Electrical and Computer Engineering
Spring 2020

ECE 632

PHOTOVOLTAIC ENERGY CONVERSION

Term:	Spring 2020
Instructor:	Prof. Siva Sivoththaman
Lecture hours:	Course to be delivered online, no scheduled meet times

Please send email to sivoththaman@uwaterloo.ca for any enquiries about this course.

COURSE DESCRIPTON:

This course is intended for engineering graduates and educates them on fundamental and applied aspects of photovoltaics (PV) energy conversion, including PV device concepts and fabrication technologies, PV modules, power conditioning; PV systems design; grid-connection; power quality; and safety aspects.

COURSE OUTLINE:

1. Photons and Solar Radiation

Review of properties of photons; wave theory; solar radiation; energy distribution; scattering theory; direct and diffuse radiations; air mass; radiation standards for photovoltaic performance evaluation.

2. Review of Semiconductor Properties for PV

Review of semiconductor materials; band theory; dynamics of electrons and holes; photon absorption; carrier generation and recombination processes; fabrication technologies of bulk and thin-film semiconductors for PV; techniques for semiconductor material evaluation.

3. Review of Relevant Device Physics for PV

Junction theory, energy band-diagrams, non-equilibrium conditions; carrier-transport mechanisms; current-voltage characteristics.

4. PV Device Operation & Performance Limits

Operating principles of PV devices; energy conversion efficiency; spectral response; equivalent circuits; illuminated and dark I-V characteristics; theoretical efficiency limits; loss mechanisms; temperature effects; device architectures and performance; advanced concepts for future devices.

5. PV Device Fabrication Technologies

Baseline technologies for silicon-based, thin-film, and compound semiconductor devices; surface passivation; optical confinement; high-low junctions; industrial processes; emerging technologies for advanced PV devices.

6. PV Module assembly & Interconnection

Module design, interconnection schemes, I-V characteristics, temperature effects, mismatch effects and mitigation methodologies; by-passing circuits; potential-induced degradation; ageing effects

7. Power Conditioning for PV

Components for back-end electronics, algorithms for maximum power-point tracking, inverter circuits; storage; blocking diodes; regulators and charge controllers; battery options

8. PV Systems and Grid-Connection

System types and operating modes; sizing and design rules; stand-alone systems; building-integrated PV; energy management; fault detection; overvoltage protection; grid-connection; system-grid interface; power quality issues: voltage imbalance, harmonics, islanding; remedial measures.

MARKING SCHEME:

Quizzes/short tests: (60%)

Course Project: 40%

TEXT:

- Course Notes will be provided
- Reading text (non-compulsory): "Applied Photovoltaics", 2nd Ed., Authors: Wenham, Green, Watt, and Corkish, UNSW, ISBN(o73342175X)

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