ECE 444 / 544

SUPERVISORY CONTROL
AND CRITICAL
INFRASTRUCTURE SYSTEMS

SESSION no. 9
Power Line Carrier

- Data communicated over the power conductor
  - high frequency on top of 60Hz

- Used utility infrastructure
- 10's kHz, MHz
- Interference concerns
  - Radiated emissions
- Containing within Section of System
- Protection applications
  - just sending a few
  - status information
- some other do not want to look up the rate
- distribution systems

- line
  - tuner
  - 2-3 channels
  - fairly low bandwidth
  - TX/EX

Infection/Receiver point

Power line
115-120% 

80-85% - instantaneous trip command

80-85% - Time delay trip
~100-200ms

1000

Power Line Carrier (PLC)

Z2 local

Z2 remote
Copper Wire
- Telephone (modulated copper wire)
  - modem
  - ISDN
- Serial connection (legacy)
  RS-232 (EIA/TIA 232)
  - recommended standard
  - electronic industries assoc
  - telecomm industry assoc
- does not define data type or protocol
- defines the conductor/termination
RX  +
\[\text{Sign & Ground}\]
TX  +

Dev A  ---->  Dev B

fully duplex - transmit or receive at same time
- prone to interference
- limit to 50 ft or less
RS 485

- differential signal

A

+ RX

- RX

B

4 wire

+ TX

- RX

Common

Voltage difference between the two conductors

500 - 1500 ft
Supports multidrop

- Coaxial
- Setting clock reference
- Twisted pair
  - Unshielded twisted pair (UTP)
  - Shielded twisted pair (STP)
Telephone systems - ICS use whatever service providers have available

- Dial up systems
- Leased lines
- Contract for broadband access - Security concerns
Fiber Optic Cables

- Most of cost is in transmitter/receiver/repeaters.
- Single mode or multimode fiber.
- Single mode is lower cost.
- Cost is lower.
- Splicing is expensive.
- High installation costs.
- Multiple wavelengths.
- Installation costs.

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Options
- Buried cables
- Overhead cables
- Follow utility right of way
- Suspend on tower
- Power conductors
- Transmission lines
- Optical ground wire

- Fiber
Wireless - Expensive - Limited to very remote sites.

Satellite - Expensive - Limited to very remote sites.

Radio frequency - Unguided - Spread spectrum radio - Good interference rejection - VHF or UHF spectrum - Random versus frequency hopping.

3G cellular - Application specific - Wideband - Application specific.
microwave
- Analog
- Digital