Ongoing List of Topics:

- URL: [http://www.ece.mtu.edu/faculty/bamork/EE5223/index.htm](http://www.ece.mtu.edu/faculty/bamork/EE5223/index.htm)
- Term Project - Due Friday (remote students can negotiate extension)
  - Invited presentations: ~5:30pm - 7:30pm Monday
- SCADA protocols, Event Recorders, transducers
- Real-time Communications for protection & control
  - PLC, leased lines, optic, VHF, UHF, MW, wireless, satellite, BPL
- Smart Grid
  - PMUs, synchrophasors
  - Station bus vs. Process bus
  - IEDs
  - Merging Unit
- Wrapup
  - Term Project Report
  - One last “assessment”
  - Term Project Presentations
Team Presentations:

GROUP 11: Advance Distance Protection Application in out of step conditions, by K. R. Dase, R. Mott, H. K. Vemparala.

GROUP 19: Study of CT Saturation in Distance Protection, by Prathap Nagu, Vaibhav Prasad, Sumit Sawai

GROUP 12: Zone 3 load encroachment with cold load pickup problem by, Y. R. Arumalla, A. P. Rohankar, W. Tuttle

GROUP 15: Fault location on transmission line using travelling waves, by M. Hergert, S. G. Kothari, A. Upadhyay

GROUP 2: Effects of saturation on CT performance of microprocessor differential relay, by Z. Browne, D. Singh, S. Goyal

GROUP 3: Integrated Protection Schemes, by Chan, Gerri; Wang, Jingyuan; Xu, Chen
Some pointers on final report:

**Executive Summary** - one page, three paragraphs
1. Orientation/refresh on what the problem was and why project carried out
2. Overview of what was done
3. Results, conclusions and recommendations

Statement of Contributions (one paragraph for each team member)
4. “Hard skill” contributions: engineering analysis, design, programing, simulation, lab testing, etc.
5. “Soft skill” contributions: literature search, technical writing/drawing/documentation, presentations, etc.
6. Name and signature below each paragraph. Whole team must agree.
SMART GRID -

\[ V_a(t) \]

\[ V_a, V_b, V_c, V_{ao}, V_{bo}, V_{co} \]

\[ I_s \]

Synchronization
IEC 61850
- PACKETS
- ISO 7-Layer
- "RGOOSE"

CONTROL CENTER

SCADA

(DNP3)

GOOSE

GPS

STATION BUS

PROCESS BUS

MERGING UNIT

SVs
The Future

IEC 61850

- XML tagged data (Next obvious step in SCADA)

- Looks like real-time control of power grid will be like a generic network.

- Cyber-security is big deal.
Security Issues Now:

- G1: Hard-wired relay-contact control logic.
- G2: Inter-operability
- G3: mProc.

Protocol Converter
- Relays of various make.
- SCADA Languages
- etc.
Communications - SCADA, CONTROL, Relaying.

- PLC: Power Line Carrier
  - Couple via CCVT
  - 30-450 KHz
  (Usually < 300 kHz if icing)

-Fog, Mist: E increased

- High-speed, narrow bandwidth
- Dedicated channel, owned by util
- Tends to be very reliable.
- Common use in Sub-Transmission.
Comm (cont'd)

- Leased Line (owned by others)
  - Copper Pair
  - Ground Pot. Rise.
  - Common in Pilot Schemes.

- Fiber Optic / MW

- MW - Point-to-point
  - 2 GHz
  - 6 GHz
  - 10 GHz
      132 Channels \( \geq 30 \text{ dB} \)
      \( \geq 40 \text{ dB} \)

- Fiber Optic - Inside Shield Wire
  - Wrap - UV/deterioration
  - Buried
- Wireless / Embedded Proc.
- BPL - Broadband over Power Line
  2 - 30 MHz (up to 80 MHz)

Practical Aps:
- N/Safety

Like coat

ISP

\{\leq 25 \text{ KV} \\
\leq 800 \text{ m} \\
Local Dist, Neighborhoods. \\
Combined w/ Wireless.\}
Relay Comm - Peer-to-peer

- Share real-time sampled waveforms
- Timing - GPS, time stamp
Event Recorders - GPS
- V, I
- Logic var, change of state.

SCADA - Comm protocols
- DNP, UCA
- XML

Mipsyscan (103)

Protocol Converter

TCP/IP - ~4 billion

IP6