single device. The system is ideally suited for

Mfd by: Amitec Electronics Ltd.
Regd. Off: 504, Nilgiri, 9 Barakhamba Road, New Delhi-110001, India, Works: 4/32, Site-4, Industrial Estate Sahibabad, NCR-201010, India,
mail@amitec.co, www.amitec.co
+91-11-41505510, +91-120-4371276

applications requiring high RF performance and great bandwidth such as 5G Physical layer prototyping, Dynamic Spectrum Access and Cognitive Radio, Spectrum Monitoring and even Networked Sensor Deployment.

The system has modular architecture with high performance synthesizers and integrated mixers allowing baseband processing. The system has independently programmable transmitter and receiver sections with programmable frequencies, ADC and DAC sampling rates, filter bandwidths, variable gain amplifiers, LNA and PA. The entry barrier is lowered to include the graduate students by providing a graphical programming environment. The burden on faculty is lowered by using courseware designed at IITD from simple FM to most complex MIMO systems. The Ultra Low-latency PCIE interface at 10Gbps serves as the connection between the baseband section and the mobile workstation. This enables the user to realize 10Gbps of real-time throughput in the receive and transmit directions in full duplex mode.

Technical Specifications	
Transmit Frequency Range	50 MHz to 3.8 GHz with 16 Tx channels
Receive Frequency Range	50 MHz to 3.8 GHz with 16 Rx channels
Mode	Full Duplex
Architecture	ASIC/FPGA/Zero IF
Instantaneous Baseband Bandwidth	50 MHz per channel
Frequency Resolution	< 50Hz
Maximum RF Output power	+5dBm
Receiver Sensitivity	-120dBm
TX Output Impedance	50 Ohms
RX Input Impedance	50 Ohms
PLL Phase Noise	-125dBc/Hz at 1MHz
Spurious Output	-50dBc
Transmit Gain Control Range	>50dB
Transmit Gain Control Step	1dB
Rx Noise Figure	<5dB
Rx Gain Control Range	>50dB
Rx Gain Control Step	1dB
IQ Phase Error	3 degree
IQ Amplitude Error	0.5dB
PLL Settling time	<10us
ADC Sample Rate	upto 120 MS/s
DAC Sample Rate	upto 120 MS/s
ADC Resolution	12 bits
DAC Resolution	12 bits
ADC Wideband SFDR	60 dBc
Input Amplitude	1Vp/p differential
DAC Wideband SFDR	60 dBc
Output Amplitude	250mV p/p differential
Frequency Accuracy	50ppb (factory calibrated)
SSB/LO Suppression	>40 dBc
FPGA	Xilinx
Integrated Transceiver	8 Gbps
Logic Elements	40,000
M9K Memory Blocks	>400
Embedded Memory	>2000 Kbits
18bit X18bit Multipliers	>100
PLL	4
Maximum User I/Os	>500
Maximum Channels	>200 Differential
Cable	RG316 SMA-SMA X4,
Antennas	Microstrip Broadband Antenna

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Upgrade	1 year upgrade of new experiments, training videos, operation manuals and firmware	
Shipping List Deliverable	**Massive MIMO Setup** **Microstrip Broadband Antennas** **Manual and Study Material**	**1** **32** **1**

Features	
Software Features: Audio, Boolean, Byte Operators, Channelizers, Channel Models, Coding, Control Port, Debug Tools, Equalizers, Error Coding, File Operators, Filters, Fourier Analysis, GUI Widgets, Impairment Models, Instrumentation, Level Controllers, Math Operators, Measurement Tools, Message Tools, Modulators, Networking Tools, OFDM, Packet Operators, Resamplers, Sinks, Sources, Stream Operators, Stream Tag Tools, Symbol Coding, Synchronizers, Trellis Coding, Type Converters, Variables, Waveform Generators	Synchronizers: Costas Loop, Clock Recovery, Frequency Locked Loop, Phase Locked Loop, Correlate and Sync, Carrier Acquisition Equalizers: Adaptive-CMA, Kurtotic, LMS DD Filters: IIR, FIR, Pulse Shaping-RRC Root Raised Cosine, High Pass, Low Pass, Bandpass, Band Stop, FFT, Frequency Translating Filter Networking: TCP, UDP, Socket, Broadcasting
Channel Coding and Decoding: Convolutional, Viterbi, Trellis	Constellation diagram, Oscilloscope, Spectrum Analyzer and Waterfall display
Analog Channel Models like: Noise: Uniform, Linear, Laplacian, Gaussian, Phase Noise Interference: Cross talk, Co-channel, Inter-symbol), Distortion (Inter modulation) Frequency Response (Attenuation and phase shift)	Spread spectrum techniques like: CSS, DSSS, FHSS, THSS and other variants Multiplexing techniques like: TDM, FDM/WDM, SDM, Polarization, Spatial, Packet Switching, MC-SS, OFDM including complete control for new research and development
On-air Transmission and Reception using Analog modulation and Demodulation techniques like: AM, DSBSC, SSB, Narrowband FM, Wideband FM, Stereo FM	On-air Transmission and Reception using Digital Modulation and Demodulation techniques like: ASK, FSK, BPSK, DBPSK, MSK, GMSK, DQPSK, QPSK, OQPSK, pi/4QPSK, 8PSK,16QAM, 64QAM, 256QAM, CPFSK, GFSK and custom modulation schemes
Channel performance measurements Spectral bandwidth Symbol Rate Bit Rate Channel Capacity Channel Utilization Signal to Noise ratio Bit Error Rate BER Latency and Jitter	Fading modeling: Slow, Fast, Selective/Dispersive, Multipath, Rayleigh, Rician Group delay Propagation Doppler Shift

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Areas of Research and Development
mmWave and cmWave Systems
Multi-Radio Access Technologies
Channel Sounding Measurements
Physical Layer Technologies
Antenna Design for 5G Cellular Networks
Small Cells
Heterogeneous Networks
Interference Suppression Receivers
Medium Access Control Design
Dynamic Scheduling of Uplink/Downlink Transmission
Cognitive Radio Networks
Co-operative Communication
Spectrum Sensing and Dynamic Spectrum Allocation
New Air Interface and Waveform Design
Contextual Awareness
Vehicular Communication
Low-latency networks
Radio Propagation Measurements
Channel Modelling
Satellite Radio Implementation
RADAR Systems
Multiple-Hop Networks
Machine Type Communication and IoT
Dynamic Adhoc Wireless Networks(DAWN)
MANET and Wireless Mesh Networks
Vandermonde Frequency Division Multiplexing(VFDM)
Wireless Network Virtualization
Massive MIMO

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