

Grid Integration of Solar PV System



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Organized by

Department of EED, National Institute of Technology Calicut, Kerala - 673101

Presented by

Dr. KUMARAVEL SUNDARAMOORTHY

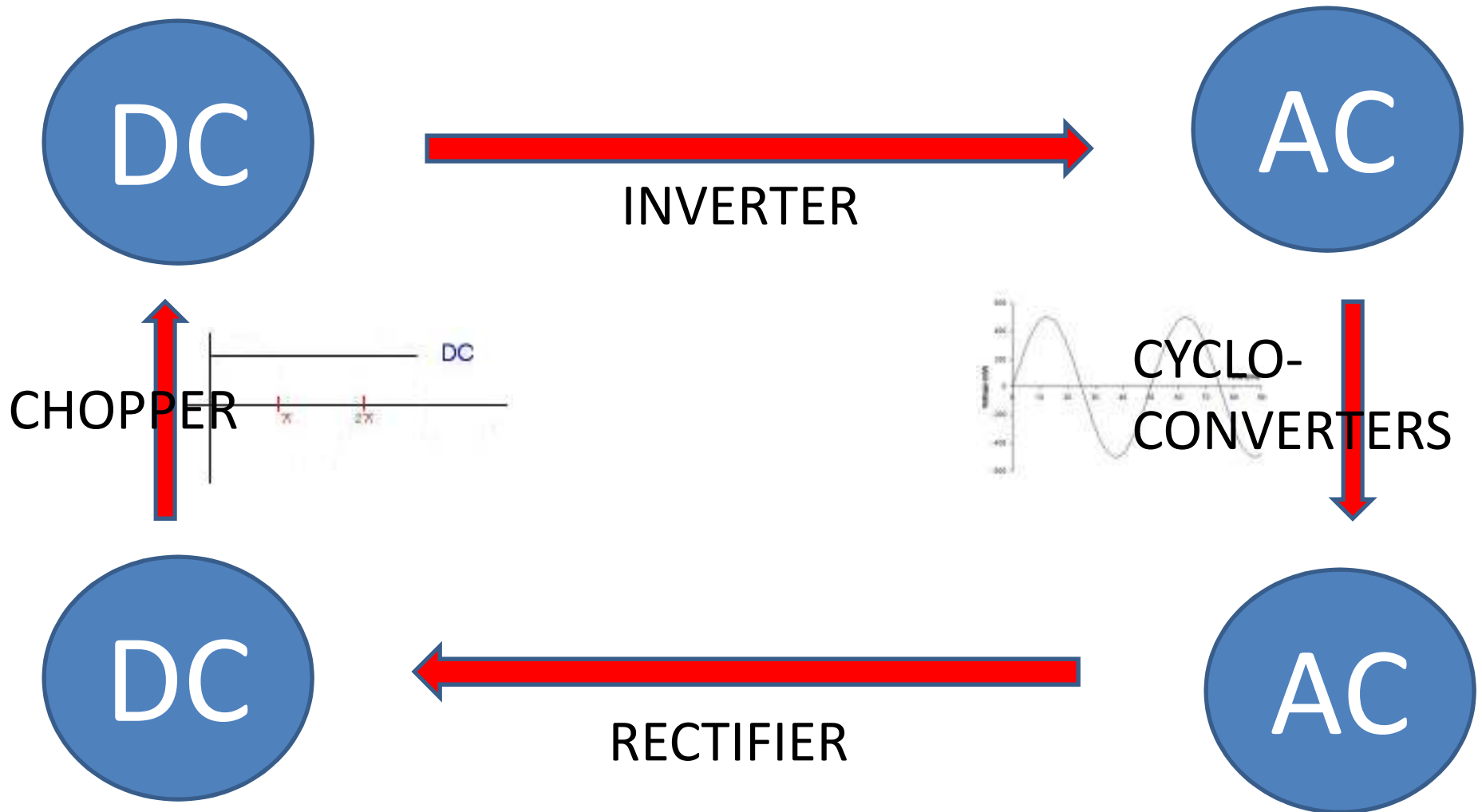
**Department of Electrical Engineering
University College Dublin**

Kumaravel/EED/NITC/16 May 2015

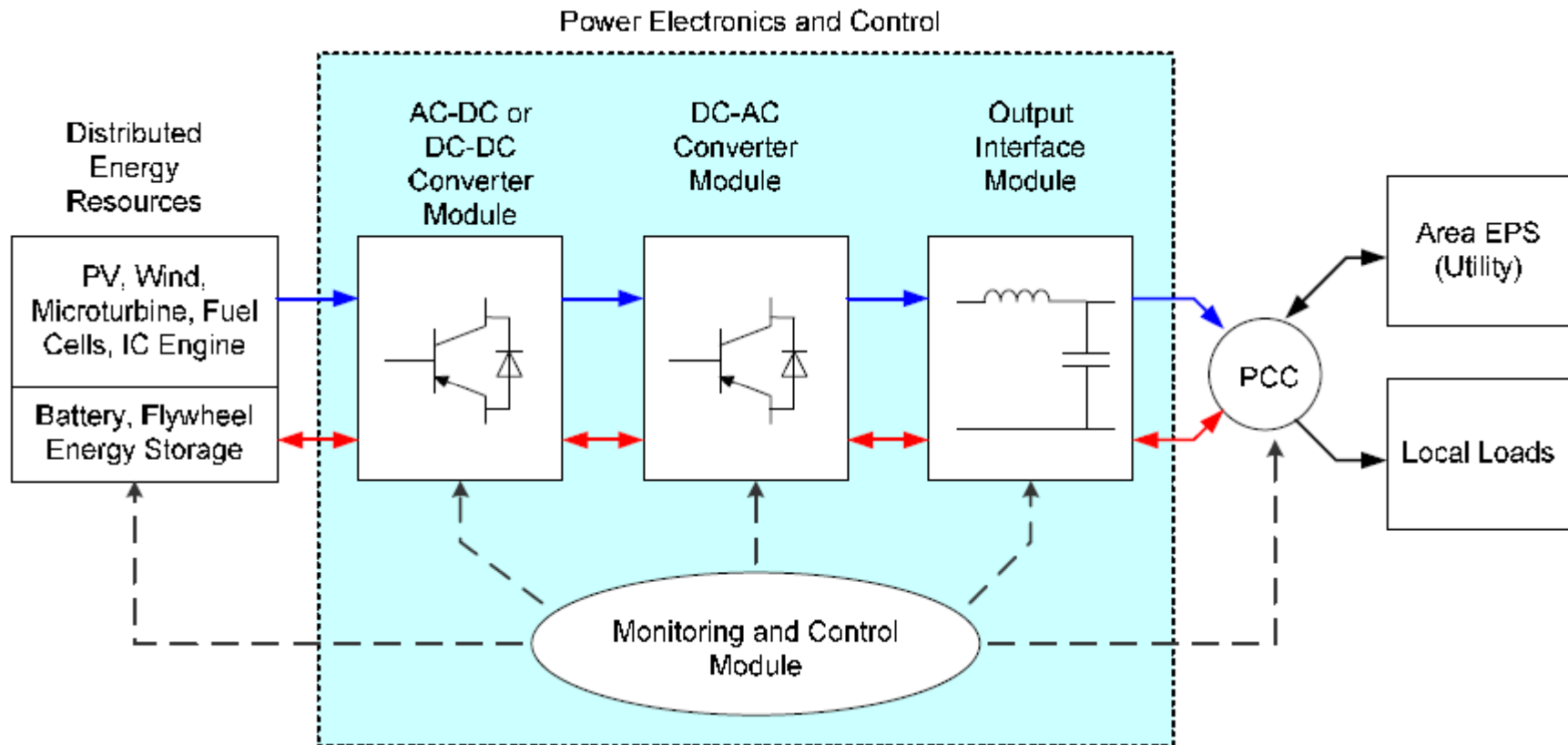
Contents

- Modeling of Solar – PV
- Fuzzy Controlled Buck – Converter
- Real and Reactive power control of solar PV Inverter
- Power quality issues in Solar - PV

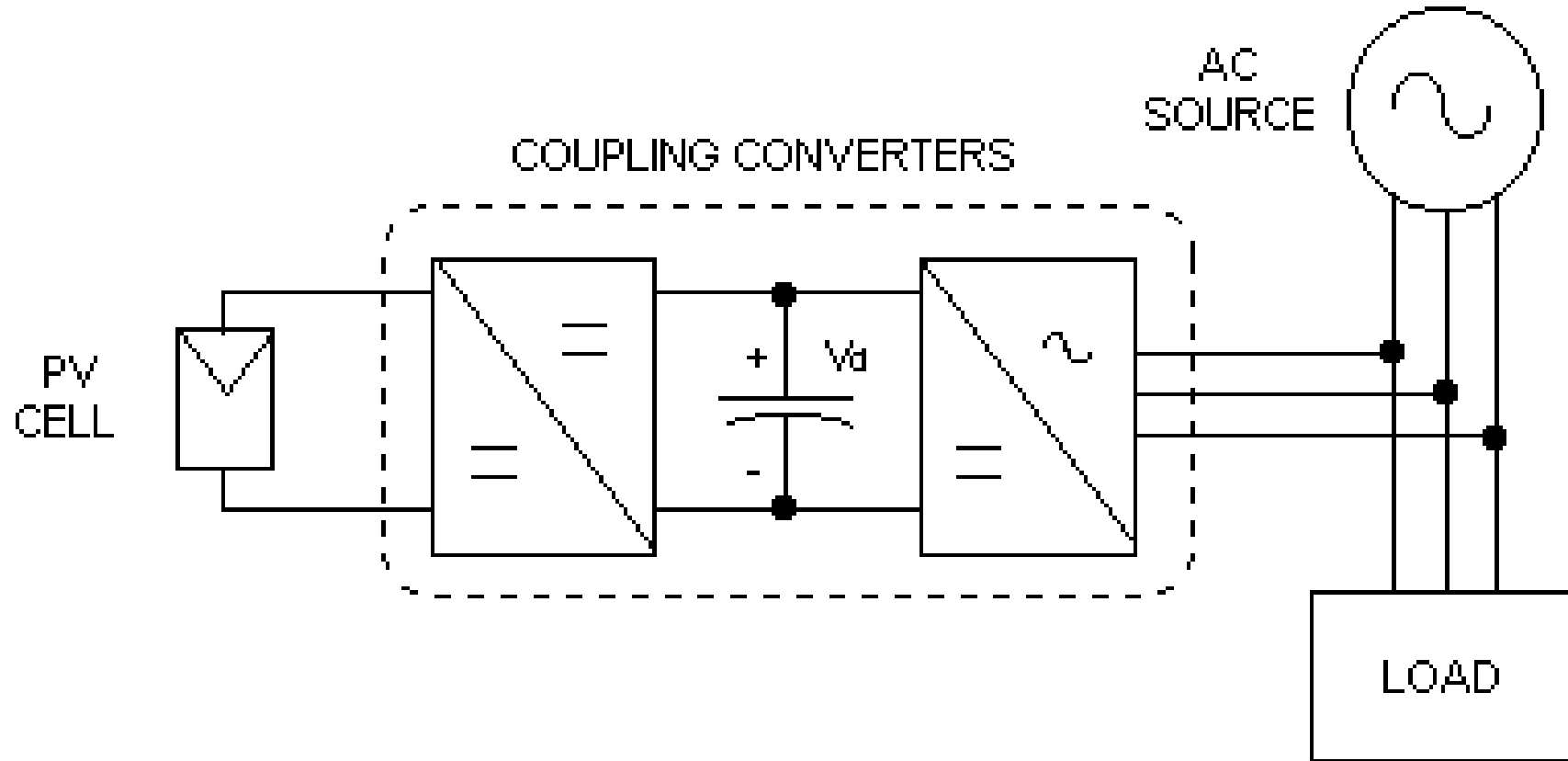
Power Converter for Renewable Energy



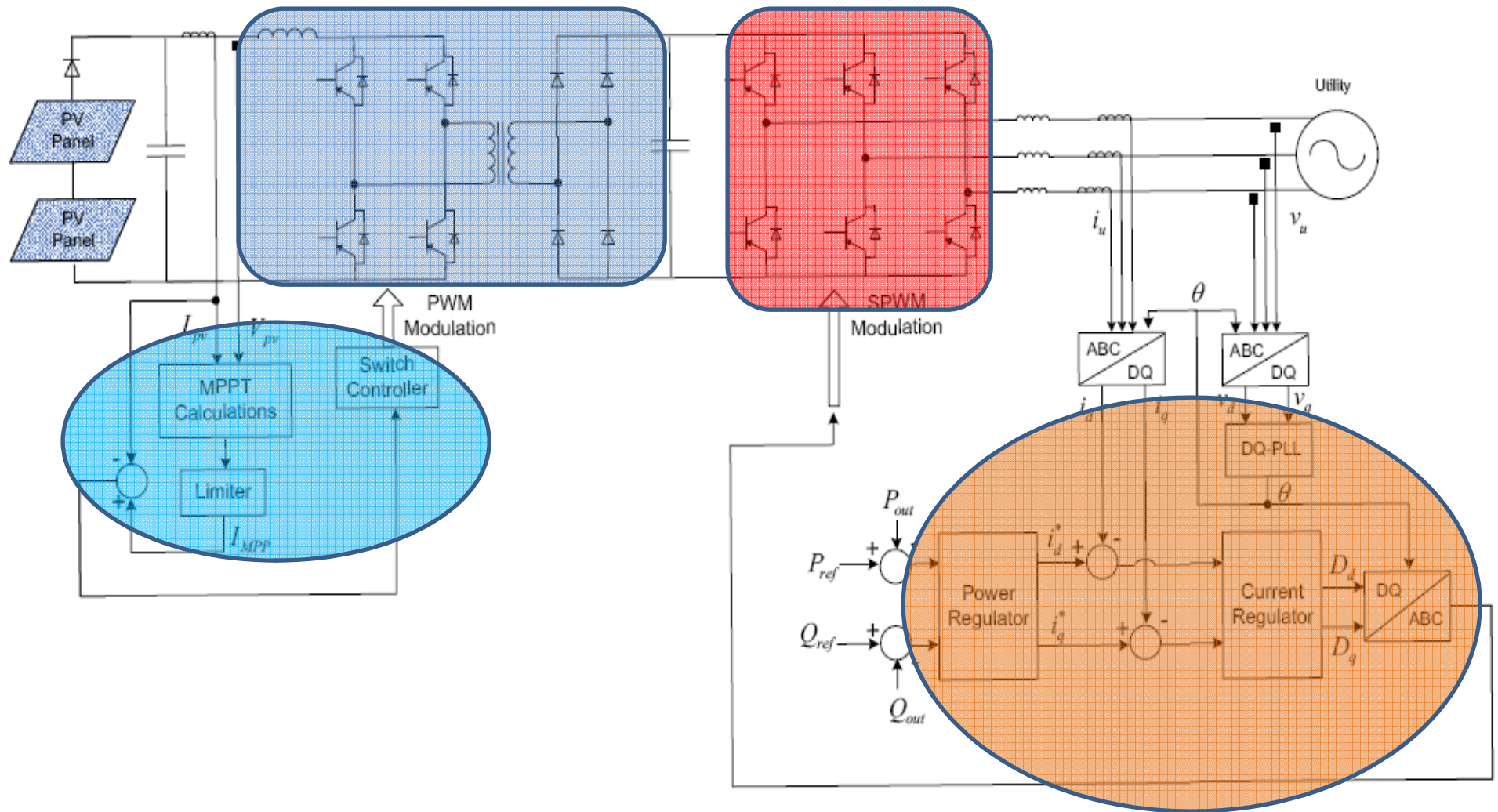
Converters for Renewable Energy



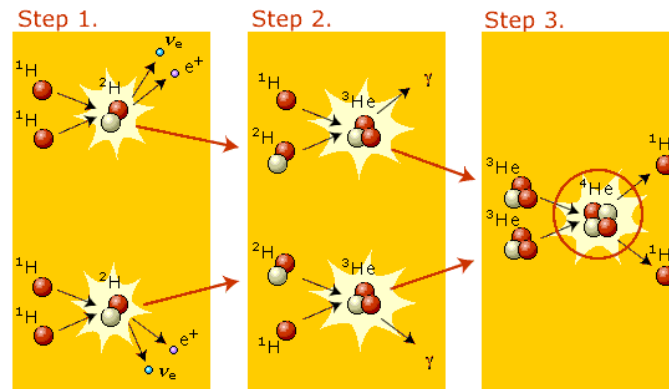
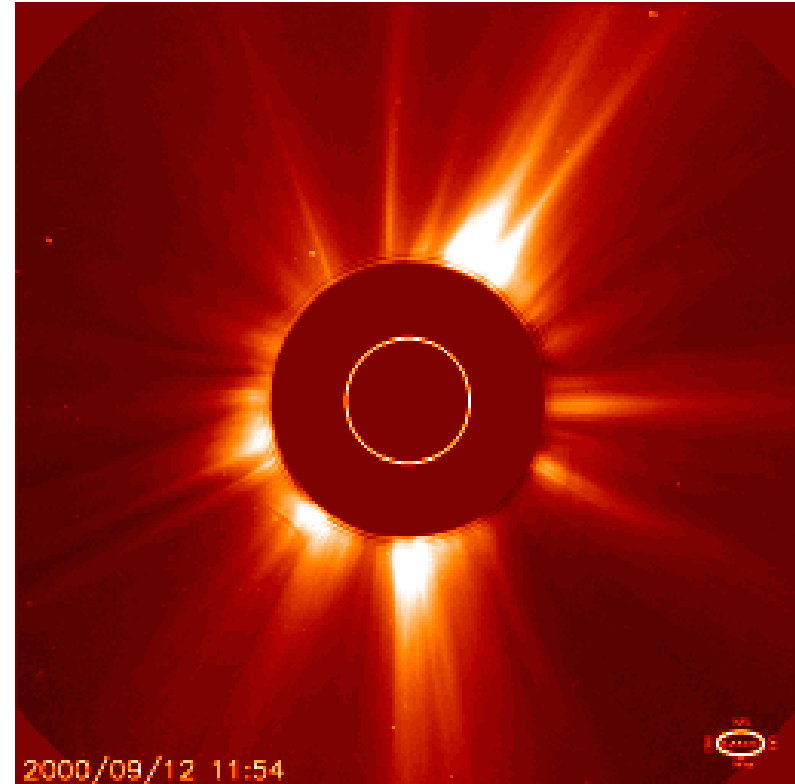
Grid Integregration of Solar – PV System



Integration of Solar-PV with Grid



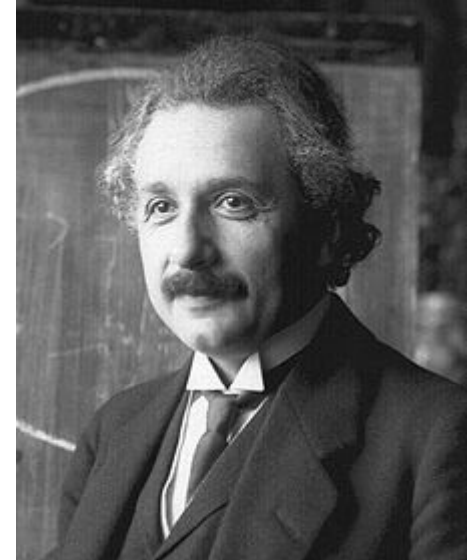
Solar Energy



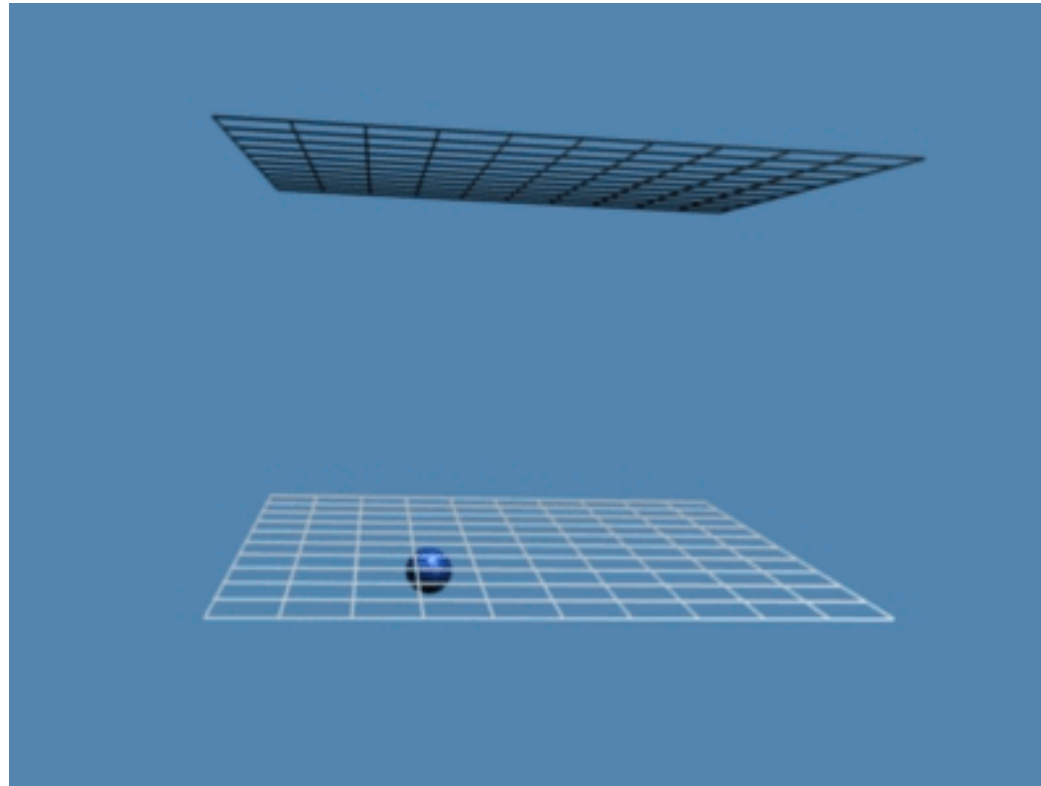
sun fusion

Einstein's Invention

- solar energy directly into electricity by Einstein himself in 1905. In 1921, he won the Nobel Prize for this original proposal.
- The theory proposed that if sunlight is shine on the metal with a specific frequency corresponding to that metal, current is produced. Since current is the flow of electron, electricity is produced.
- In 1954, the first photovoltaic technology is developed the silicon photovoltaic cell at Bell Labs.

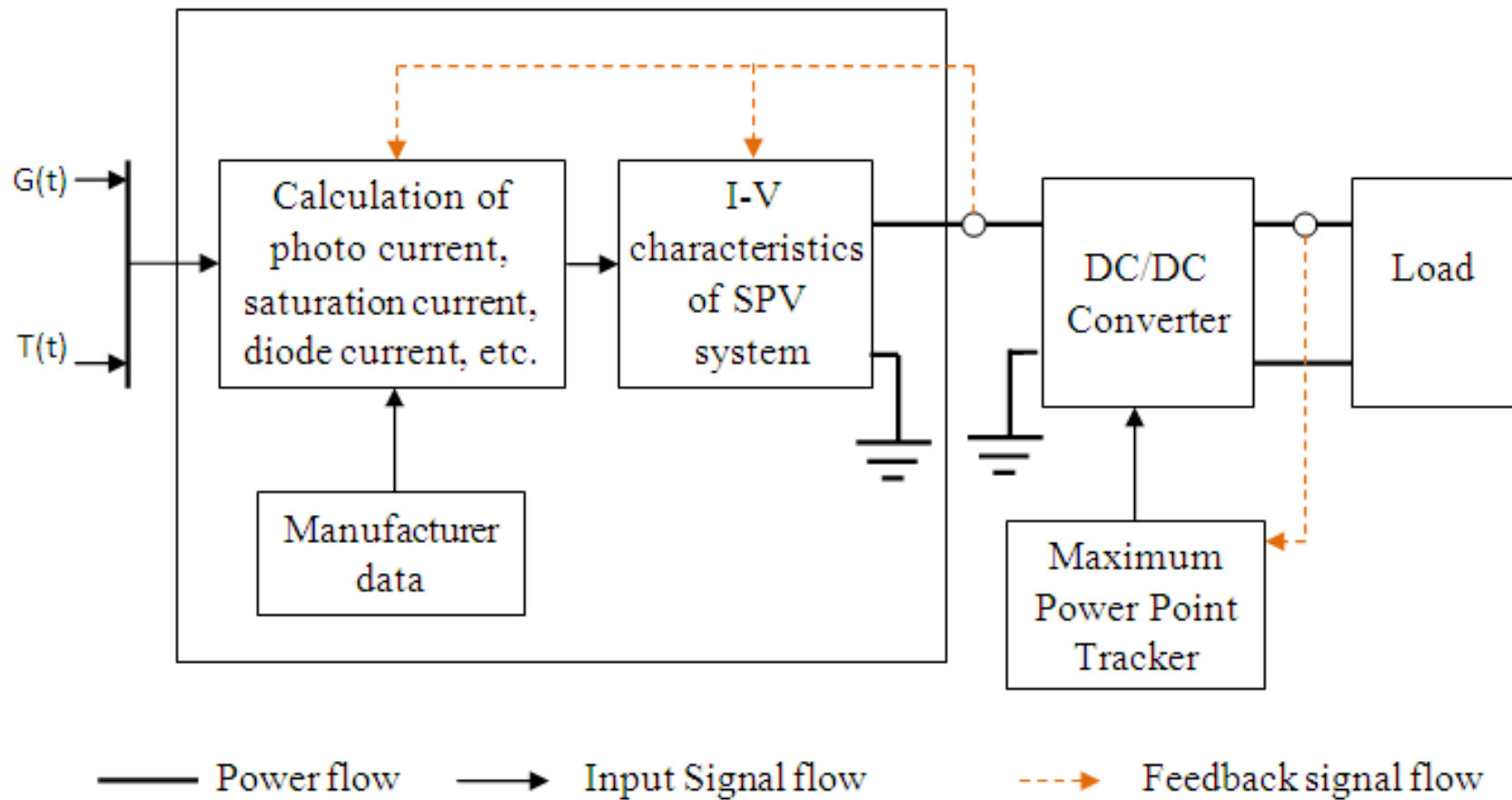


Electron Generation

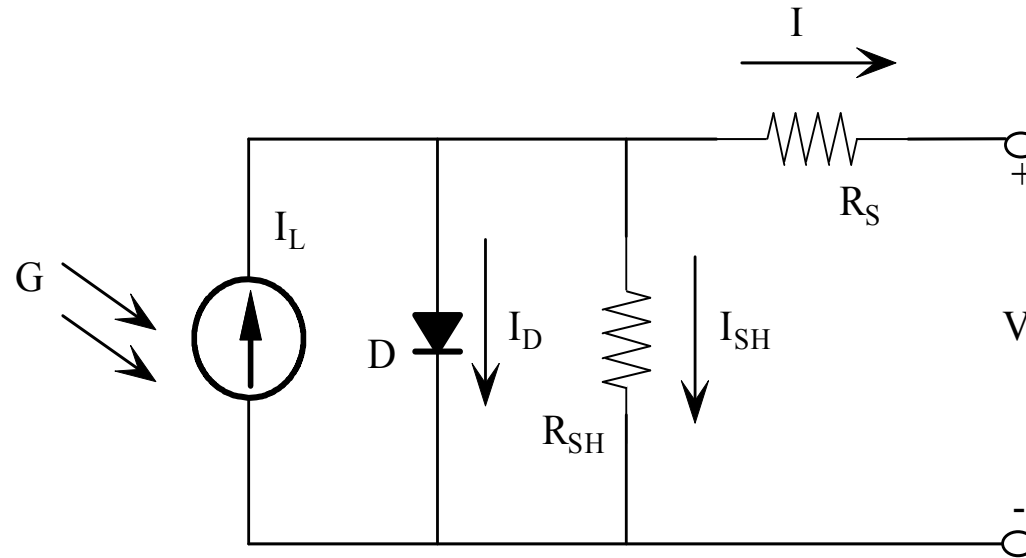


A photon (yellow) excites an electron (blue) to a higher energy and is pulled away by some mechanism of charge separation.

Mathematical Model of Solar-PV



Mathematical Model of Solar-PV

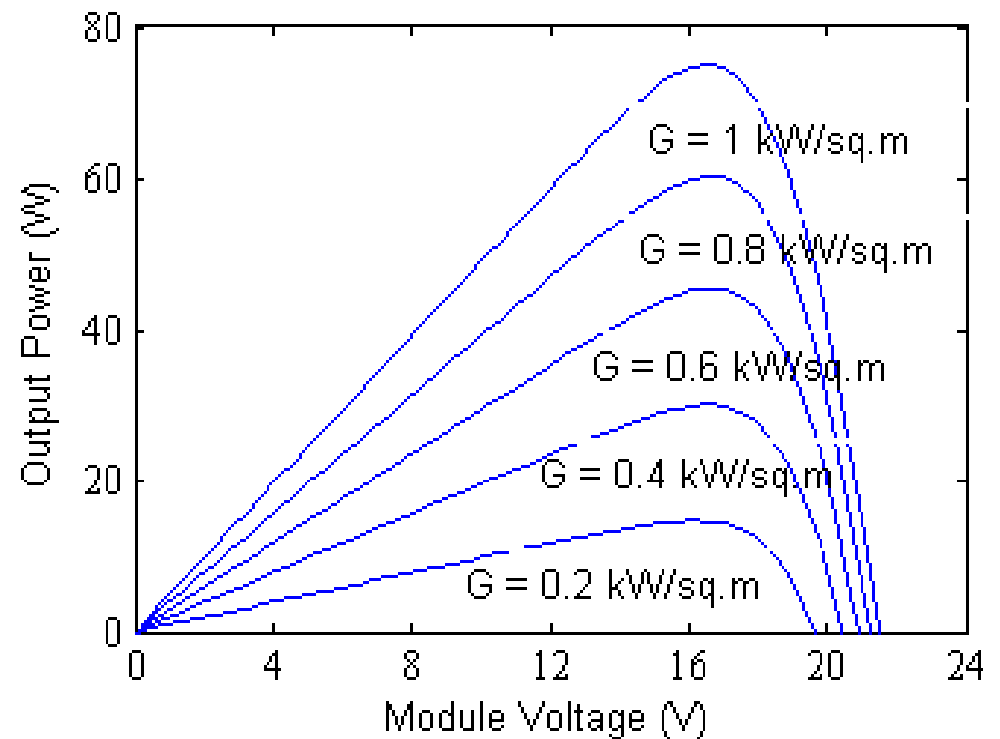
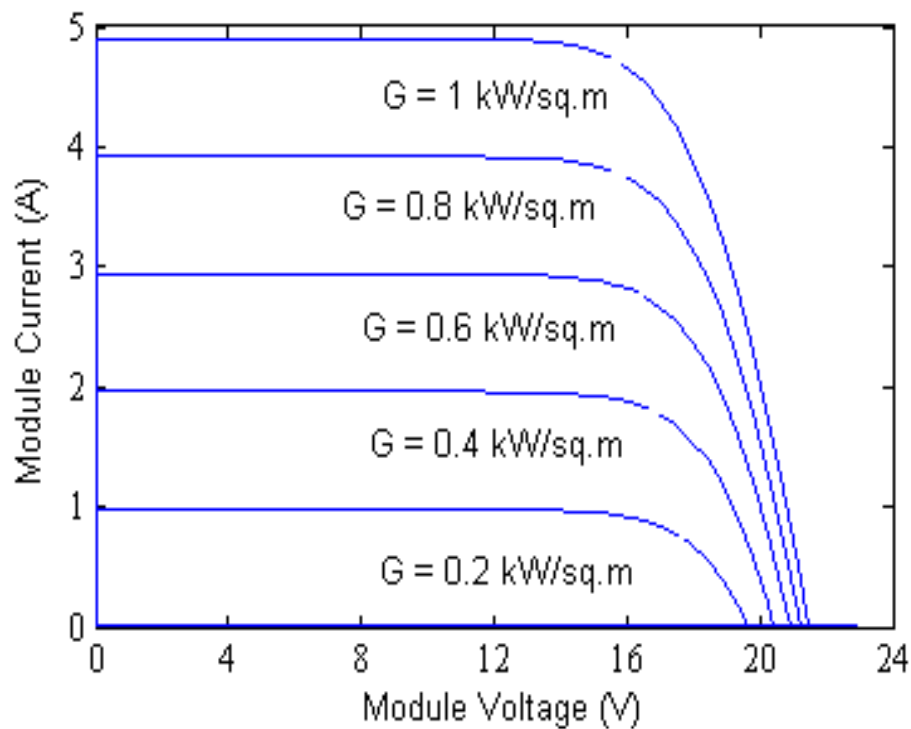


$$I = I_L - I_0 \left(e^{\frac{q(V + IR_s)}{nkT}} - 1 \right) \dots\dots(1)$$

$$V_{oc} = \left(\frac{nkT}{q} \right) \ln \left[\frac{I_L}{I_o} \right] \dots\dots(7)$$

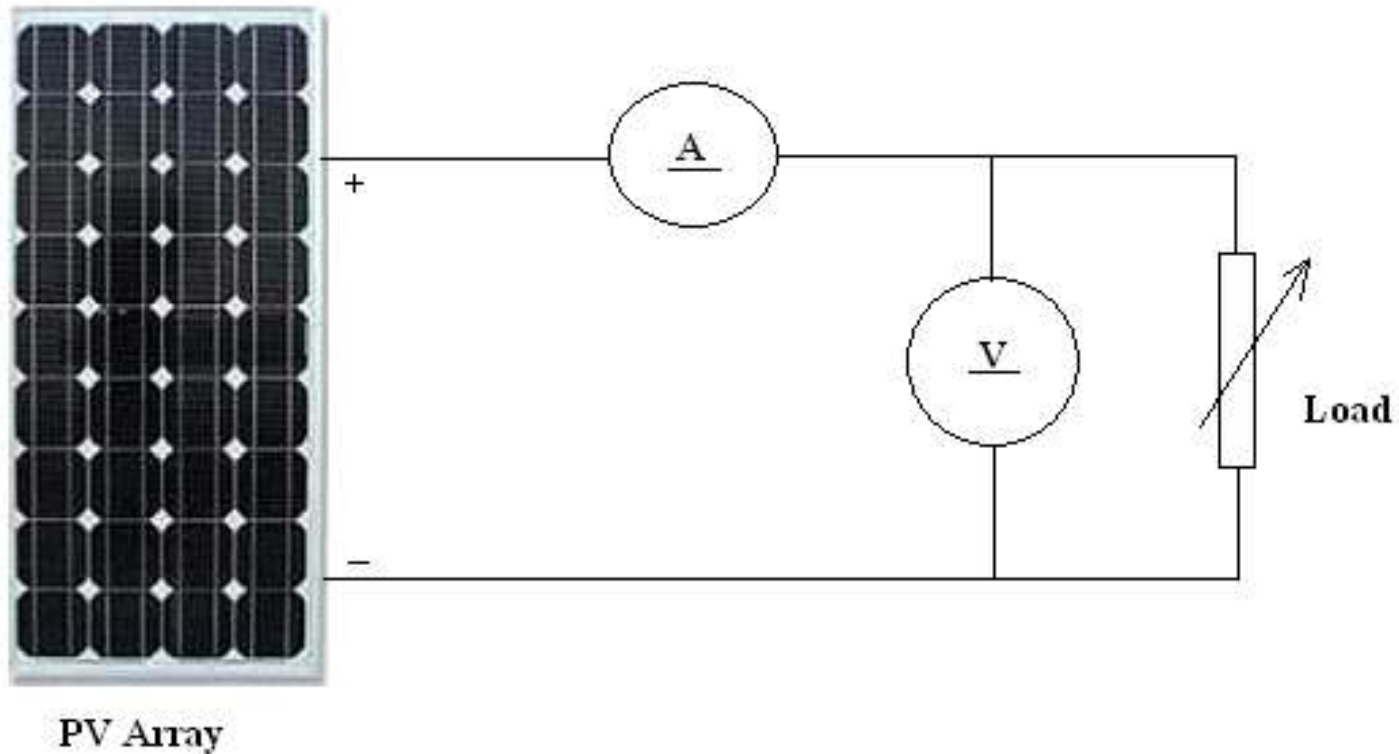
Simulated I-V and P-V Characteristics of Solar-PV Module

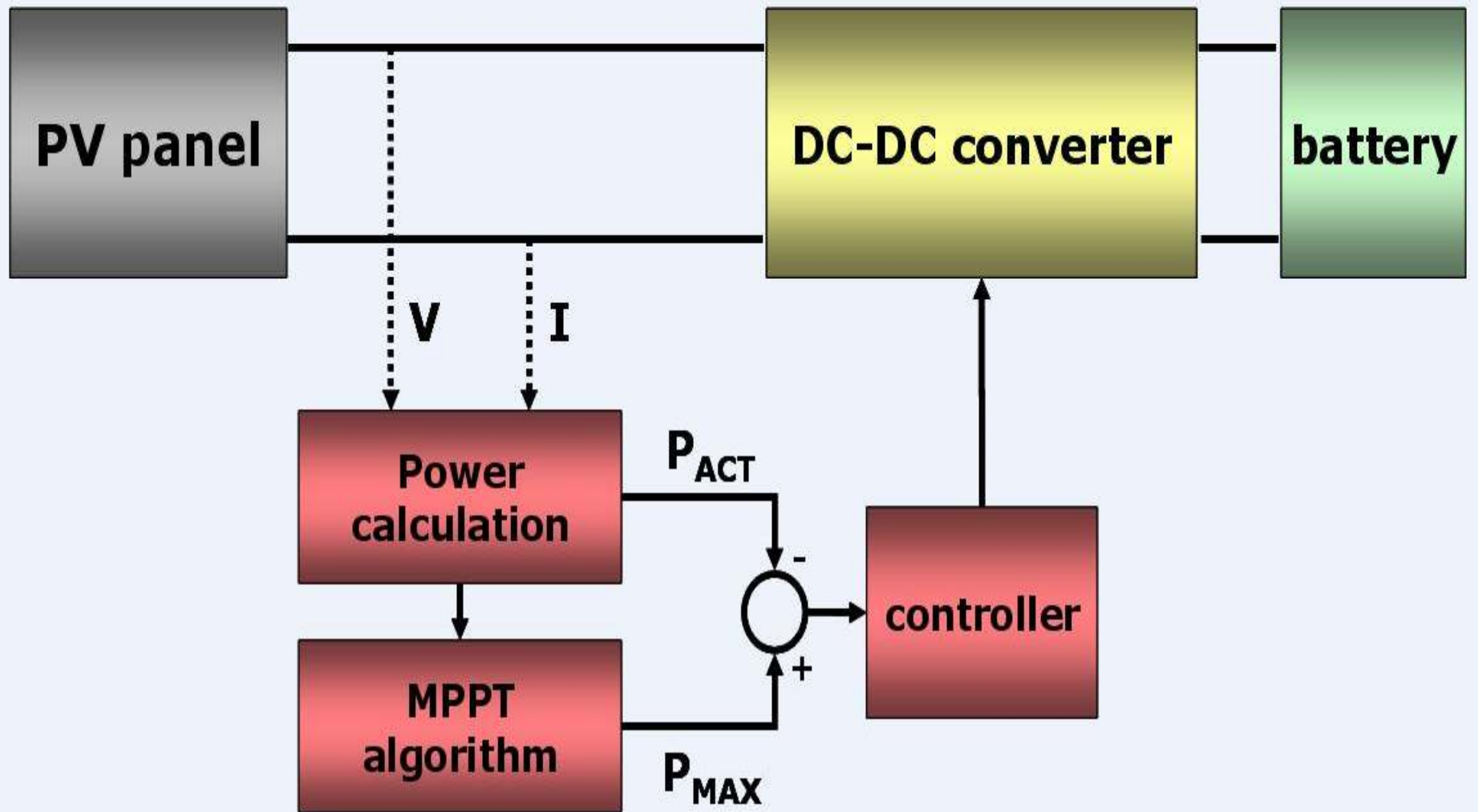
For Different Solar Radiation



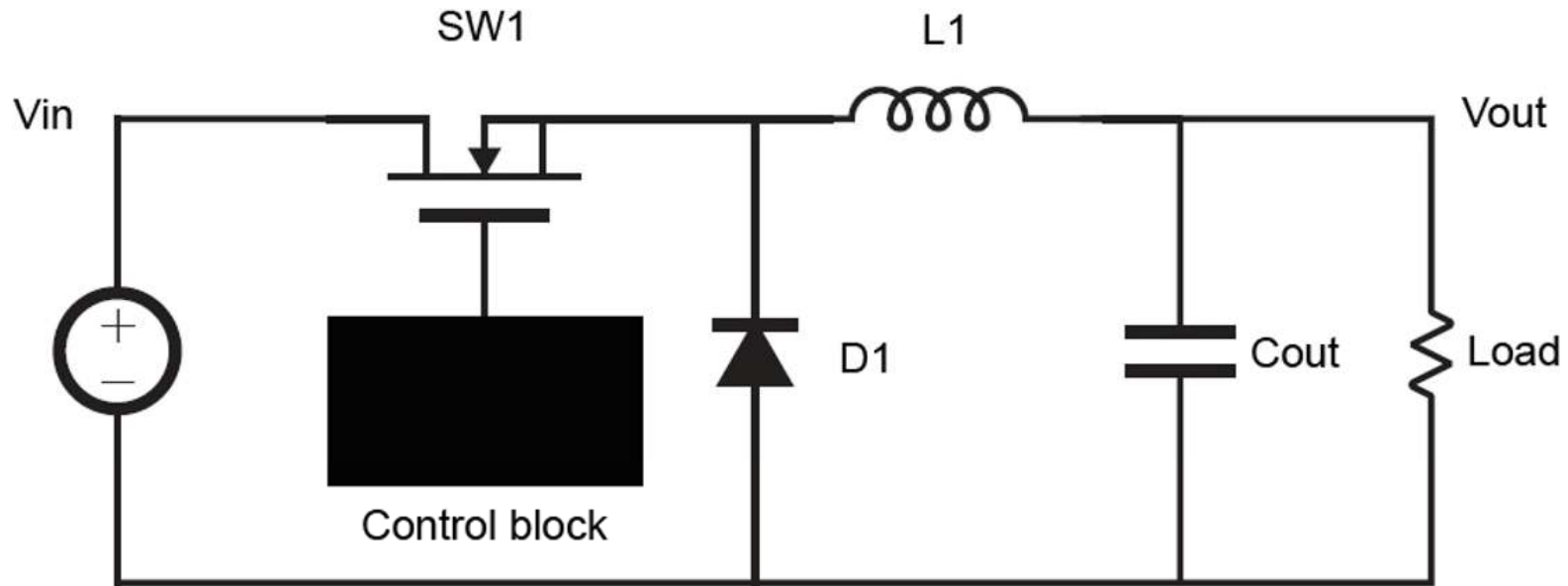
Atmospheric temperature 25°C

Peak Power Point Tracking





Buck DC/DC Converter



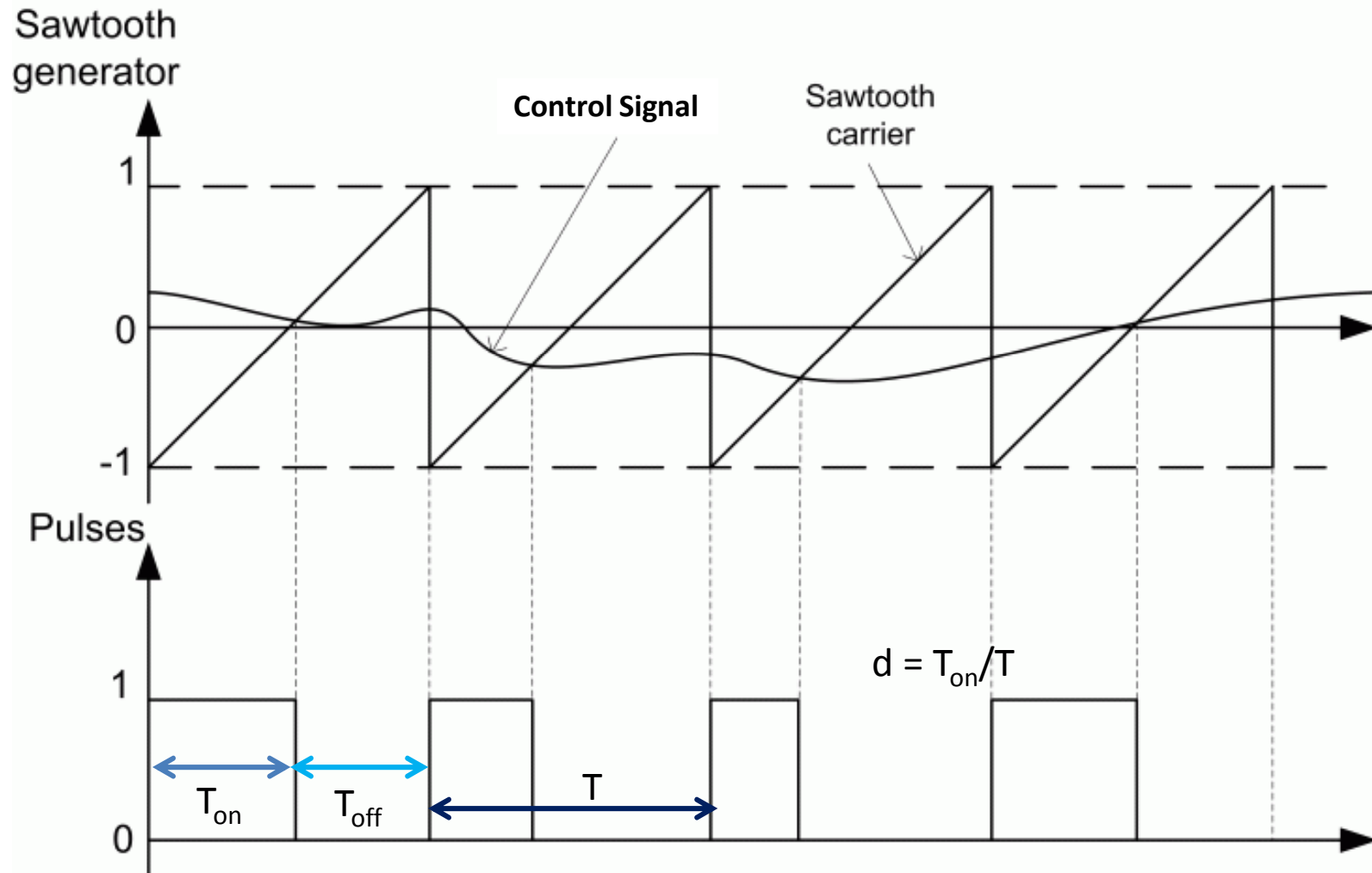
$$V_{\text{out}} = d V_{\text{in}}$$

V_{out} – Output DC Voltage in Volt

V_{in} – Input DC voltage in Volt

d - duty ratio

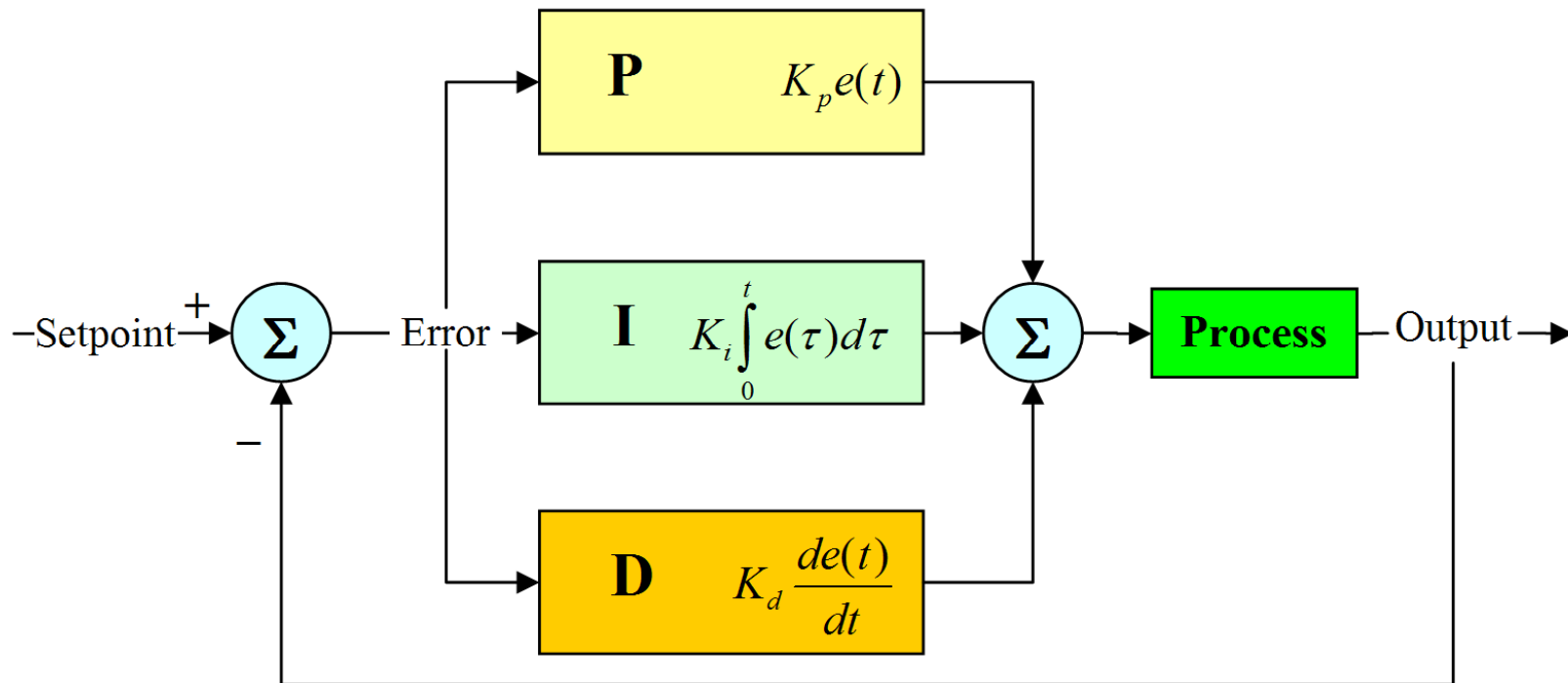
PWM Pulses for Controlling Duty Ratio 'd'



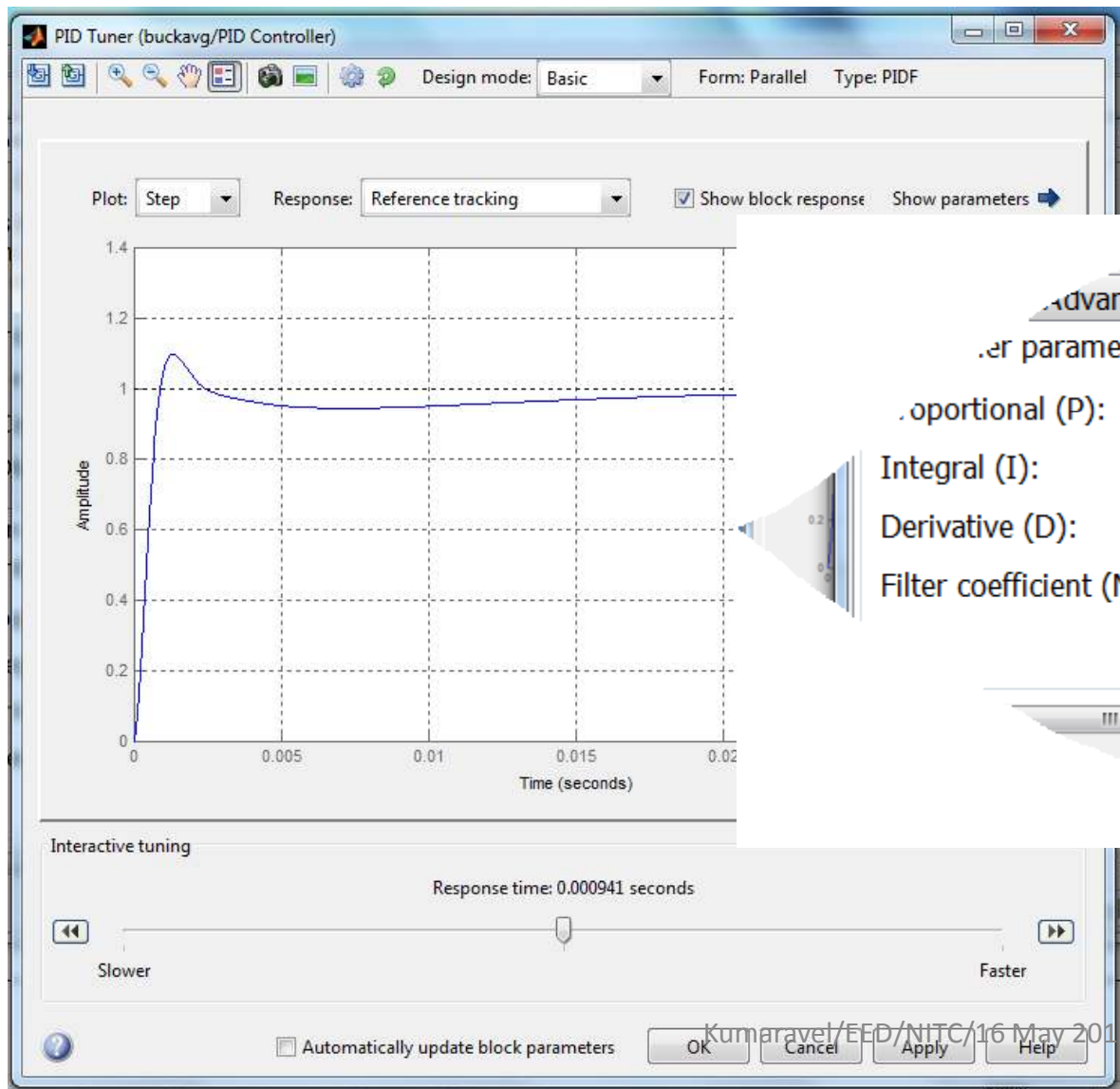
Buck Converter Specifications

Parameter	Ratings
Input voltage	100 V
Output voltage	0-100 V
Output power	1kW
Inductor	33mH
Capacitor	500 μ F
Switching Frequency	10 kHz

PID Controller



Tuning of PID for Buck Converter

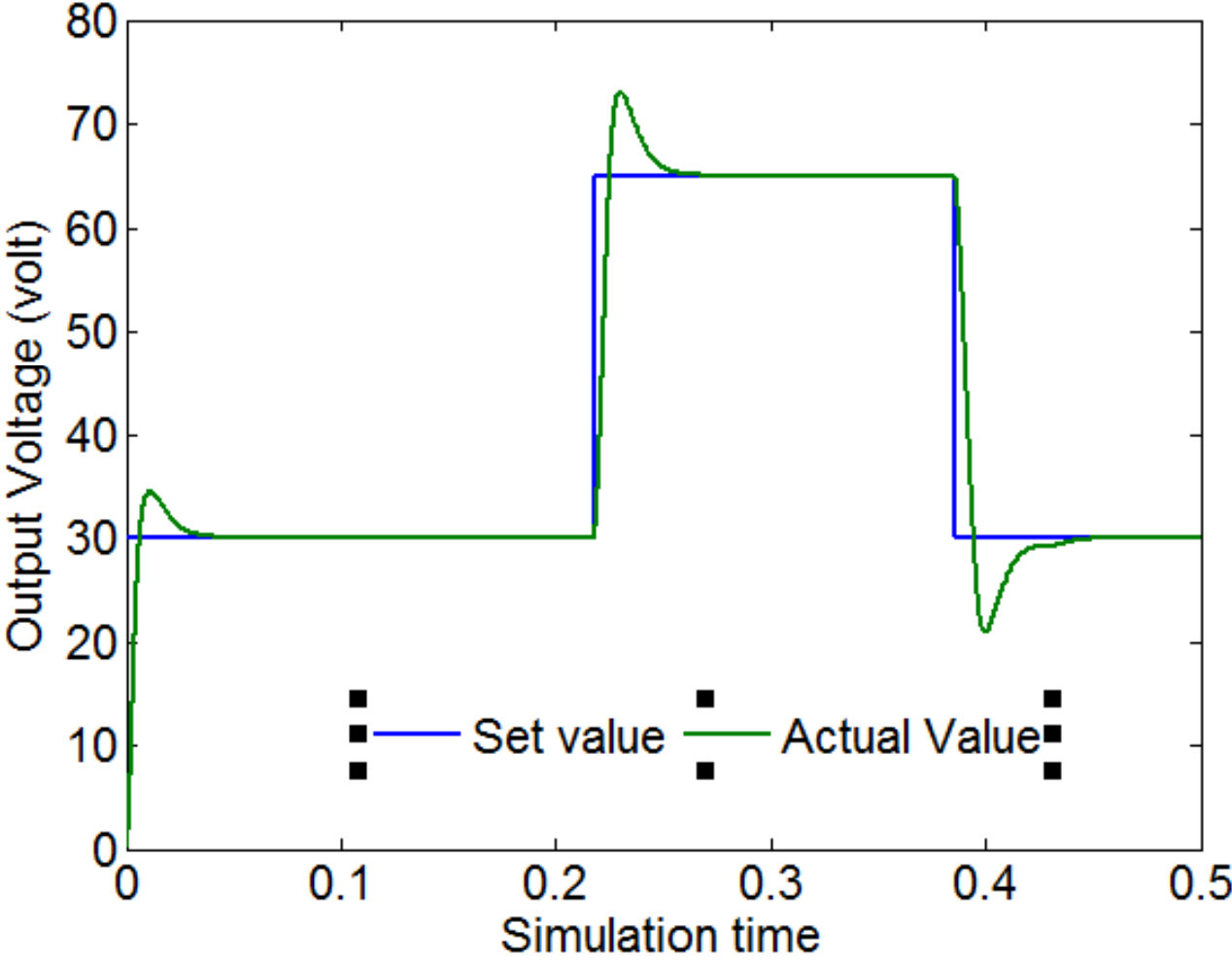


Advanced Data Types
Controller parameters

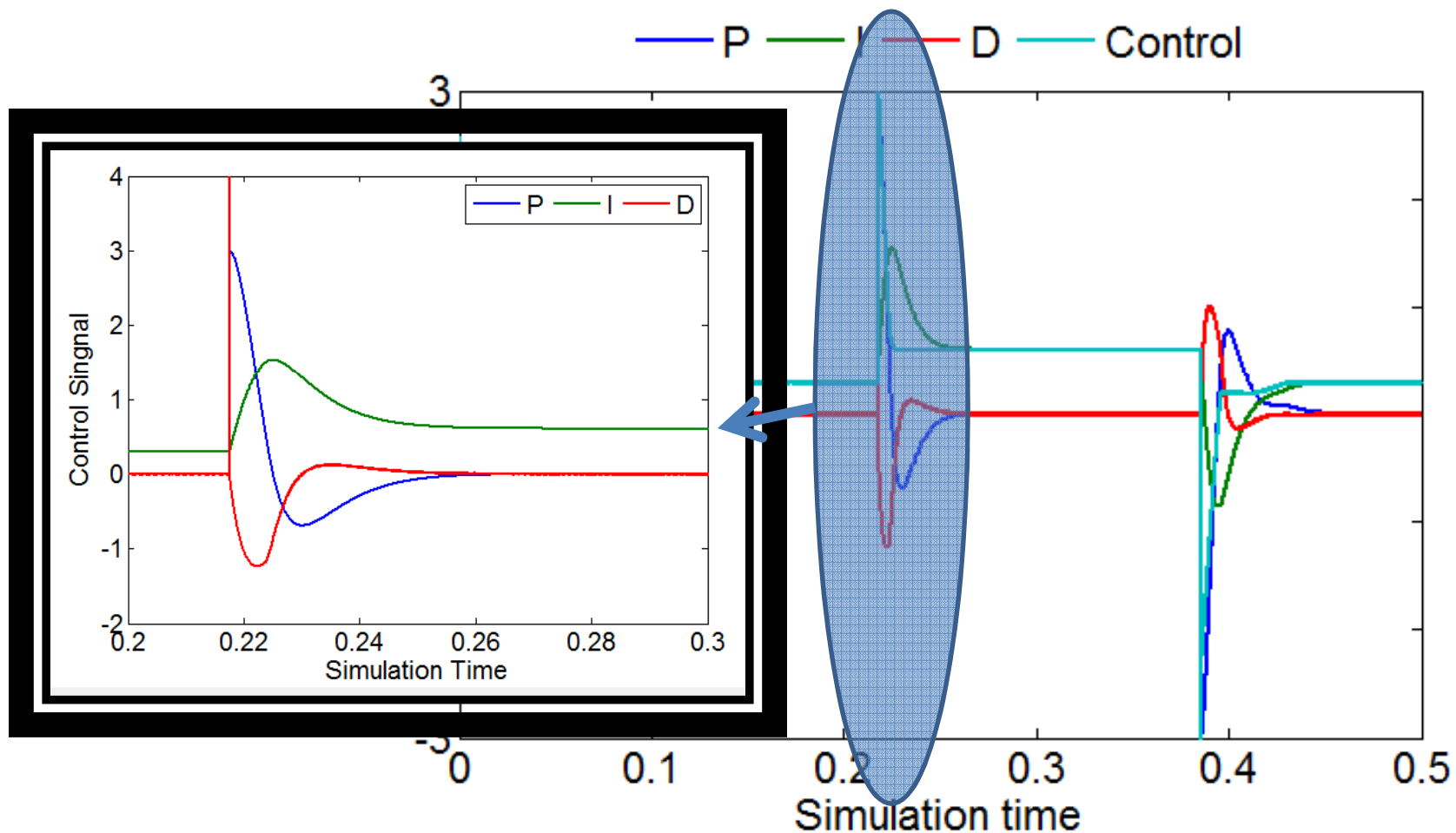
Proportional (P):	0.0856161067835126
Integral (I):	8.32459377333492
Derivative (D):	0.000209912051394575
Filter coefficient (N):	4511.05854914726

OK Cancel

Output Response of PID controller for Buck Converter



Variation of the Control Signal by PID



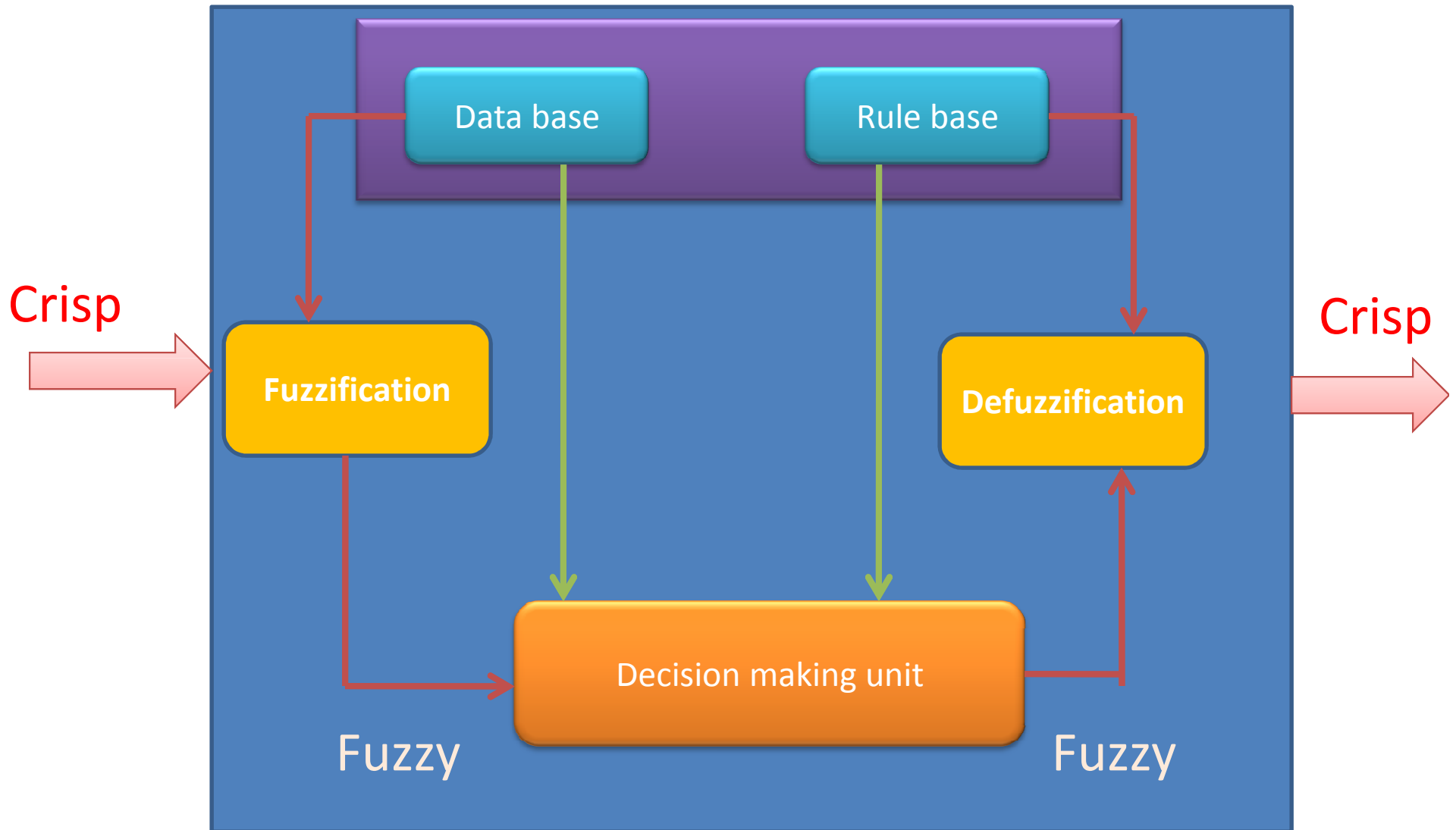
Intelligent to Artificial Intelligent



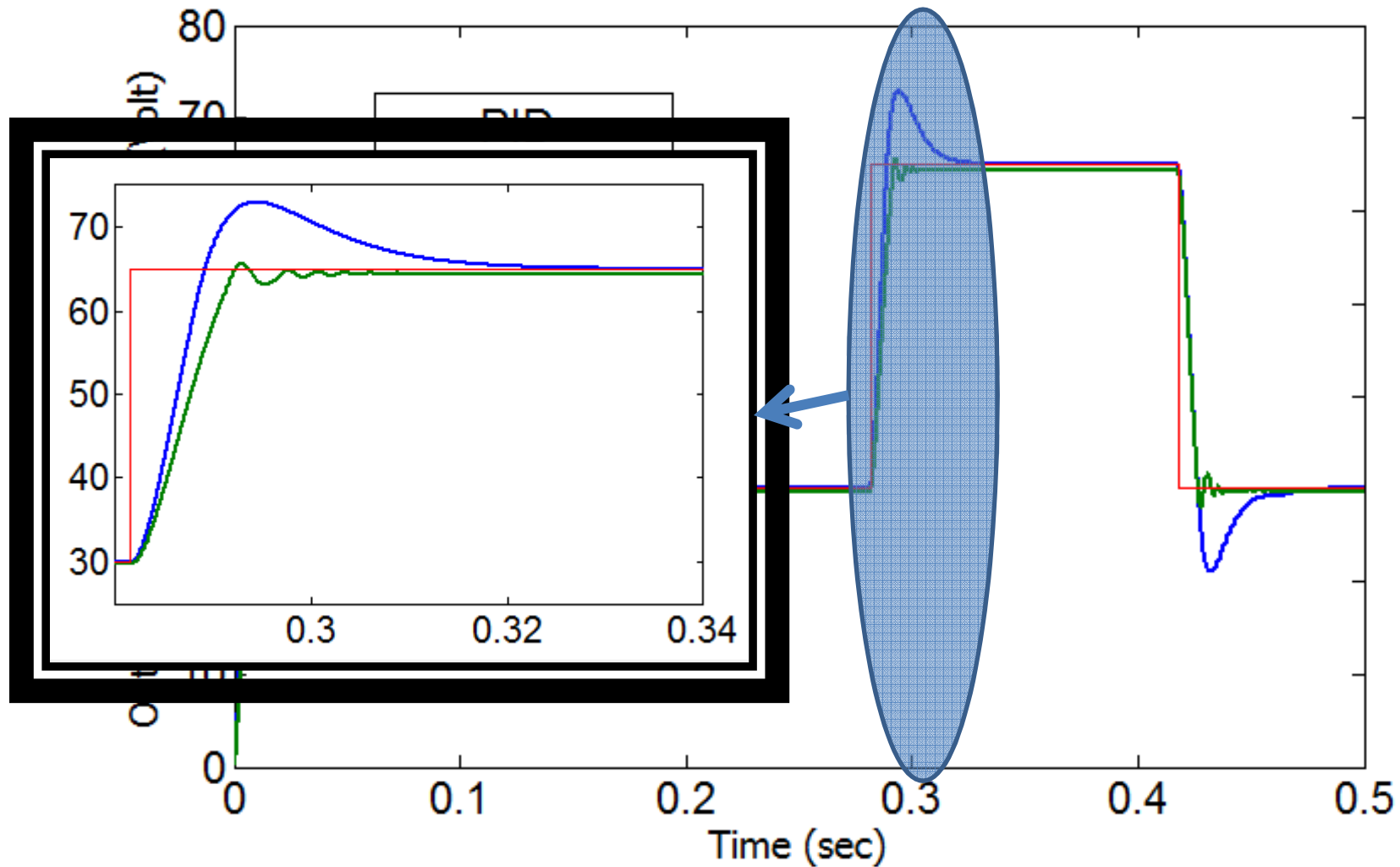
Different AI Techniques

- Fuzzy logic
- Artificial neural network
- Genetic algorithm
- Practical swarm optimization
- Simulated annealing
- Ant colony algorithm
- Artificial immune system algorithm

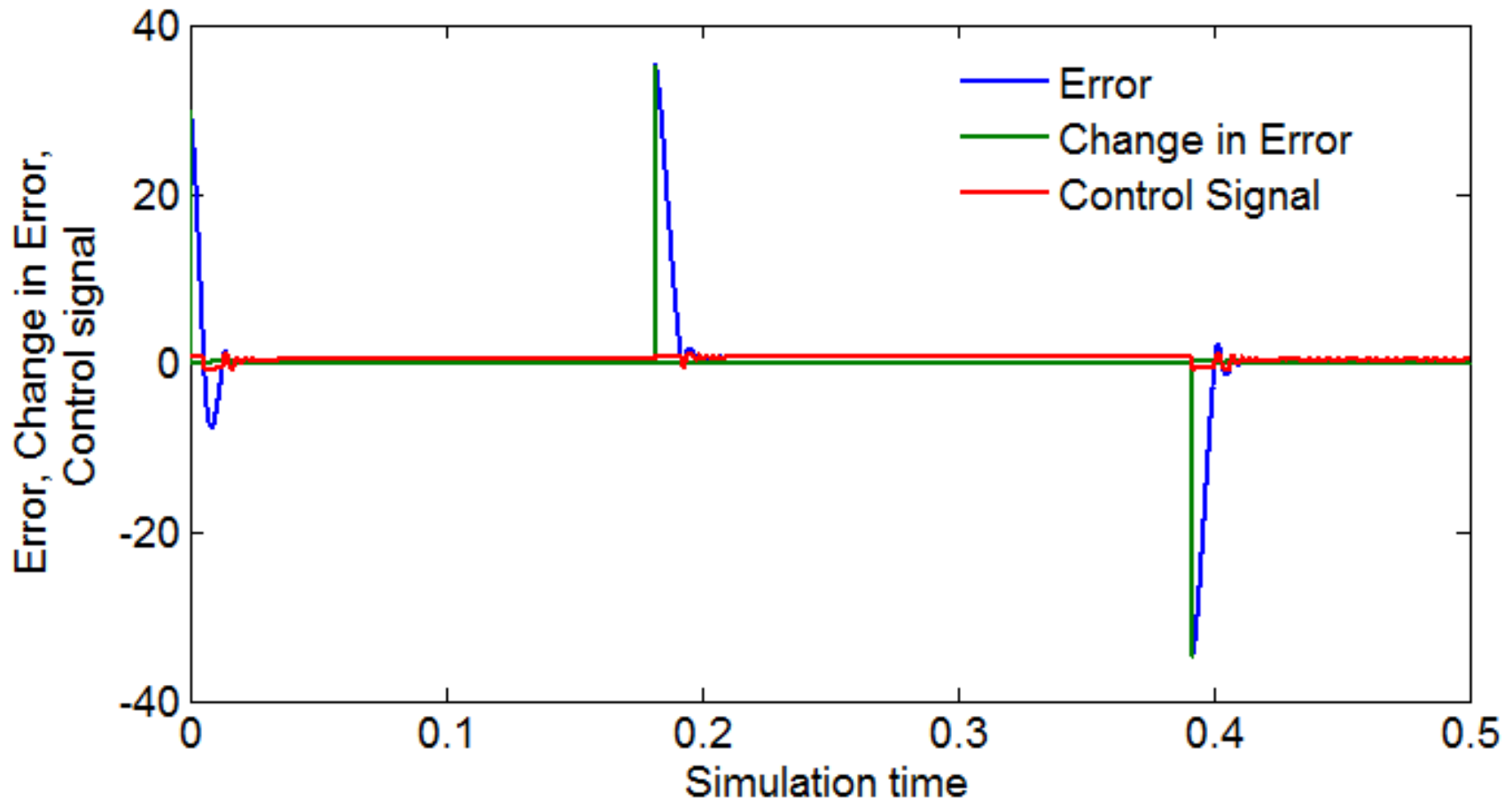
Fuzzy Inference Engine



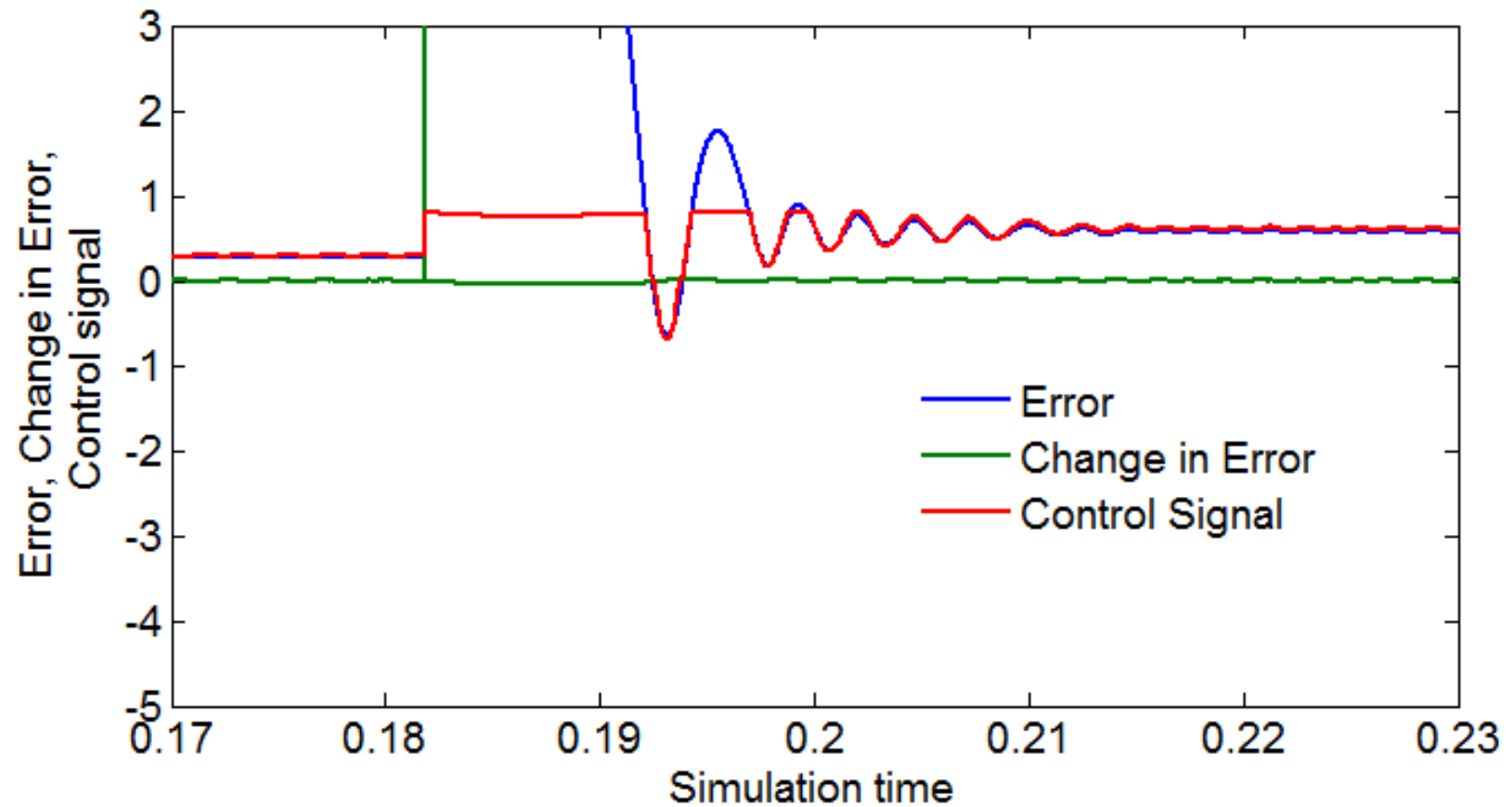
Output voltage of Buck converter for PID and Fuzzy controller



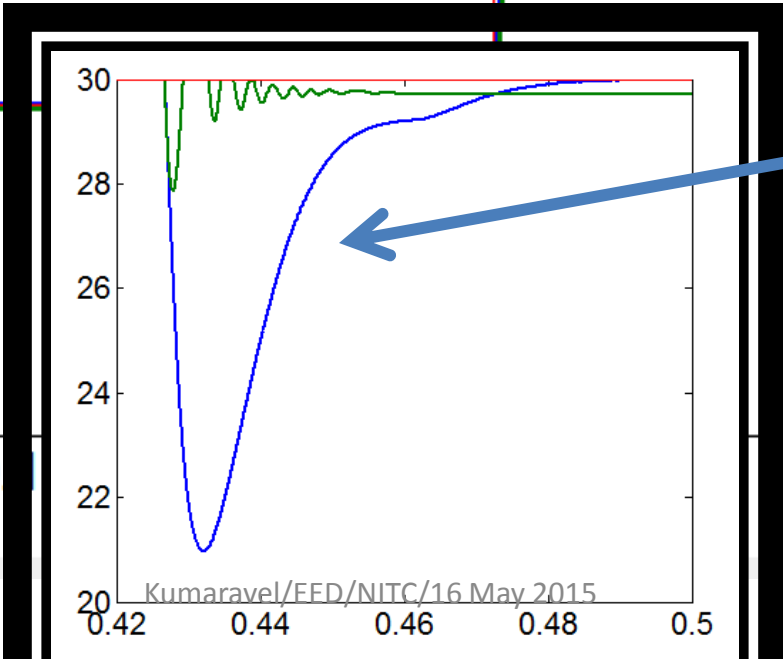
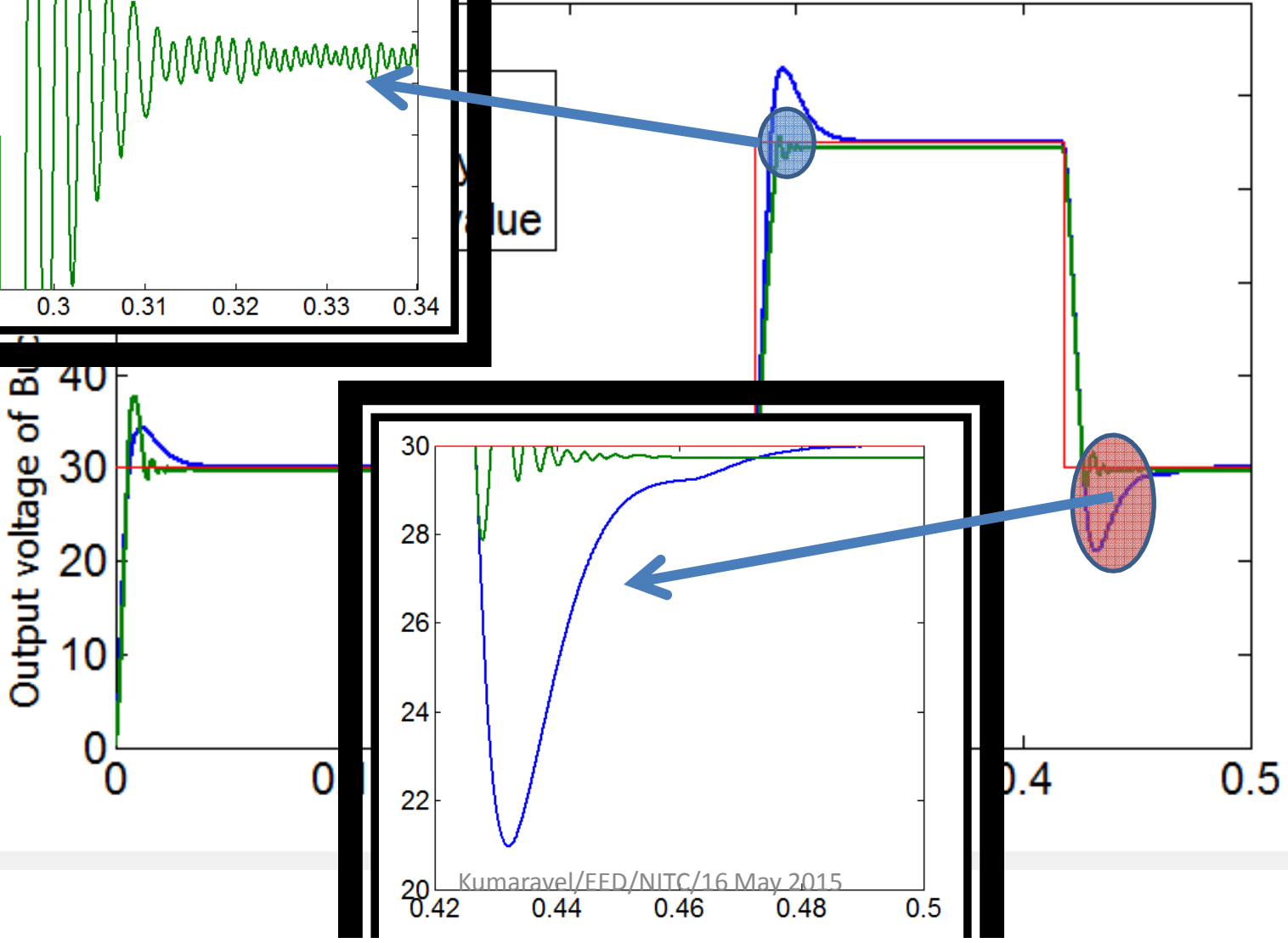
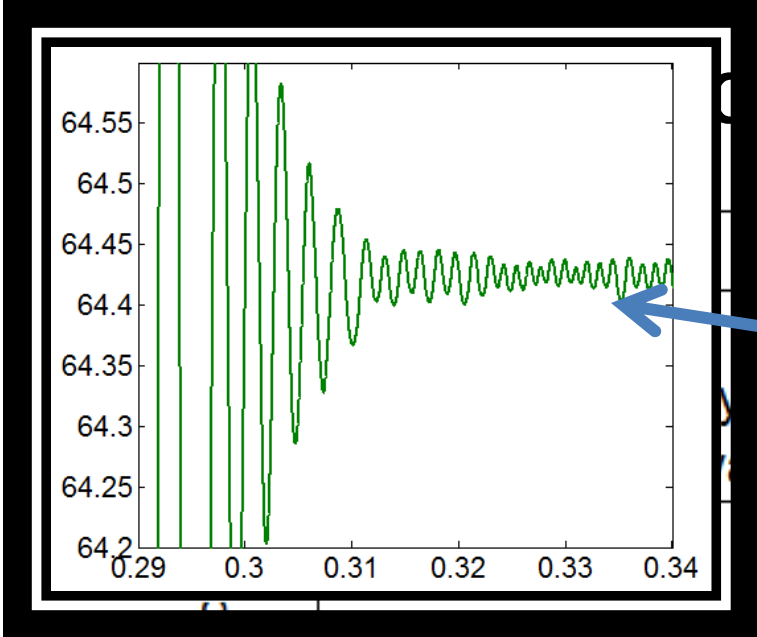
Response of Fuzzy Controller



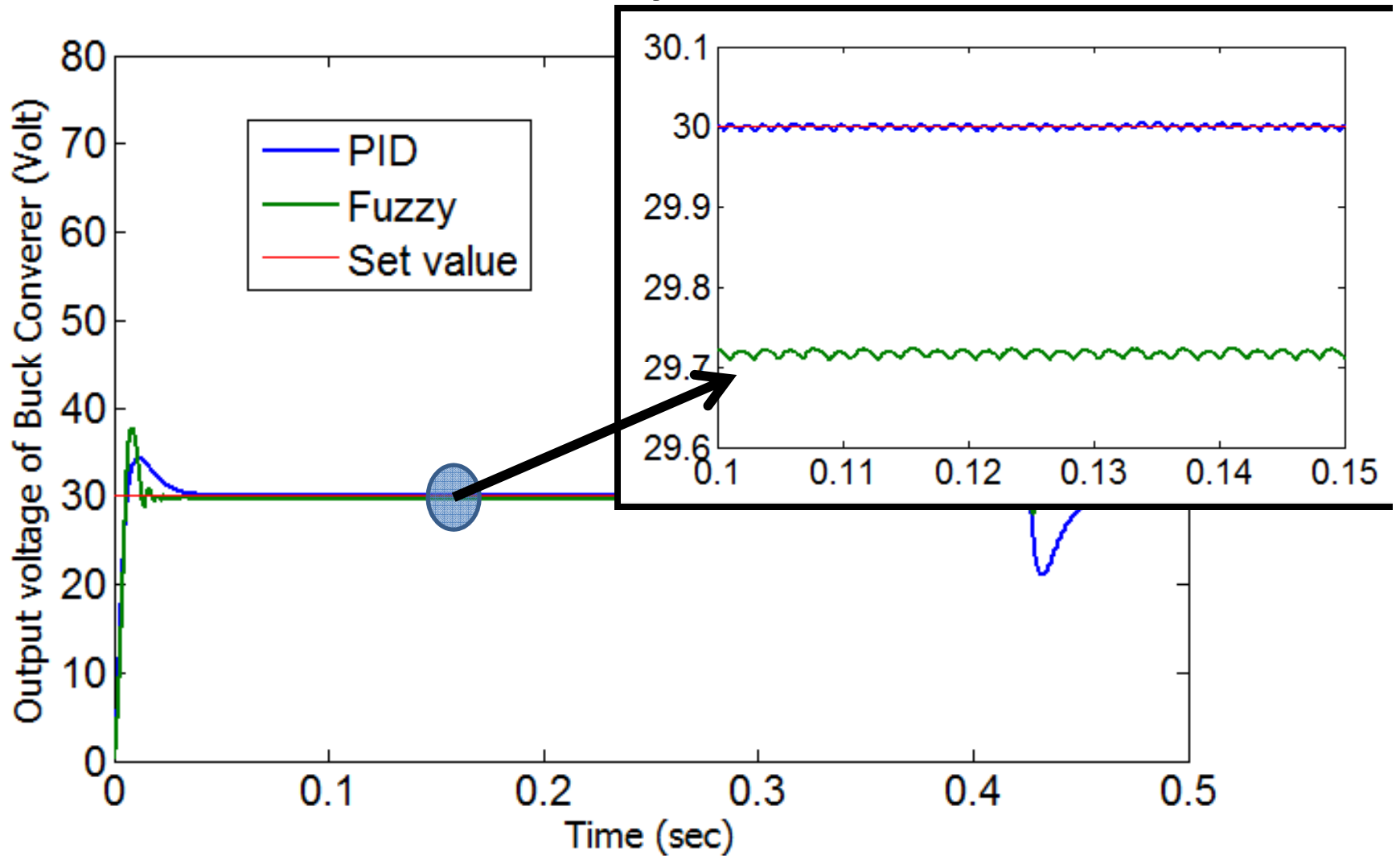
Response of Fuzzy Controller



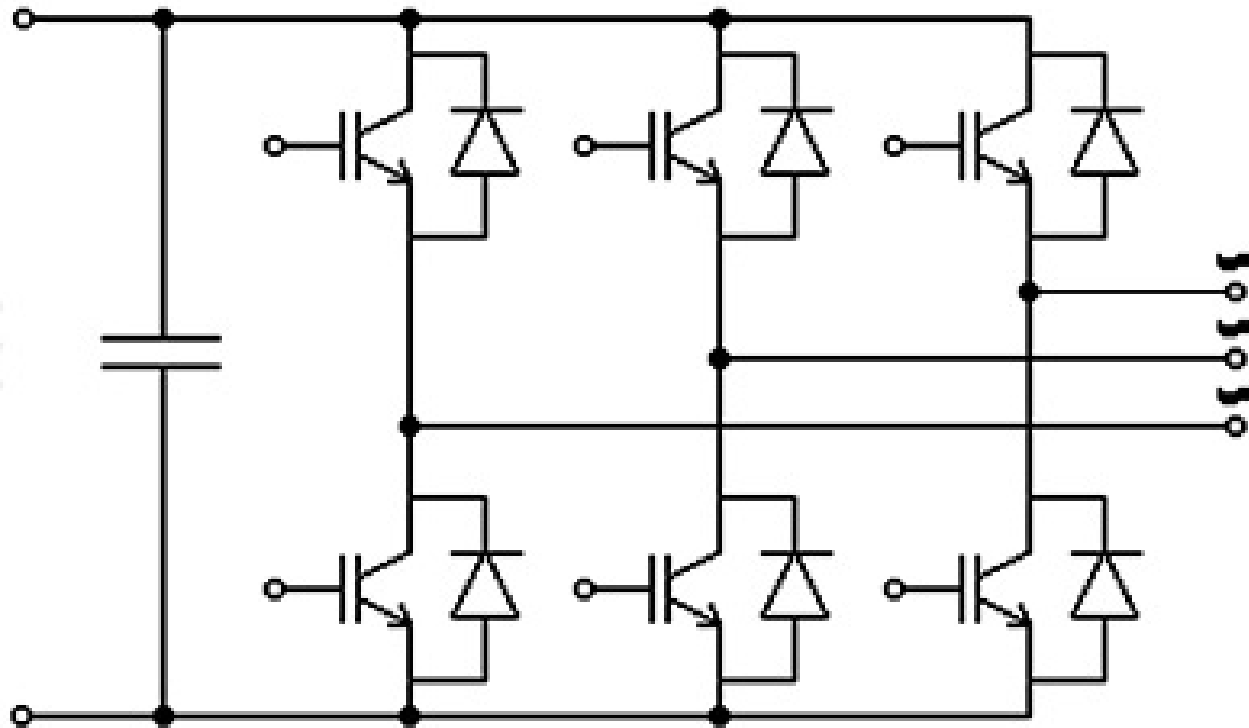
Output voltage of Buck converter for Fuzzy controller



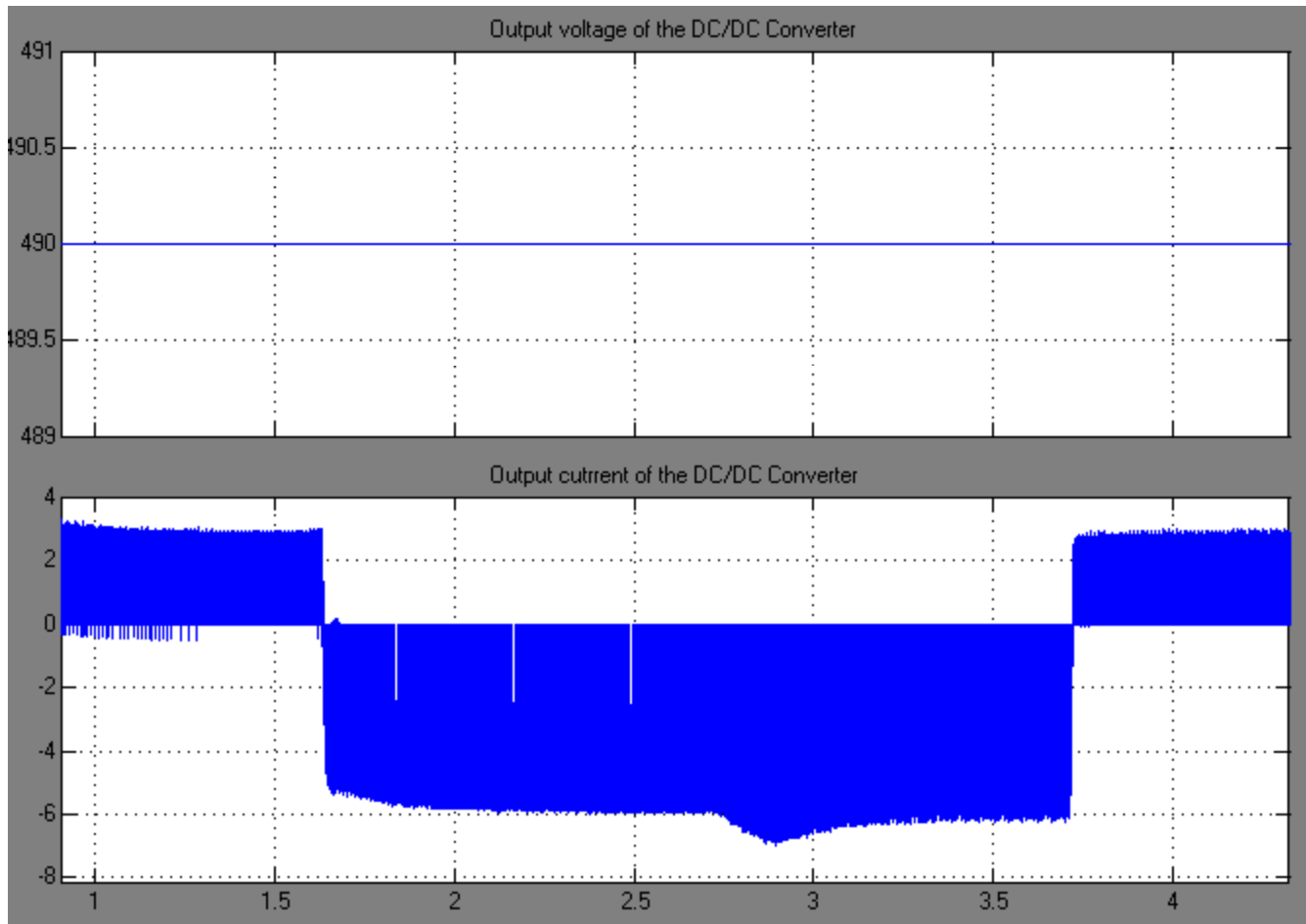
Output voltage of Buck converter for PID and Fuzzy controller



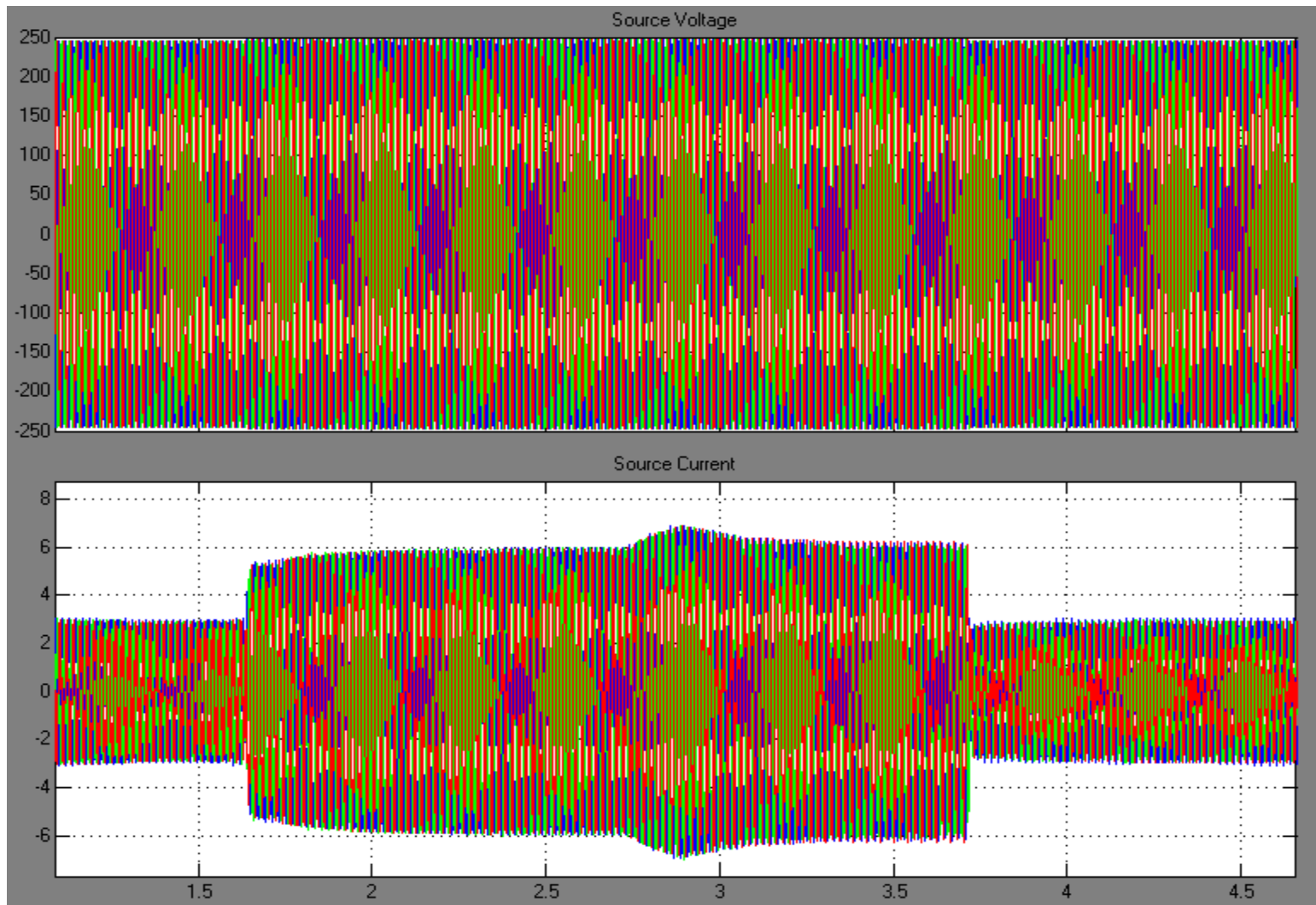
Inverter Control



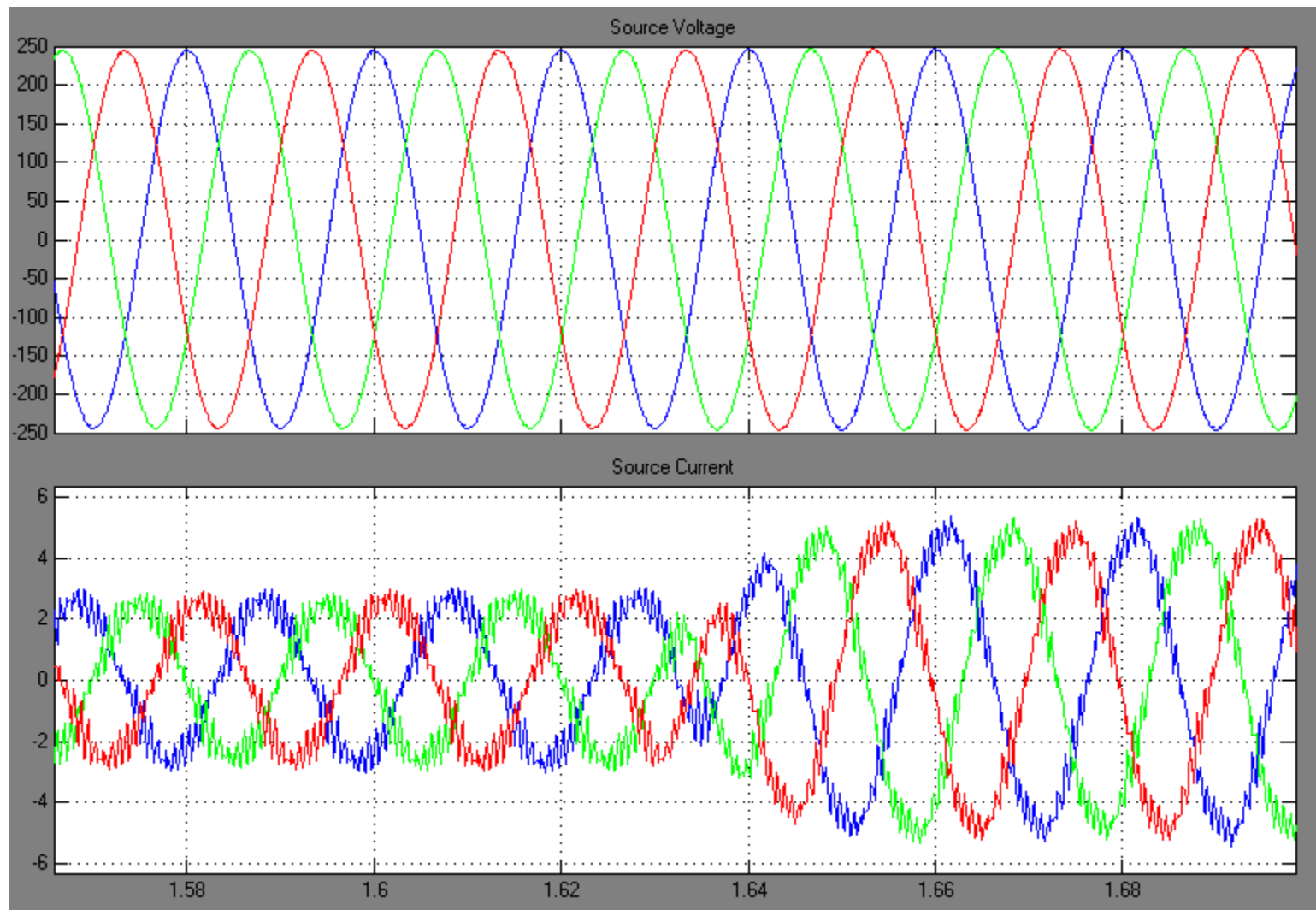
Output Voltage and Current of the DC/DC Converter



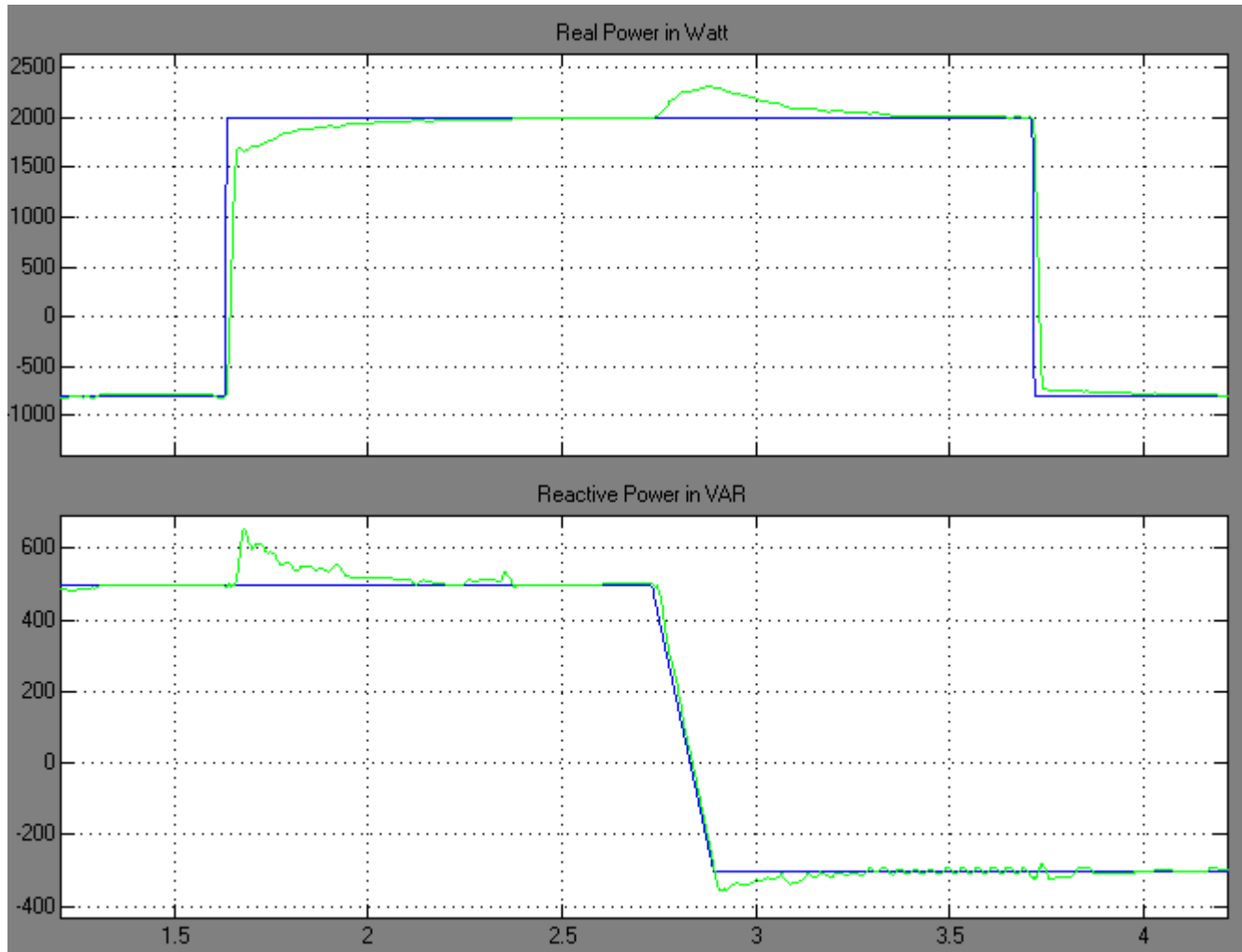
Source Voltage and Source Current



Source Voltage and Source Current

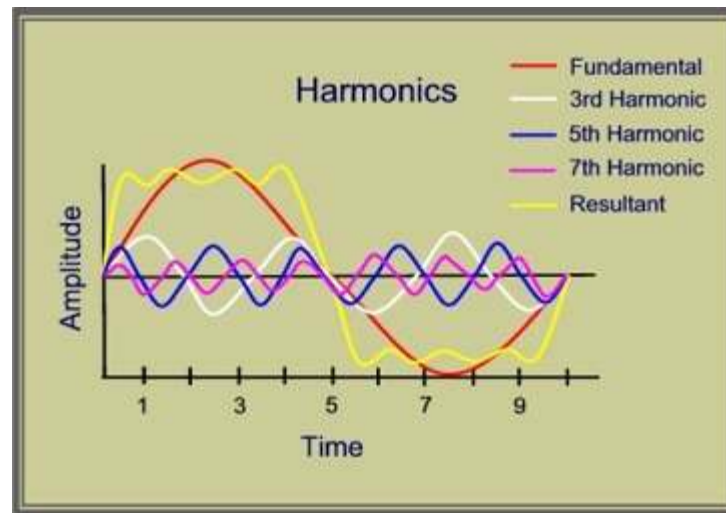


Real and Reactive Power Control of Inverter



What are Harmonics?

- Harmonics are currents or voltages with frequencies that are integer multiples of the fundamental power frequency being 50 or 60Hz

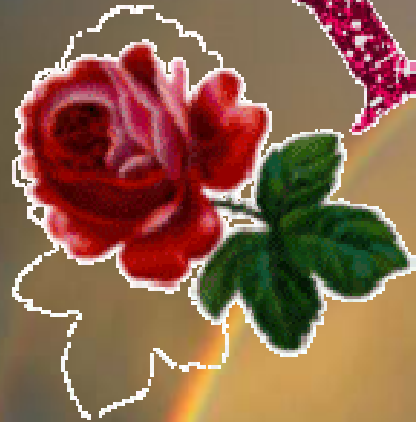


Effects of Harmonics

- [Distorted voltage](#)
- Overheated transformers and motors
 - Increases hysteresis losses in steel and iron cores
- Heating of neutral conductors
 - Skin effect – increased amount of current flowing on the outside conductors
- High neutral current
- EMI problems
- Measurement problems



Thank You



By



Dr. Kumaravel
Sundaramoorthy



Kumaravel_s@nitc.ac.in

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