EE 5223 - Lecture 2

Topics for Today:

- URL: http://www.ece.mtu.edu/faculty/bamorik/EE5223/index.htm
- Labs - EE4224/5224 - Begin in Week 2
- Term Project - form teams of ~3, begin in week 4 or 5
- Software - Aspen 2004 - One-Liner - Tutorial
  - Zones of protection - look at Assignment #1
  - Bus Configurations (Ch. 10, sect 10.1 - 10.10)
  - Single Bus, Single Bus w/tie
  - Main & Transfer
  - Ring Bus
  - Breaker-and-a-half

How to read a one-line (print out week 1 handout "Sub Schem")
Instrument transformers: VTs, CTs, CCVTs, MOCTs, etc.
Study Chapter 5, info relating CT saturation & accuracy
Print out "CT" handout.
## EE 5223 Class Roster - Spring 2005

<table>
<thead>
<tr>
<th>Name</th>
<th>e-mail</th>
<th>Affiliation</th>
<th>Location</th>
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<tbody>
<tr>
<td><strong>26 Local Students:</strong></td>
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<tr>
<td><strong>11 Remote Students:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barber, Michael W.</td>
<td><a href="mailto:mbarber@wpsci.com">mbarber@wpsci.com</a></td>
<td>Wolverine</td>
<td>Cadillac, MI</td>
</tr>
<tr>
<td>Blecke, Scott C.</td>
<td><a href="mailto:sbleckc@glenergy.com">sbleckc@glenergy.com</a></td>
<td>GL Energy</td>
<td>Boyne City, MI</td>
</tr>
<tr>
<td>Bramer, Steve</td>
<td><a href="mailto:sbramer@mpw.org">sbramer@mpw.org</a></td>
<td>MPW</td>
<td>Muscatine, IA</td>
</tr>
<tr>
<td>Carr, Sean</td>
<td><a href="mailto:scarr715@sbcglobal.net">scarr715@sbcglobal.net</a></td>
<td></td>
<td>Chicago, IL</td>
</tr>
<tr>
<td>DeCour, Daniel H.</td>
<td><a href="mailto:ddecoeur@wpsci.com">ddecoeur@wpsci.com</a></td>
<td>Wolverine</td>
<td>Cadillac, MI</td>
</tr>
<tr>
<td>Ernst, Thomas W.</td>
<td><a href="mailto:t.w.ernst@ieee.org">t.w.ernst@ieee.org</a></td>
<td>Minn Power</td>
<td>Duluth, MN</td>
</tr>
<tr>
<td>Ferguson, Reginald</td>
<td><a href="mailto:fergusonr@bv.com">fergusonr@bv.com</a></td>
<td>Black &amp; Veatch</td>
<td>Ann Arbor, MI</td>
</tr>
<tr>
<td>Fultz, Christopher T.</td>
<td><a href="mailto:fultzct@bv.com">fultzct@bv.com</a></td>
<td>Black &amp; Veatch</td>
<td>Ann Arbor, MI</td>
</tr>
<tr>
<td>Rollenhagen, Mark W.</td>
<td><a href="mailto:mrollenh@tclp.org">mrollenh@tclp.org</a></td>
<td>TCL&amp;P</td>
<td>Traverse City, MI</td>
</tr>
<tr>
<td>Schneider, Marc</td>
<td><a href="mailto:mschneider@atcllc.com">mschneider@atcllc.com</a></td>
<td>ATC</td>
<td>Waukesha, WI</td>
</tr>
<tr>
<td>Wyman, Jeffrey N.</td>
<td><a href="mailto:jwyman@itctransco.com">jwyman@itctransco.com</a></td>
<td>ITC</td>
<td>Ann Arbor, MI</td>
</tr>
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The World’s Most Widely Sold Current Transformers

Type IMB, 36-300 kV
Type AOK, 245-550 kV

ABB Switchgear has delivered a total of 130,000 outdoor current transformers. The IMB is probably the world’s most widely sold current transformer.

IMB tank type (hairpin design) current transformers, are mostly sold for the 72-300 kV voltage range. This transformer is very flexible, with regard to core space. The primary conductor is insulated with a special paper, which gives a high insulation resistance, low dielectric losses and good ageing properties. The cores are located in the bottom tank, and the complete transformer is filled with a unique mixture of quartz sand and oil. As a result of this filling, it has been possible to design an expansion system entirely without moving parts.

For very high voltages, over 300 kV, the AOK type current transformer of the top core, or inverted type will be more cost effective. In the AOK, the cores are located in a strong aluminium housing, which is supported by a steel tube. As with the IMB, the insulation is mostly machine wound to ensure a high and uniform quality. The oil expansion is contained by a bellow system, made of ageing resistant synthetic rubber.
Inductive Voltage Transformers

Type EMFC, 24-170 kV

The EMFC is one of the most common inductive voltage transformers, used both in power networks with insulated or earthed neutral points. More than 40,000 transformers of this type have been delivered to date.

The EMFC has an extremely low core flux density, making it able to withstand continuous overvoltages. Ferroresonance, with consequent overheating and damage is effectively counteracted by the overdimensioning of the core.

The core and windings are located in the hot-dip galvanised bottom tank; which, like the IMB, is filled with quartz sand and oil. The EMFC also has the same simple nitrogen-filled expansion system as the IMB. The EMFC has proven itself capable of withstanding conditions, in which many other transformer types break down.

The porcelain insulator is mounted on the hot-dip galvanised bottom tank, which is then filled with quartz sand and oil.

Insulation of windings.

Vacuum treatment, oil filling and tightness testing.
Capacitor Voltage Transformers

*Types CPA/CPB, 72 - 550 kV*

ABB Switchgear capacitor voltage transformers, types CPA and CPB, are intended for connection between phase and earth in networks with insulated or earthed neutral point.

The dielectric we use in the capacitor divider consists of a combination of oil impregnated paper and polypropylene film, resulting in the CPA and CPB being practically impervious to temperature variations.

The transformer, compensating reactor and damping circuit are assembled into a hermetically enclosed, oil filled aluminium tank, with an expansion volume at the top. The windings for ratio adjustment are easily accessible, to allow the user to optimise the transformer accuracy.

The CPA and CPB are equipped with a low-voltage terminal for power line carrier equipment.

From the design point, the CPA and CPB are identical, apart from the CPB having a larger iron core, enabling it to withstand higher loads. For example, the CPB is ideal for retrofits, in which the existing, high-burden metering and protection equipment is retained.

In our opinion, due to their ferroresonance and temperature stability properties, the CPA and CPB are probably the world's best capacitor voltage transformers.
The New Generation of Instrument Transformers

*Digital Optical Instrument Transducers, (DOIT) for current and voltage measurement.*

The DOIT is a completely new generation of instrument transformers, in which optronics replace conventional technology. Their lower installation and transport cost, reduced space and inspection requirements offer substantial economic benefits.

The current transformer is designated Digital Optical Current Transducer (DOCT). It is small, weighs about 50 kg, and can be mounted directly on the busbar. It can also be integrated into other equipment, such as circuit breakers. In the DOCT the primary current is measured as the voltage drop across a fixed burden resistor, connected into the secondary circuit of a current transformer.

The voltage transformer, Digital Optical Voltage Transducer (DOVT), measures the secondary voltage of a capacitor voltage divider. The measured value is digitised in the transducer, and is transmitted by optical fibre to the metering and protection equipment.

The reliability of circuits and components, and the installation technique are well documented, and are equivalent to the standards set by the aerospace industry. Moreover, the built-in processor offers self-monitoring functions.

The DOIT opens a new era in compact substation design, with untold opportunities for reducing the necessary space of outdoor switchgear by way of combined function equipment. In addition, it offers advantages in measuring efficiency, signal interference etc.

The DOIT is available as both current and voltage transducers. These units are virtually maintenance-free.
Single Bus

Overlap of Zones

Cable
c) Circle the zones of protection for the following power system.

\[ \Sigma I_{\text{in}} = 0 \]

b) State which CB's trip for a fault at:
1) L1
2) Bus III
3) G2
4) T4
5) Bus II
6) Load
7) M1

c) For a fault on Bus I and CB3 fails which CB opens as backup.

d) Does CB2 need to operate for a Bus I fault?

e) For a fault on L4 which CB's back up CB11

f) For a fault on L2 which CB's back up CB4

g) CB5 & 9 trip -> where was fault?

h) CB 6, 9, 8, 11 trip -> where was fault

i) CB2 trips where was fault

j) CB1 trips where was fault

k) CB7 trips where was fault

l) For a fault on Bus III, which CB's

1) Trip First
2) If the ones which should trip first don't which ones should trip next.
Zones of Protection

- Overlapping
- Preferably at CB

(Note: CT is actual boundary of Zone!)

Zone A

EE 5210 - Power Systems Protection

Spring 2001