ECE 404-TD / 504-TD

ST: T&D APPLICATIONS OF
VOLTAGE SOURCE CONVERTERS

SESSION no.   6

AC Circuit - Triangle wave ref

- Synchronous PWM

→ switching frequency integer multiple of system freq

measurement as reference

Phase Locked Oscillator

frequency of B as offset of the A frequency secondary mass

doppler shift

primary...

University of Idaho
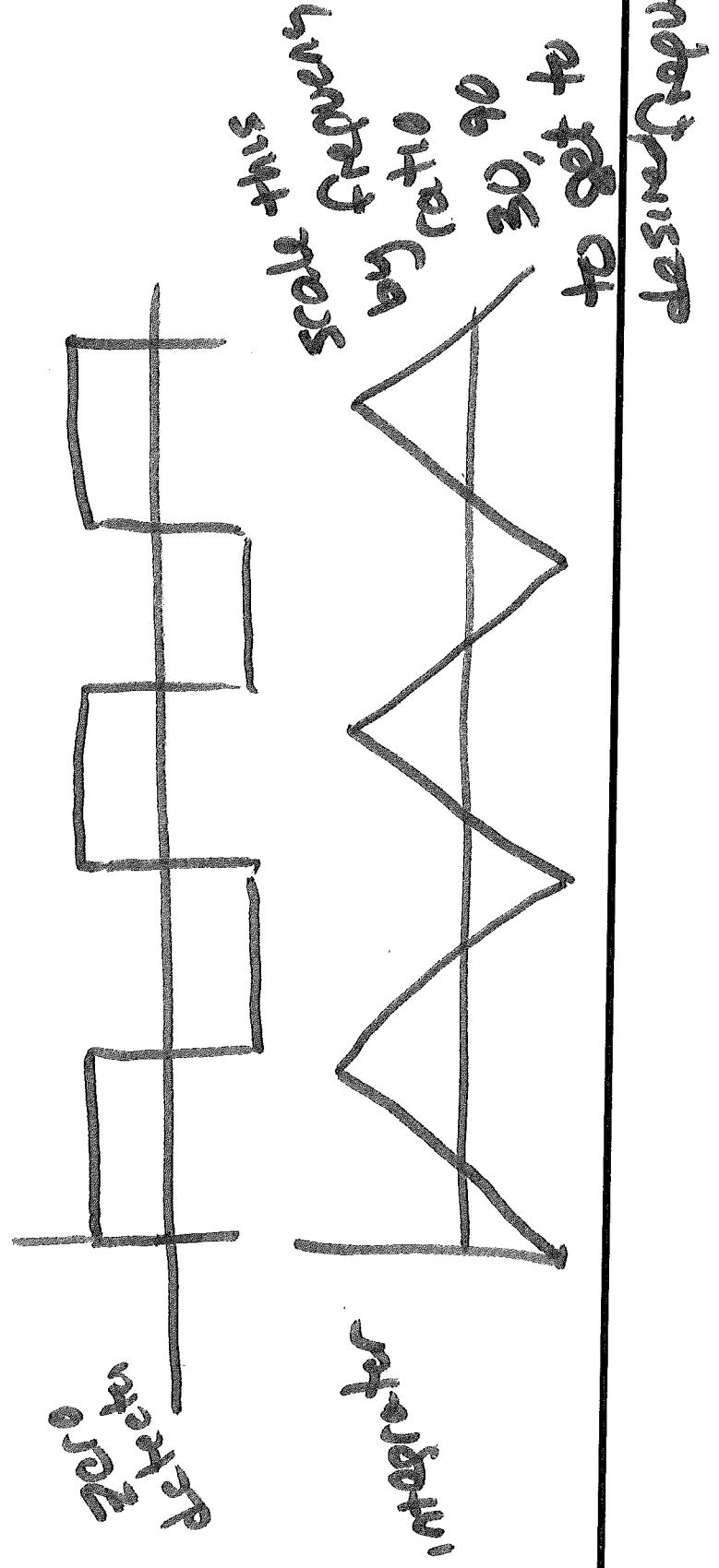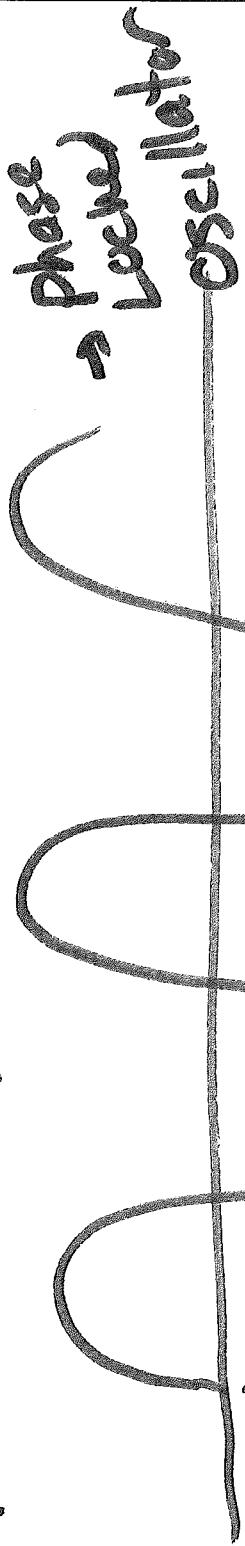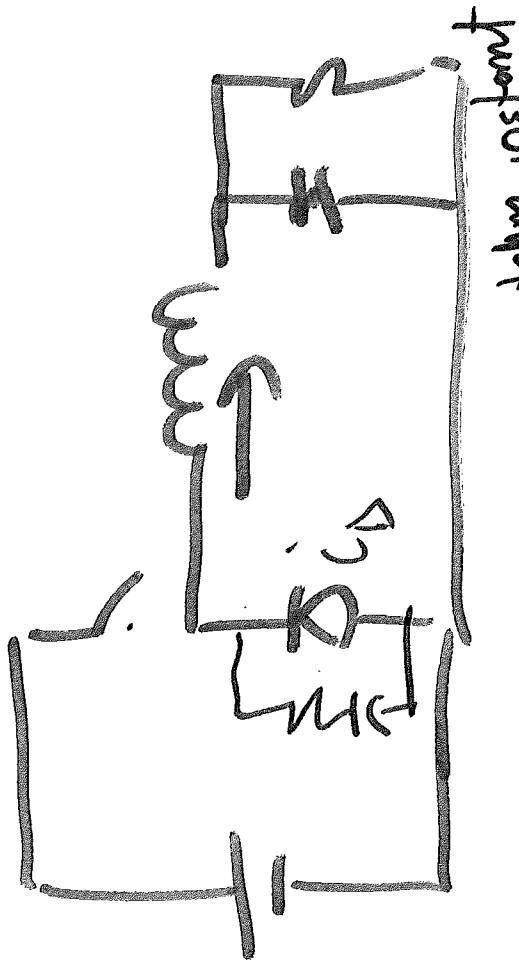
switching instant

produced volt 0 cross inducts

$\frac{\Delta I}{\Delta t}$

L

it

VSW

cSW=i
cy=0

Oper
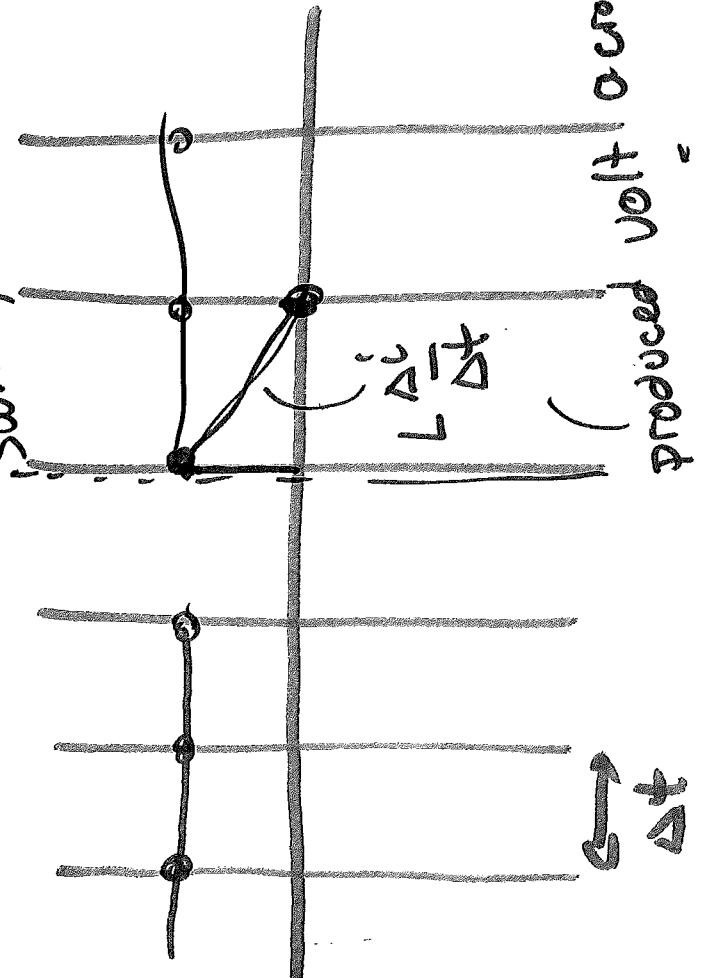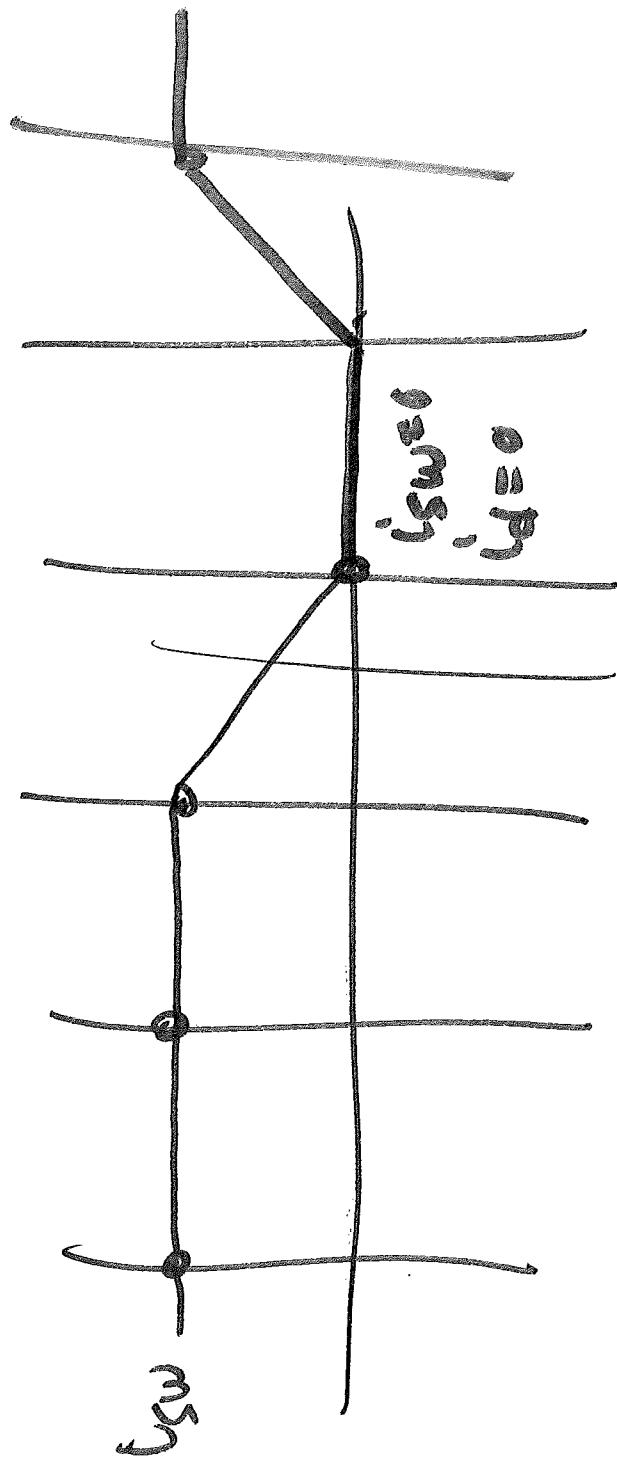
U_I Getting PSCAD/EMTDC

- Education Edition available in the Senior Design and PC lab, hopefully on VLAB too.
  - » Version 4.2 and 4.5.1
- Also a free student edition (15 node limit)
  - » Version 4.5.1
  - » Only available for Windows Vista or later (not XP)
- Go to: http://www.pscad.com/
  - » Create account through "MyCentre"
  - » Follow installation instructions—including Fortran compiler

1   Spring 2013

U_I PSCAD 4.2 versus 4.5.1

- Examples will be created using version 4.2
  - » Will run under 4.5.1
  - » Cases created using 4.5.1 can't go back to version 4.2
- May run into issues with 15 node limit in free edition
- Try to learn from the examples that install with the program

2   Spring 2013

1

Creating a file in PSCAD/EMTDC vers 4.2

- Create new project
- Set project as active (blue icon)
- Double click on project to open schematic drawing pallet
  - » Can view an inactive project by not run it

master (Master Library)
noname
simpleac Simple AC Pow
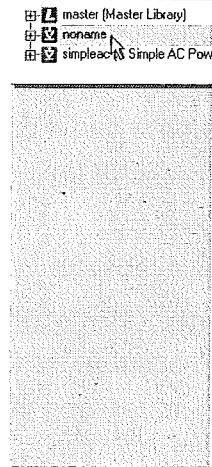
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Adding components (1)

- A few basic components in bars on right of screen
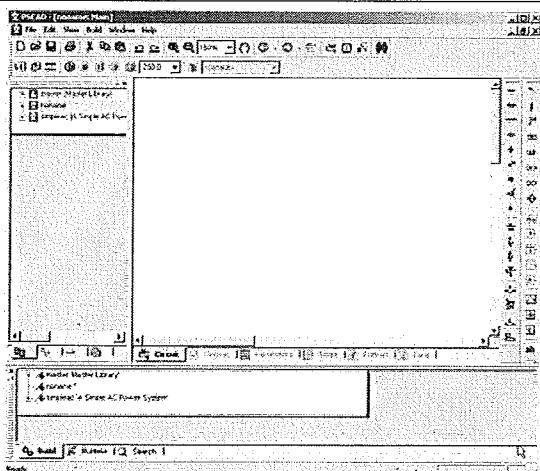
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U_I Adding components (2)

- Can also add components by right clicking mouse in drawing area
  - » Add Component
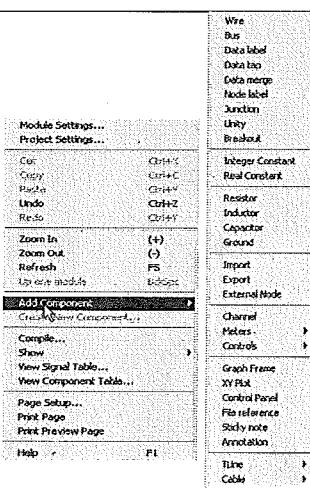
5

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U_I Adding Components (3) Master Library

- Libraries for different types of components
  - » Select one to expand it
  - » Copy the component you want to use
  - » Need to double click on your project
  - » Paste the component

6

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3

Moving Up Modules

U_I
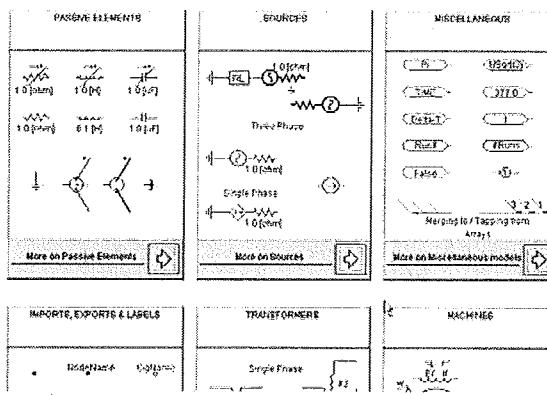
- When you are
  in a submodule
  you can move
  up with:

|	
Module Settings...	
Project Settings...	
Cut	Ctrl+X
Copy	Ctrl+C
Paste	Ctrl+V
Undo	Ctrl+Z
Redo	Ctrl+Y
Zoom In	(+)
Zoom Out	(-)
Refresh	F5
Up one module	Bck Spc
Add Component	▶
Create New Component...	
Compile...	
Show	▶
View Signal Table...	
View Component Table...	
Page Setup...	
Print Page	
Print Preview Page	
Help	F1
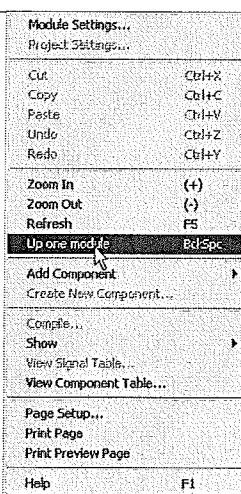
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Setting up your simulation

U_I

- Right click in
  drawing area
  » Select "Project
    Settings"

Module Settings...	
Project Settings...	
Cut	Ctrl+X
Copy	Ctrl+C
Paste	Ctrl+V
Undo	Ctrl+Z
Redo	Ctrl+Y
Zoom In	(+)
Zoom Out	(-)
Refresh	F5
Up one module	Bck Spc
Add Component	▶
Create New Component...	
Compile...	
Show	▶
View Signal Table...	
View Component Table...	
Page Setup...	
Print Page	
Print Preview Page	
Help	F1

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4
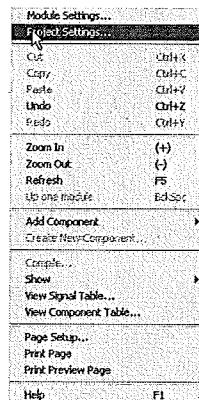
Project Settings

- Usually interested in "Runtime"
  - » Duration
  - » Solution time step
  - » Channel plot step
- May want to save channel to disk

Project Settings - Lec9ex

General | Runtime | Simulation | Dynamics | Mapping | Fortran | Link |

Time Settings

|	
Duration of run (sec)	
Solution time step [uS]	50
Channel plot step [uS]	50

Startup method: Standard
Input file: Browse...
Save channels to disk? Yes
Output file: Lec9ex.out
Timed snapshot(s): None
Snapshot file: noname.snp
Time: 0.3
Multiple runs: None
Output file: run.rn
runs: 10

☑ Remove time offset when starting from snapshot.
☐ Send only the output channels that are in use.
☐ Start simulation manually to allow use of integrated debugger.
☑ Enable component graphics state animation.

OK   Cancel   Help

9

Adding a Single Phase Source

- Copy source from library
  - » Double-click for dialog box
- Several pulldown menus
  - » First configuration

1.0 [ohm]

[source_1] Single Phase Voltage Source

Configuration

Source Name	Source1
Source Impedance	Resistive
Is this source grounded?	Yes

Specified Parameters
- ⦿ Behind the Source Impedance
- ○ At the Terminal

Input Method
- ⦿ Internal
- ○ External

Source Type
- ⦿ AC
- ○ DC

OK   Cancel   Help...

10
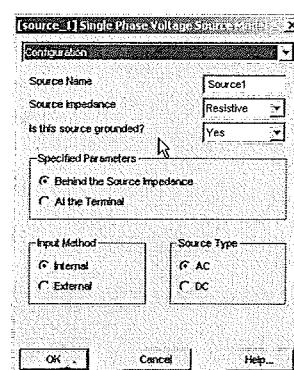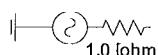
# U_I Source Configuration

- Enter source name
- Source impedance
  - » For example ideal
    - – Circuit symbol changes when done
- Can also specify
  - » Grounding
  - » AC/DC
  - » Input internal or external
    - – External allows user interactive or control loop
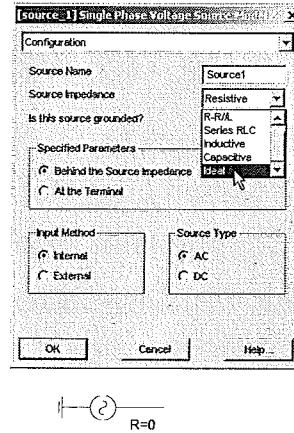
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# U_I Other data entry points

- Signal parameters
  - » RMS magnitude
  - » Ramp-up time
    - – Remember no steady-state solution
  - » Initial phase (sine wave)
  - » Frequency
- Impedance fields won't allow entry for ideal
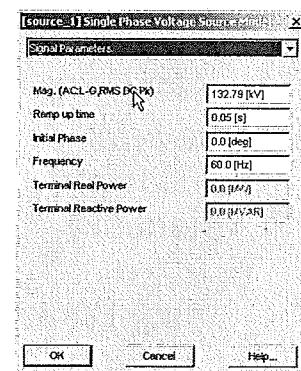
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Resistors, Capacitors, Inductors

- For single phase branches can get from menus in window or master library
  - » Need to get from master library for polyphase
  - » Have option of 3 phase view of single line diagram view in later versions of program
- Enter R in ohms, L in H and C in μF

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Connecting circuit together
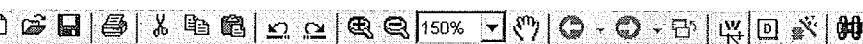
- Wire icon on top toolbar
  - » Pencil symbol appears
  - » Trace with left mouse clicks
    - – Click each time change direction
  - » Right click or escape to complete
    - – Right click lets you select points to rescale
- "Junction" to connect wires as cross each other (otherwise disconnected
 - » Get from right click in drawing space ●

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Voltage and Current measurements

- Voltage measurements
  - » Can do line to ground and arbitrary
    - – Need to connect to circuit
    - – Name the measurement (default is Ea)

  V_s E_a
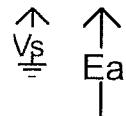
- Current measurement
  - » Need to connect to the line, don't copy on top of a wire.

  I_a

25
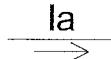
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Output Channels

- Create output channel next
  - » Again need signal
  - » Connect to "Output channel"
- Choose Input/Output Reference

V_s V_s

IFault   IFault

Edit Parameters...	
Edit Definition...	
View Properties...	
Cut	Ctrl+X
Copy	Ctrl+C
Paste	Ctrl+V
Rotate Left	L
Rotate Right	R
Rotate 180	
Mirror	M
Flip	F
Bring to Front	
Send to Back	
Set Sequence Number...	5
Compile Module	
Input/Output Reference	▶
Copy as Meta-File	
Copy as Bitmap	
Help...	F1

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Slide 1:
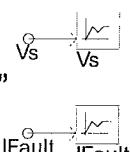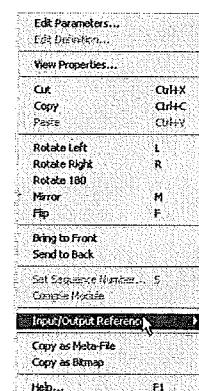
Input/Output Reference Graphs

U_I

- Several Options
  - » Add Overlay Graph Most Common
  - » If choose "Add as Curve"
  - » Paste to existing graph
    - Right click in white part

Menu options shown:
Add as Curve
Add as Control
Add as Meter
Add as PolyMeter
Add as PhasorMeter
Add Overlay Graph with Signal
Add Poly Graph with Signal

Graph Properties...
Cut Graph
Copy Graph
Paste Curve
Copy Data to Clipboard
Zoom
Preferences
Move Graph Up
Move Graph Down
Move Graph to Top
Move Graph to Bottom
Copy Frame as Meta-File
Copy Graph as Bitmap
Synchronize Channel Limits to Graph
Help   F1

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Slide 2:

Complete Circuit

U_I

0.149 [ohm]   0.00473[H]
R=0
Timed Fault Logic   Fault
Vs
IFault   IFault
Main...
Vs
6.38506e-010

Main: Graphs (Vs)
Main: Graphs (Fault)

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Complete Circuit: without graphs shown

R=0

Vs 0.149 [ohm] 0.00473[H]

Timed Fault Logic — Fault

Fault

Vs Vs

IFault IFault

Main ...
Vs

-2   2
kV
6.38536e-010

30
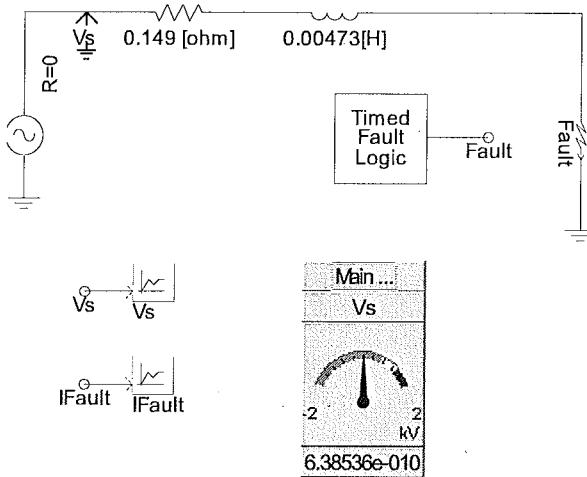
Power Electronic Circuits

- Start with the master library
- Can build a converter from switches
- Or use a completed modules

HVDC, FACTS & POWER ELECTRONICS

Com.
Bus
AM
GM

2

AO
KB

2

6 Pulse
Bridge

More on
Power Electronics/HVDC/FACTS

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Slide 32:

U_I
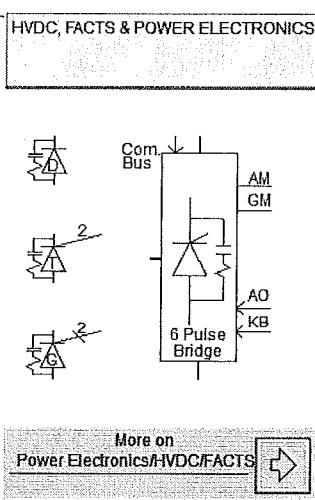
ECE 404/504
Lecture 6

Power Electronic Devices

- Symbols for several devices
- Transistor, IGBT and GTO all very similar
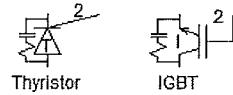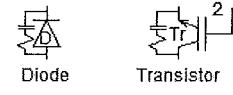
Thyristor   IGBT
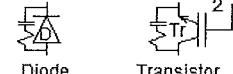
Diode   Transistor

GTO

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Slide 33:

U_I

ECE 404/504
Lecture 6

Switch dialogs

[peswitch] Power electronic switch

Configuration

Device Label (optional)
Device Type   IGBT

Enable Snubber Circuit?   Interpolated Pulse?
  Yes   No
  No   Yes

OK   Cancel   Help...

[peswitch] Power electronic switch

Main Data

Thyristor ON Resistance	0.01 [ohm]
Thyristor OFF Resistance	1.0E6 [ohm]
Forward Voltage Drop	0.0 [kV]
Forward Breakover Voltage	1.0E5 [kV]
Reverse Withstand Voltage	1.0E5 [kV]
Minimum Extinction Time	0.0 [us]
Snubber Resistance	5000.0 [ohm]
Snubber Capacitance	0.05 [uF]
Protected against Forward Breakover?	No

OK   Cancel   Help...

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U_I Switching controls

- Interpolated switching
  - » Adjusts if switching instance falls between time steps
  - » Allows larger time steps
  - » Also interpolated controls to improve accuracy

U_I Switching controls

- Interpolated switching
  - » Adjusts if switching instance falls between time steps
  - » Allows larger time steps
  - » Also interpolated controls to improve accuracy

Interpolated firing
pulse generator

U_I
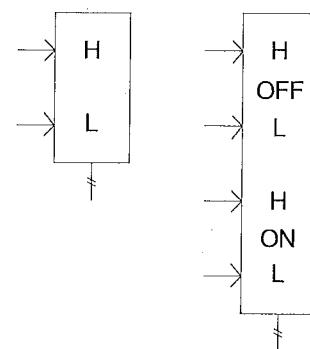
Switching controls

» One for thyristor and one for controlled turn off devices

Interpolated firing pulse generator

[fp_int] Interpolated Firing Pulses

Configuration

Thyristor or GTO?
- (•) Thyristor
- ( ) GTO

Number of Pulses
- (•) One
- ( ) Six

Add Block/Deblock Signal?
- (•) No
- ( ) Yes

Format of pulse,time output:
- (•) To Individual Devices (6 outputs of dimension 2)
- ( ) To Six Pulse Thyristor Group (2 outputs of dimension 6)

Band Limit Proximity Correction
- (•) Disarmed
- ( ) Armed (must indicate H input band limits)

[OK]   [Cancel]   [Help...]

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U_I

Simple firing control

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