IIT Mandi

Course Name	: **Basic Laboratory Course for Quantum Technologies**
Course Number	: QT 304P
Credits	: 2-0-1-3
Prerequisites	: Engineering Mathematics (Linear Algebra, Complex algebra, basics of 2nd of ODEs and initial value problems, 2nd order PDEs and boundary value problems, Probability and Statistics, Random variables). Maxwell's equations and EM theory at the level of the core physics syllabus from AICTE model
Curriculum Intended for	: UG/PG/PhD
Distribution	: Elective PG/Elective UG
Semester	: Odd/Even

Preamble: This course is meant to provide students a quick hands-on experience in required for understanding and the applications to areas within Quantum Technologies. Students of this course learn (i) Basic experimental techniques in optics, (ii) Basic experimental techniques in characterising resonators and RLC circuits, (iii) Basic digital circuits, (iv) Fundamental techniques in RF engineering, (v) Interfacing instruments with computers and carry out data acquisition

Course Content and syllabus:

- Optics
  - Interferometry – wavelength measurements, intensity measurements
  - Diffraction – single slit, grating
  - Microscopy – magnification, aberration
  - Polarization optics – PBS, HWP, QWP
- RLC circuits
  - Series and parallel RLC circuits – Verifying the quality factor formulae
  - Extracting intrinsic losses
- Digital circuits
  - Adder, Multiplier
  - Encoder, Decoder
  - D flipflop, shift registers
  - How to use common Integrated Circuit chips
- Radio Frequency Technology:
  - Using Oscilloscope
    - Ring-up and ring-down time measurements of RLC circuits
    - Measurements of different pulse-shapes generated by a function generator
  - Using Vector Network Analyser
    - Transmission and reflection measurements of coaxial cable in open, short and matched termination
    - Voltage standing wave ratio measurement
    - Amplitude and Phase quadrature, In-phase and Out-of-phase quadrature plots and Quality factor measurement of RLC circuits

        - Characterising S-parameters, ABCD and Z matrices of common 2 port networks – coaxial cable, attenuator, low pass high pass bandpass filters etc.
        - Characterising 3 port networks – directional couplers, circulators, isolators
    - Using a spectrum analyser
        - Noise from a resistor at different temperatures

- Interfacing instruments with a computer

- Data acquisition
    - Signal demodulation – heterodyne vs Homodyne, Mixing of signals
    - Sampling, digitisation using ADCs – under-sampling and aliasing, oversampling and noise
    - Averaging and interpolation techniques
- Quantum Simulators
    - Running quantum protocols in a quantum simulator
    - Implementing simple quantum algorithms on cloud-based quantum computers (depending on availability of time on such machines)
- Running simple algorithms on cloud-based quantum processors (optional)

Course References:

1. Optics, Eugene Hecht, A. R. Ganesan, 5th edition, Pearson (2019)
2. Art of Electronics, Paul Horowitz and Winfield Hill, 3rd edition, Cambridge University Press (2015)
3. Digital Design, Morris Mano, Michael D. Cilletti, 6th edition, Pearson Education (2018)
4. Microwave Engineering, David Pozar, 4th edition, Wiley (2013)
5. Discrete-time signal processing, Alan V. Oppenheim and Ronald W. Shaffer, 4th edition, Pearson (2009)
6. Optical quantum information and quantum communication, A. Pathak and A. Banerjee, SPIE Spotlight Series, SPIE Press (2016)