University of Idaho

ECE 444 / ECE 544 / CS 444 / CS 544 Supervisory Control and Critical Infrastructure Systems

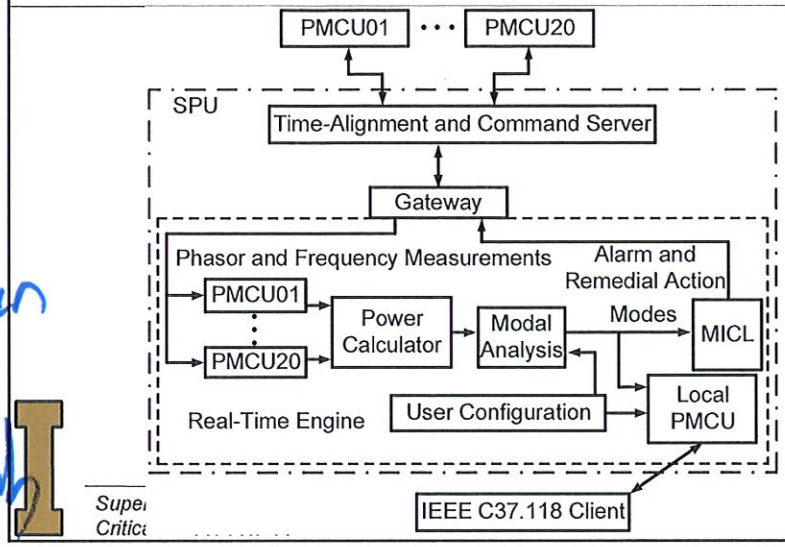
Session 25

L23 4/12

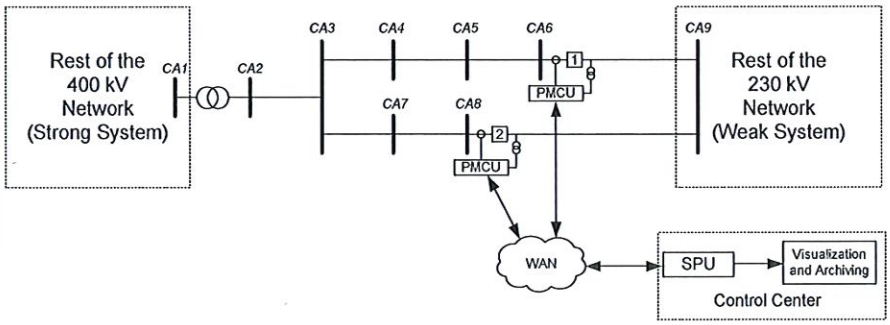
Low frequency oscillations

- Post Processing
- System model verification
- Support system integrity protection

Real-Time Modal Analysis for Detecting Inter-Area Oscillations



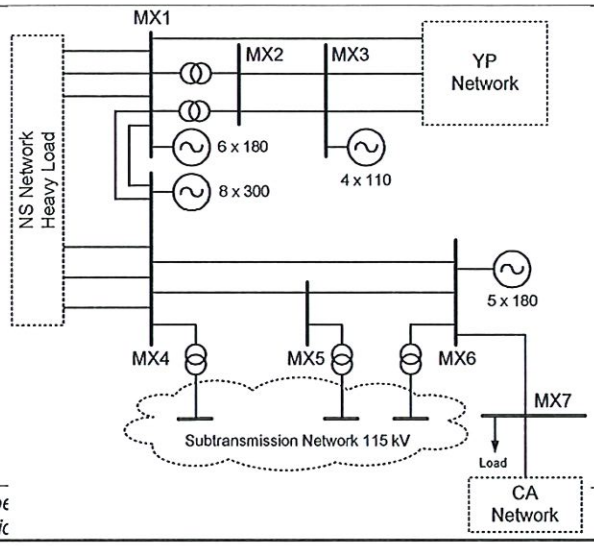
Field Installation to Detect Inter-Area Oscillation



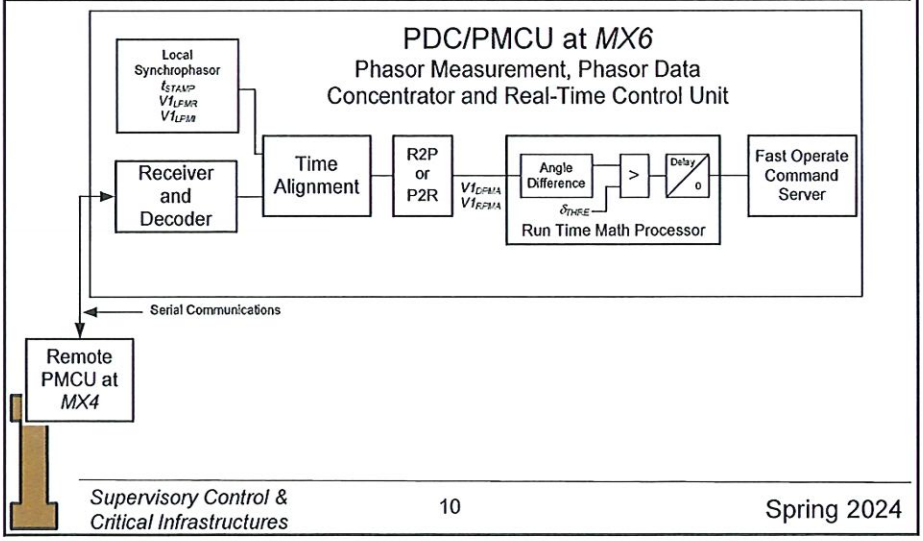
Load shedding

too fast for human operators

Automatic Generator Shedding Scheme Using Synchrophasors



Angle Dif. Between MX4 and MX6 for Single Contingencies – Less than 100 ms



→ If frequency is too high

→ generation exceeds load

→ Too Low

→ not enough generation

→ Load or Generation shedding schemes

↓

- under-frequency

- undervoltage

- over-frequency

Protection schemes

→ respond to faults (short circuits)

- fast response

→ detect fault in cycle or less on transmission systems

- Local measurements

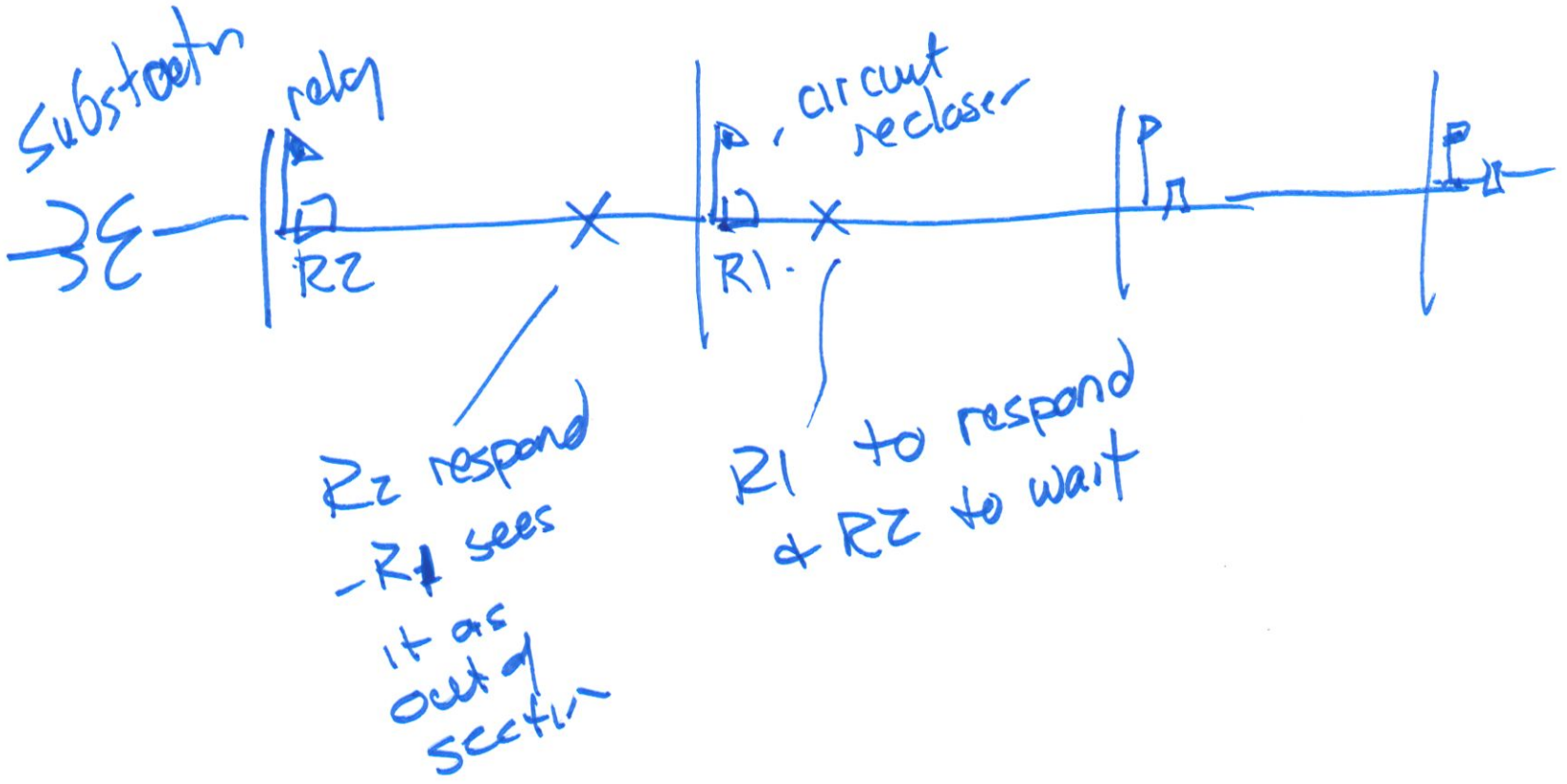
→ always have as backup for communication assisted/based schemes

communications to enhance performance

→ Goals

- sensitivity (detect faults)
- security (don't trip for faults out Zone of responsibility)
  - If other protection can respond first – let it do so – minimize disruption
- reliability (dependability) – operate consistently over long time
- speed
- cost

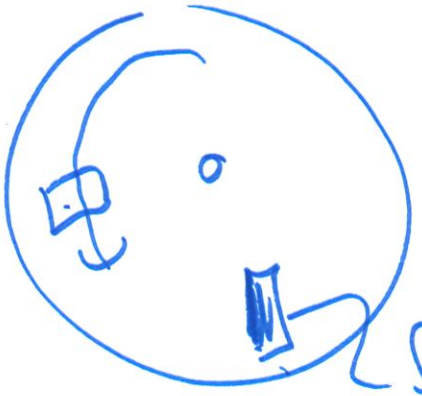
Distr. butn syst



L25 7/12

- overcurrent
- over/under voltage
-

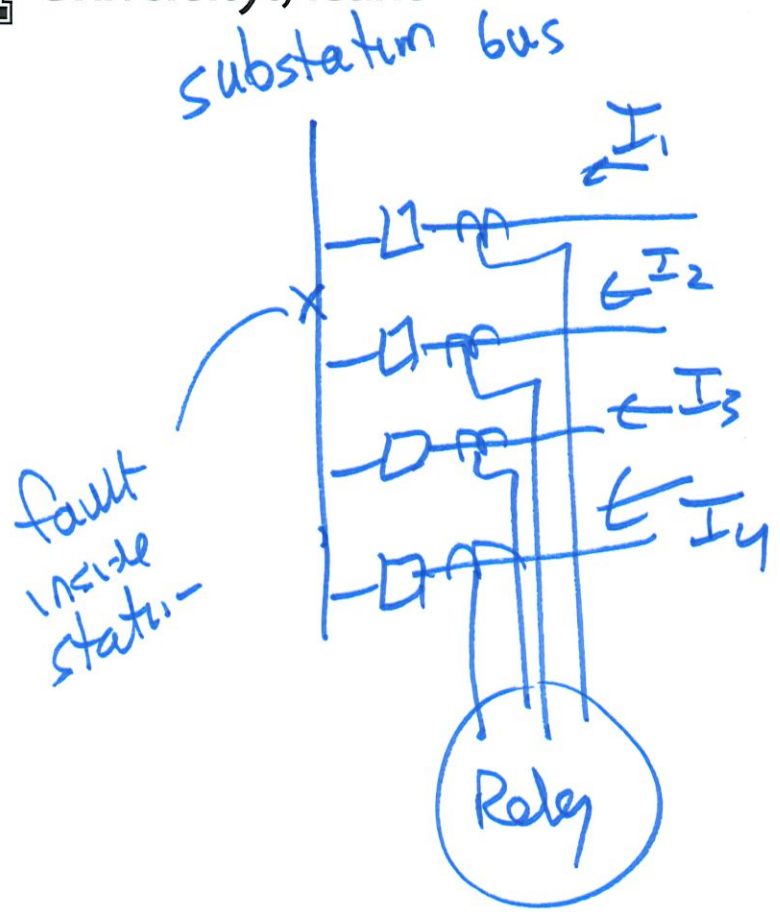
} compare with threshold(s)



fixed contact

inverse time overcurrent

- instantaneous overcurrent
  - If current exceed a threshold
    1. send trip command
    2. start a timer



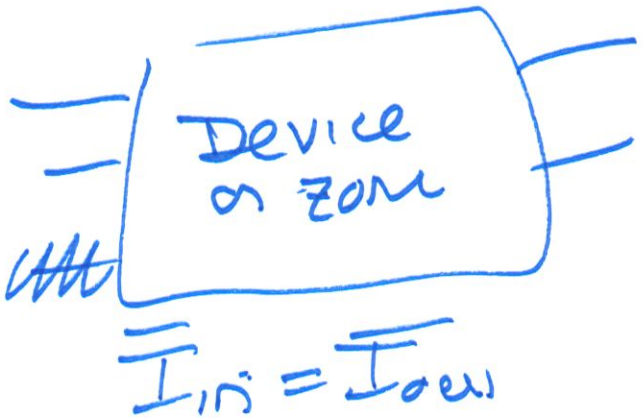
Normal load

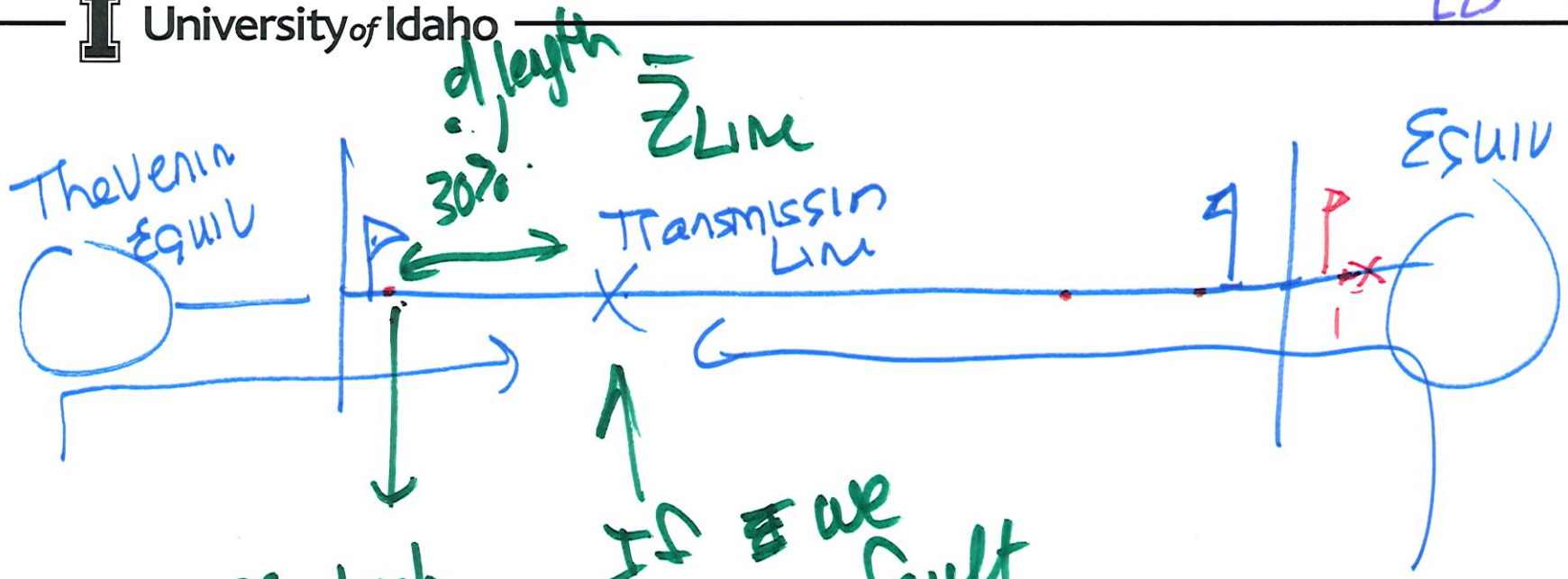
$$\bar{I}_1 + \bar{I}_2 + \bar{I}_3 + \bar{I}_4 \doteq 0$$

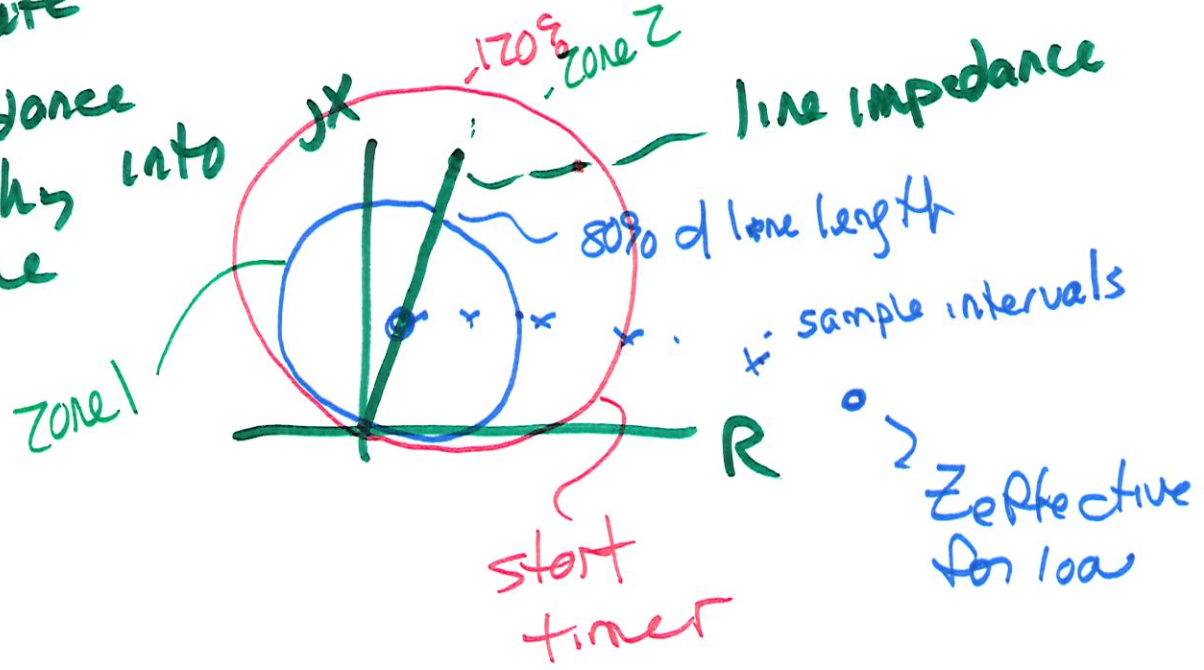
Internal fault

sum of currents $\neq 0$

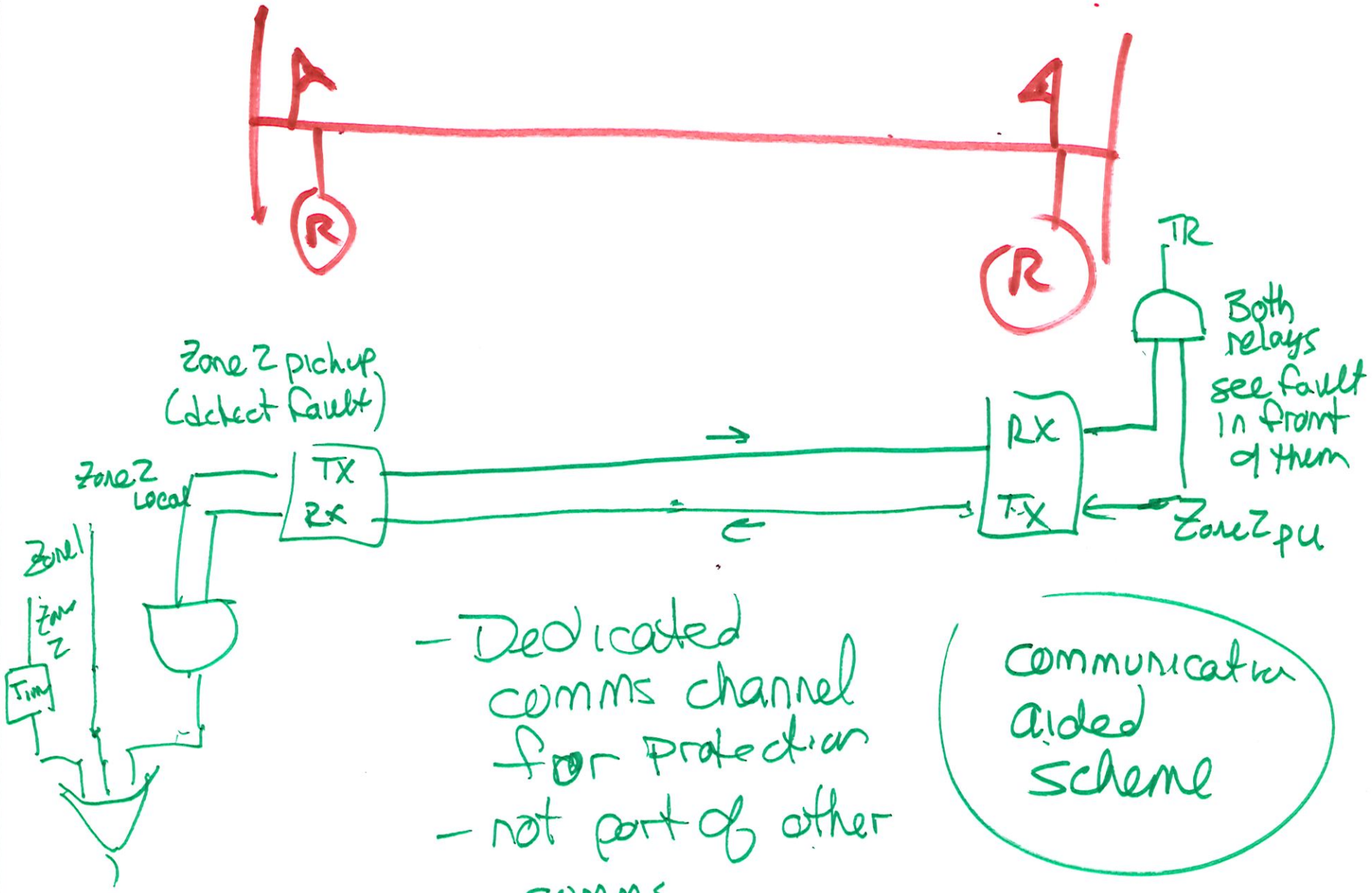
Differential Protection




d length
$\bar{Z}_{LINE}$
Thevenin Equiv
30%
Transmission Line
Equiv
Effectively calculate Impedance looking into line
If we have fault


120% Zone 2
jX
line impedance
80% of line length
sample intervals
Zone 1
R
Zeffective for loa
start timer

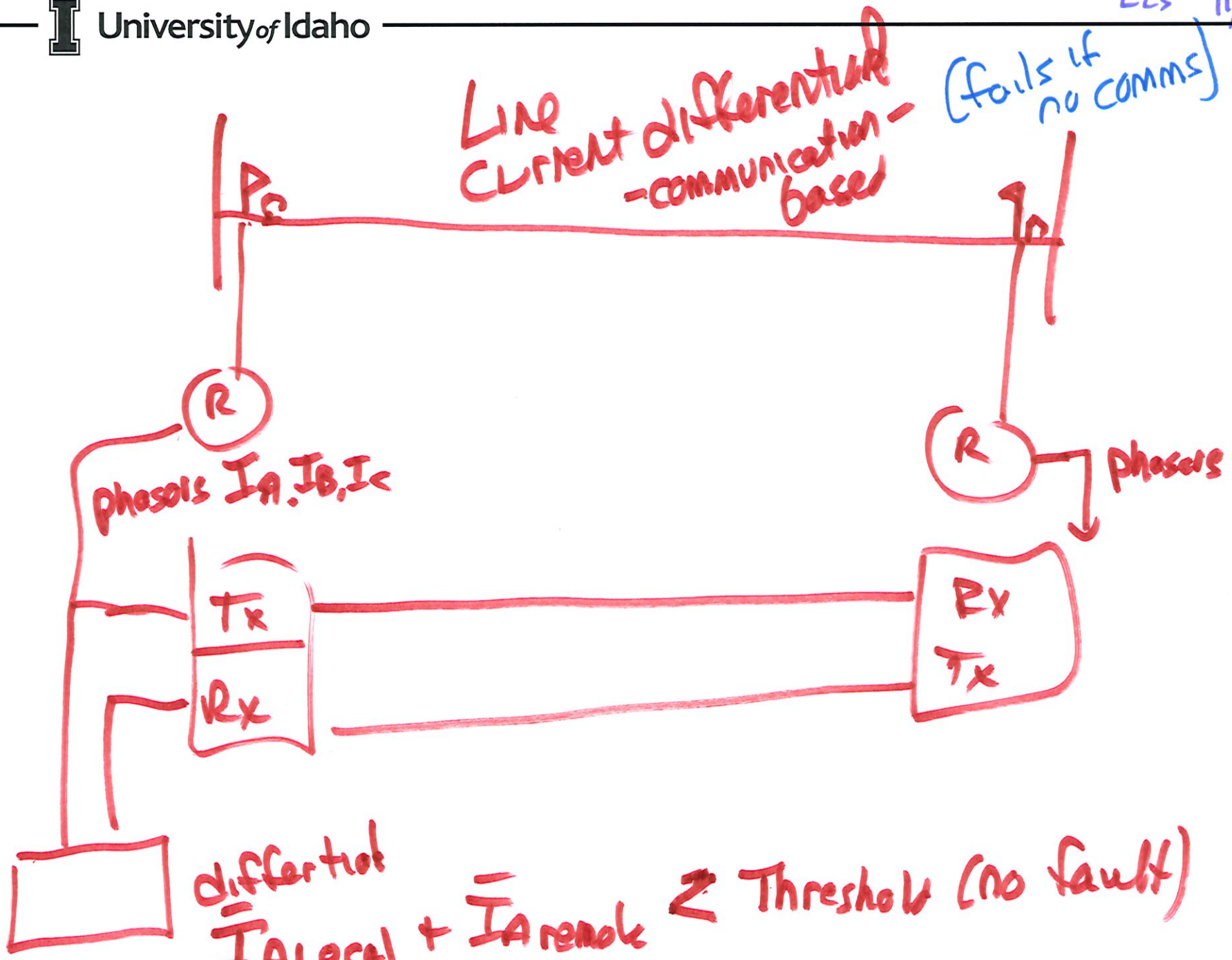
L25 16/12



- Dedicated comms channel for protection
- not part of other comms

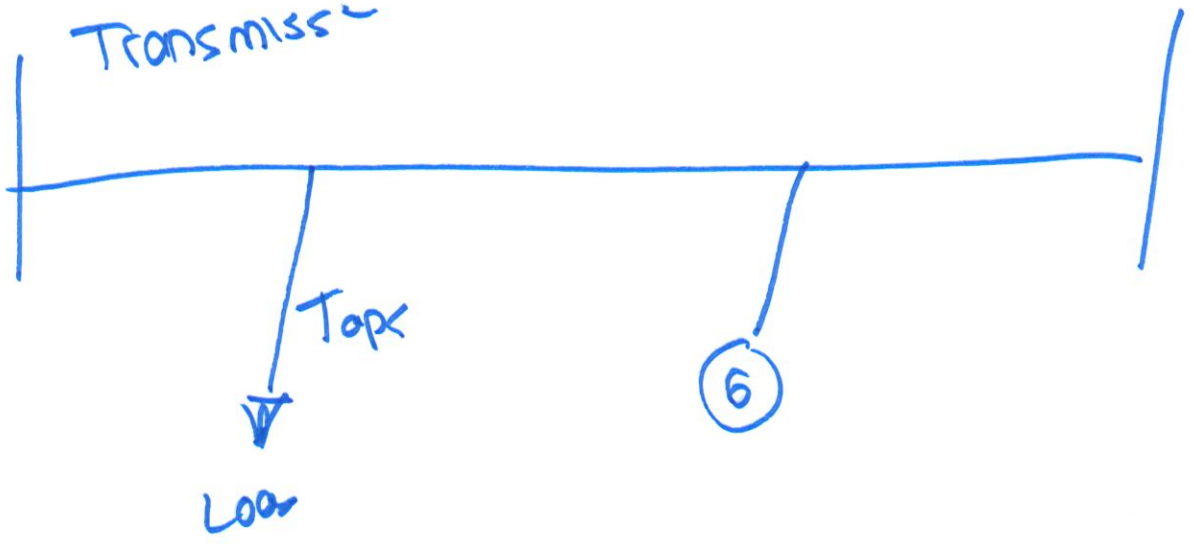
Communication aided scheme

L25 11/12


Line current differential
-communication-based
(fails if no comms)
Pc
Ip
R
R
phasors
phasors IA, IB, Ic
Tx
Rx
Rx
Tx
differential
$\bar{I}_{A\,Local} + \bar{I}_{A\,remote} \geq$ Threshold (no fault)

Distribution systems

- much more complicated networks



Distribut
- many taps
- no measurements at tap points

} increasing interest in adding automation to improve operation
→ reduce customer outages
→ improve efficiency