AC circuit - Triangle wave ref
- Synchronous PWM
  - Switching frequency integer multiple of system freq
measurement as reference

Phase Locked Oscillator

Zero detector

Integrator

Scale this by frequency ratio 30:90 to get to desired frequency
Switching instant

produced volt across inducta

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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

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
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

Adding components (1)

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

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

Adding Components (3)

- 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
Moving Up Modules

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

Setting up your simulation

- Right click in drawing area
  » Select “Project Settings”
**UI**

**Project Settings**

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

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**UI**

**Adding a Single Phase Source**

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

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
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 $\mu$F

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
Voltage and Current measurements

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

- Current measurement
  - Need to connect to the line, don’t copy on top of a wire.

Output Channels

- Create output channel next
  - Again need signal
  - Connect to “Output channel”

- Choose Input/Output Reference
Input/Output Reference
Graphs

• Several Options
  » Add Overlay Graph Most Common
  » If choose “Add as Curve”
  » Paste to existing graph
    – Right click in white part

Complete Circuit
Complete Circuit: without graphs shown

Power Electronic Circuits

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

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

Switch dialogs
Switching controls

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

» One for thyristor and one for controlled turn off devices

Simple firing control