Common Mode and Differential Mode Discovery Techniques

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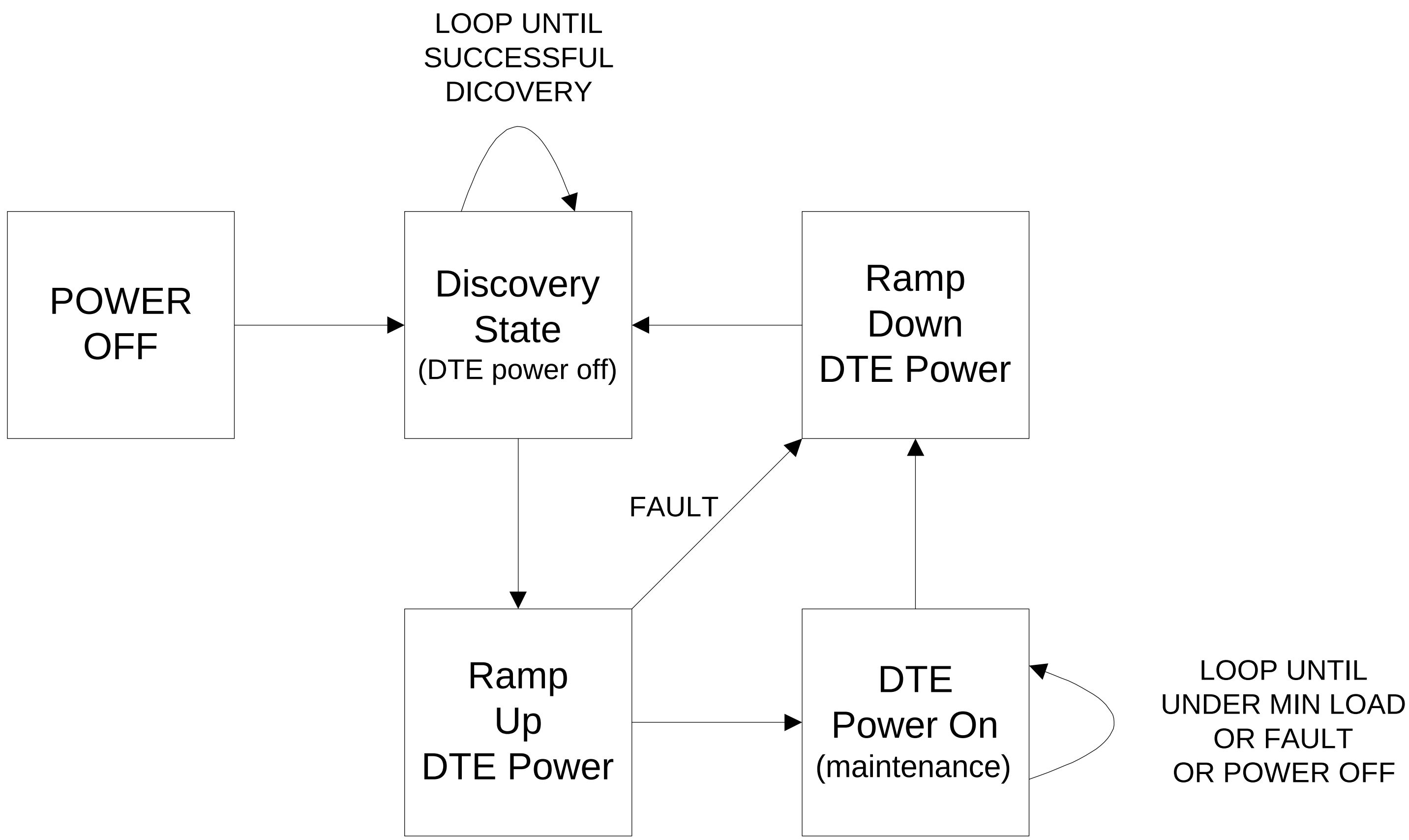
Discovery Process Goals

- **identify appropriate power hungry devices**
- **identify cable and connection problems**
- **avoid powering legacy equipment**
- **minimize the probability of a false detection**
- **provide a robust system solution**
- **practicable at a relatively low cost**
- **allow transparent use of straight and crossover cables**
- **enable powering without the need for management**
- **allow for the use of multiple DTE power sources**
  - want to be independent of power sequencing
  - discovery method needs to be independent of data transmission
  - alternatives would be some form of management via data path

Basic Flow Diagram

- **Discovery waits to find a power hungry device before power is applied**
- **Power maintenance is handled by the power source minimum load current**

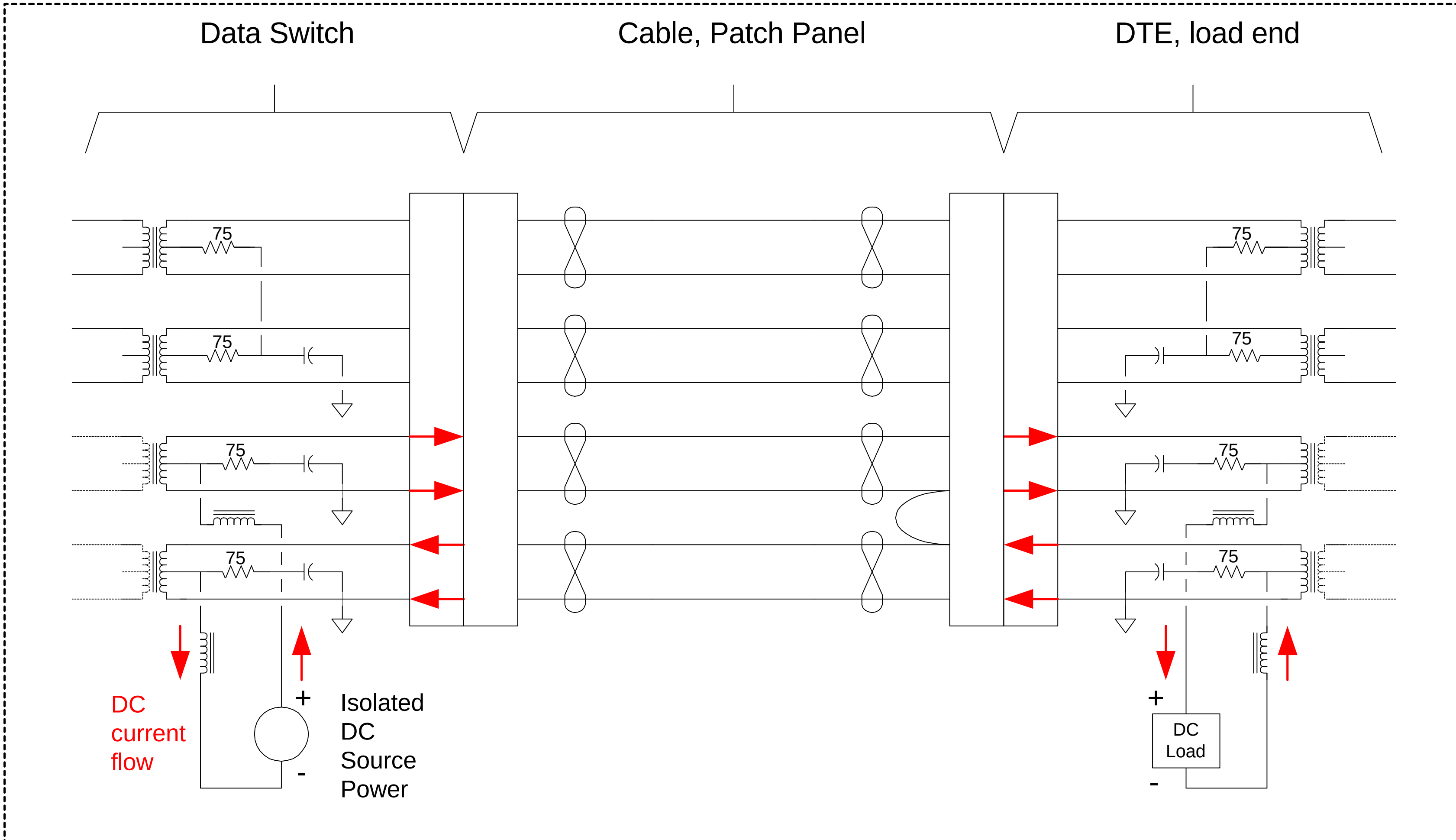


Differential Mode Discovery

- **several proposals have been presented**
- **uses well known 10/100 types of signals**
- **managed by the PHY**
- **Loops a signal through one pair, down the cable, and returns a modified signal on the other pair**
- **Pros**
  - tests all four wires
  - best chance of finding unwanted parallel connected wires, especially if long
  - uses well known and characterized IEEE802.3 signals, low EMC risk
  - tests on the same wires that will receive DTE power
  - robust, digital signature can be used
- **Cons**
  - does not test the wires in the mode that will be excited by the power source
  - may not be able to sense common mode shorts, opens, intermediate resistance
  - depending on pair used, could require a few more parts than common mode

Differential Mode Discovery - undiscovered cable fault

- **Since only the differential mode is excited, common mode shorts, or other impedances cannot be detected**

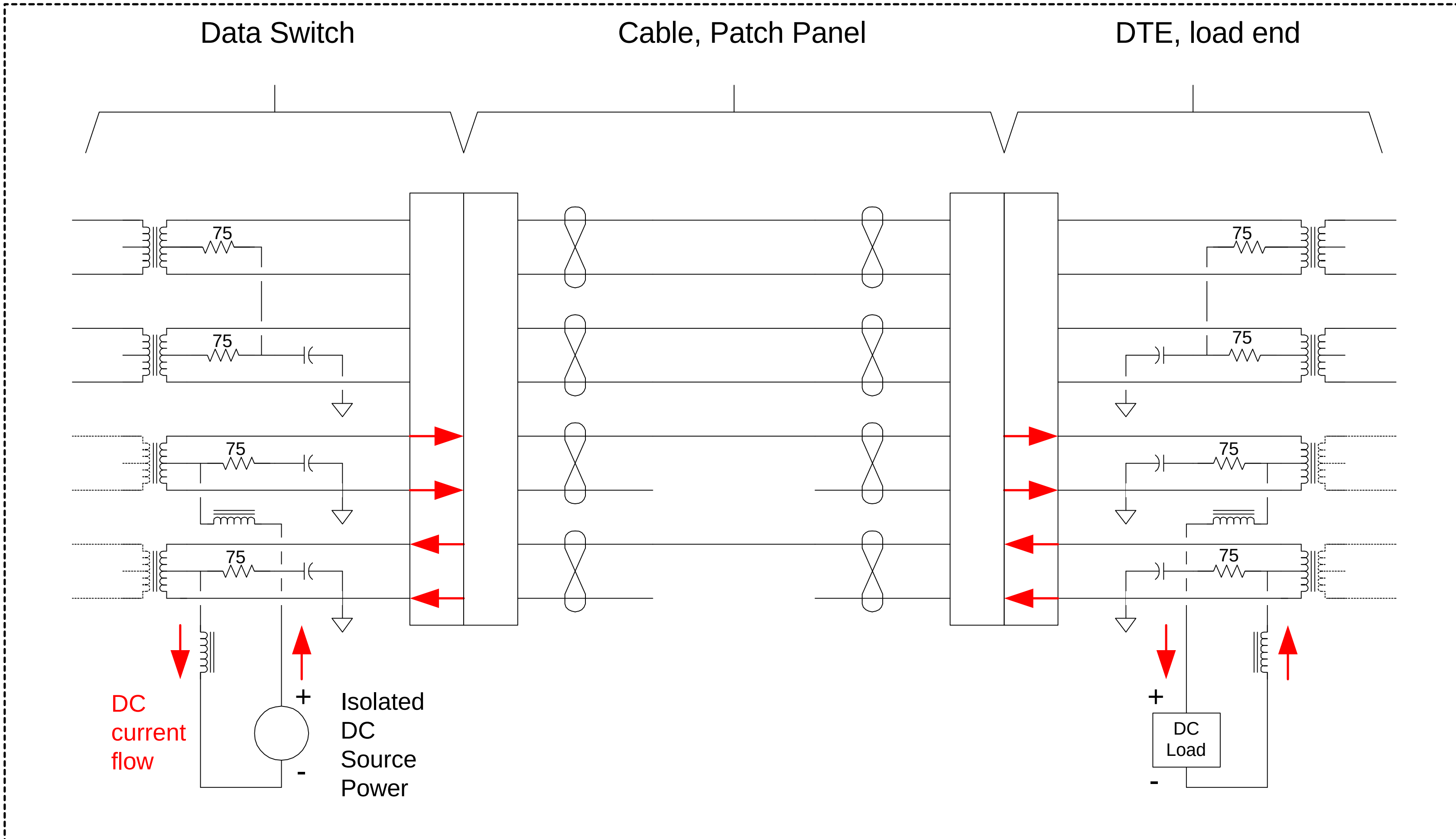


Common Mode Discovery

- **several proposals have been presented**
- **Resistive, diode, AC coupled diode, and current reg diode identity networks**
- **uses low frequency signals**
- **can be managed by the PHY, or the power source**
- **Pros**
  - tests on the same wires that will receive DTE power
  - test the wires in the same mode that will be used by the power source
  - low frequency signals are used; out of band for 10/100/1000
  - robust, digital signature can be used
  - inherently independent of data, allows for multiple DTE power sources
- **Cons**
  - does not test all four wires, unless more circuitry is added
  - will probably not find parallel wires unless they are shorted
  - can not sense if a single wire is open in one or both pairs
  - resistive schemes could be fooled by leakage mechanisms
    - organic fluxes, leaky electrolytic caps, etc….

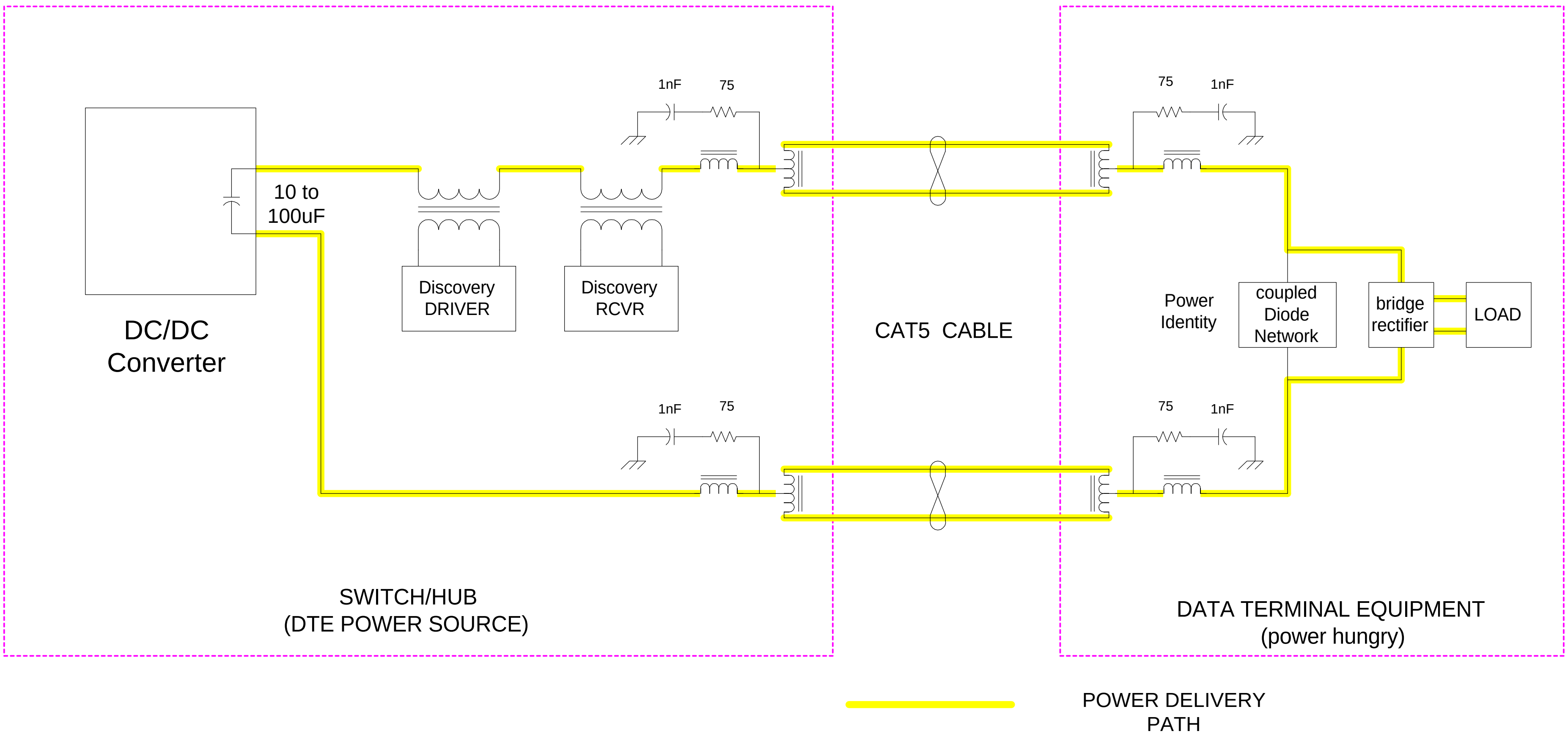
Common Mode Discovery - undiscovered cable fault

- **partial open circuit cable fault not found with most common mode discovery techniques, unless more circuitry is used**
- **at higher power, this could limit the voltage available at the load**



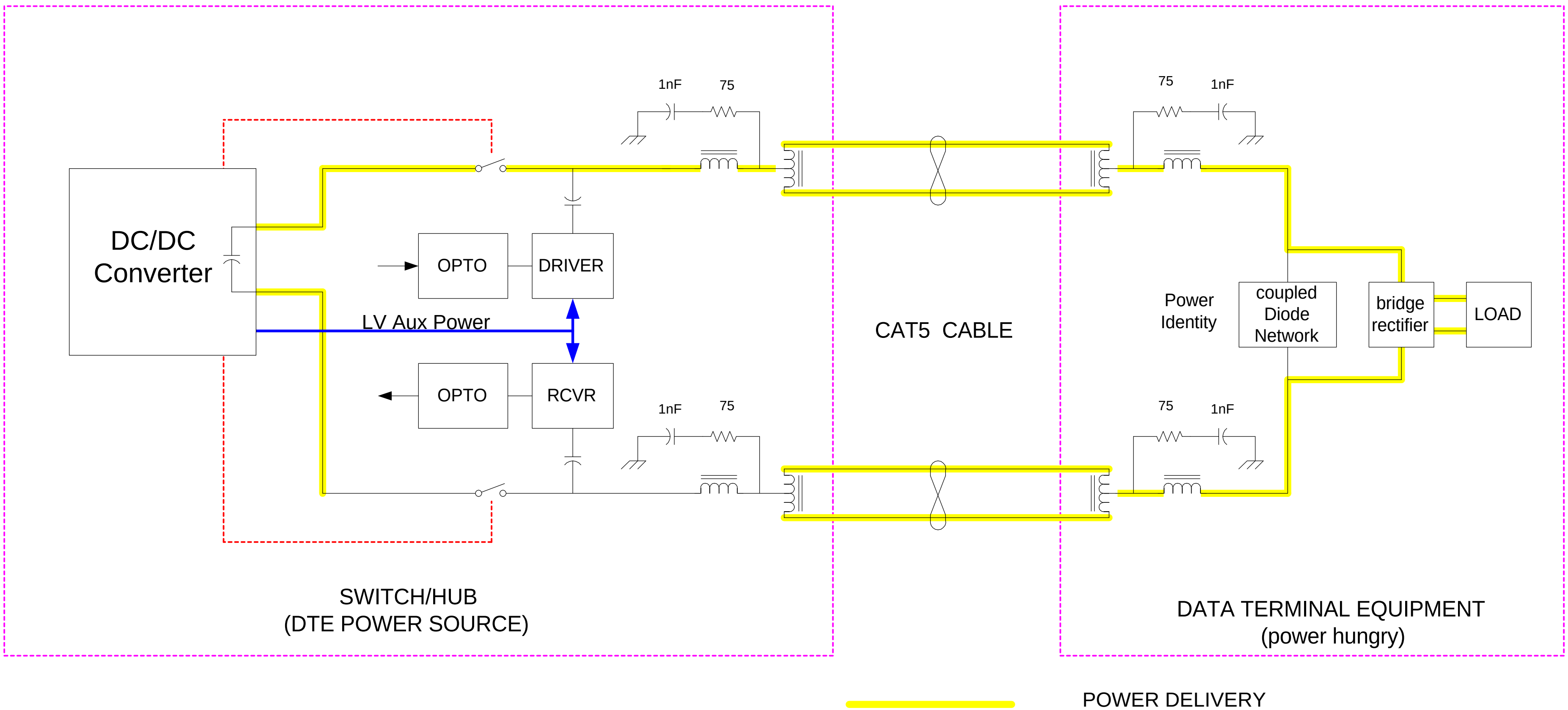
Common Mode Discovery, transformer isolated version

- **transformer coupled common mode technique provides 2200 VDC isolation**
- **uses an AC coupled diode network for polarity sensitive detection**
- **pulses and synchronous detection are digitally controlled**



Common Mode Discovery, opto-isolated version

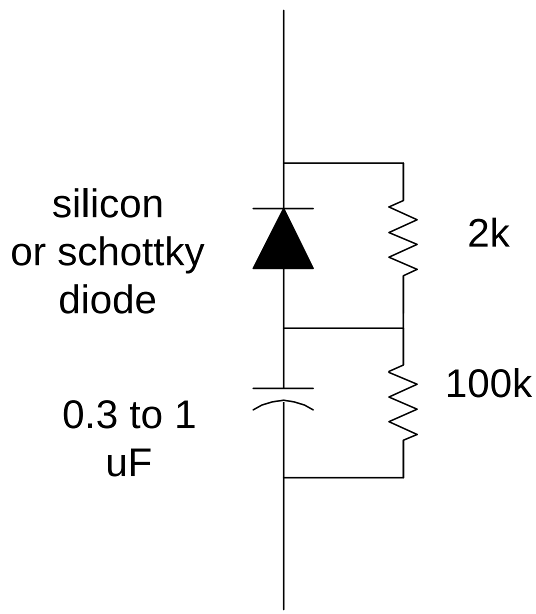
- **Opto coupled discovery, opto-isolators provide the 2200 VDC isolation**
  - could be integrated into DC/DC power converter
- **similar features to transformer isolated version**
- **A low voltage, low power aux DC power supply is needed**



NORTEL NETWORKS

Common Mode Discovery,   AC coupled diode network

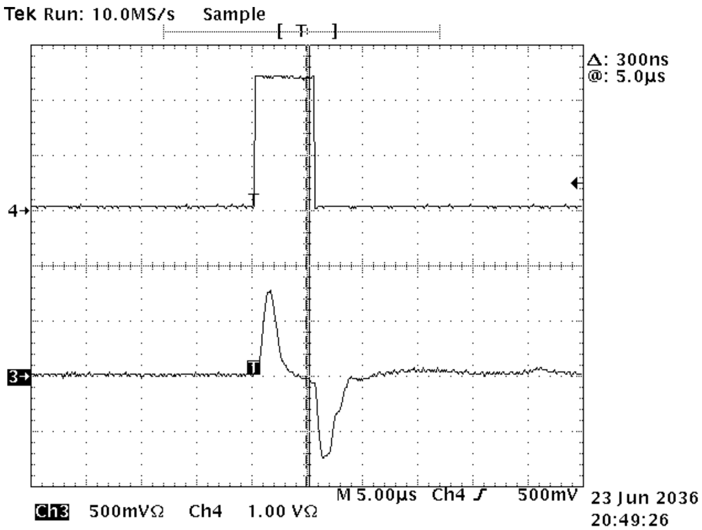
- **Diode detection modified to allow either polarity of DTE power**
- **allows for low voltage, polarity sensitive discovery using low duty cycle 5us pulses**
- **with high duty cycle discovery pulses, can be made to look like an open circuit**
  - provides a higher level of discovery confidence
- **becomes high impedance at +/- 48 VDC**
  - resistors can be small size, or integrated
- **easily handles 48 volt transients (intermittent contacts, etc…)**

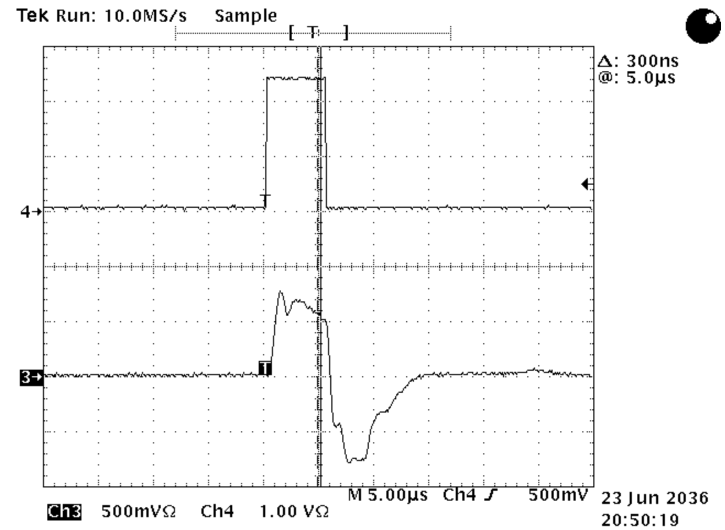


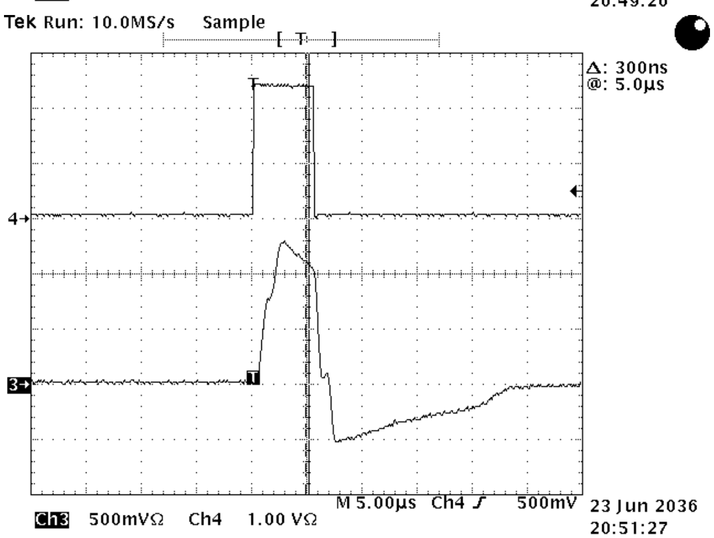
AC coupled diode network

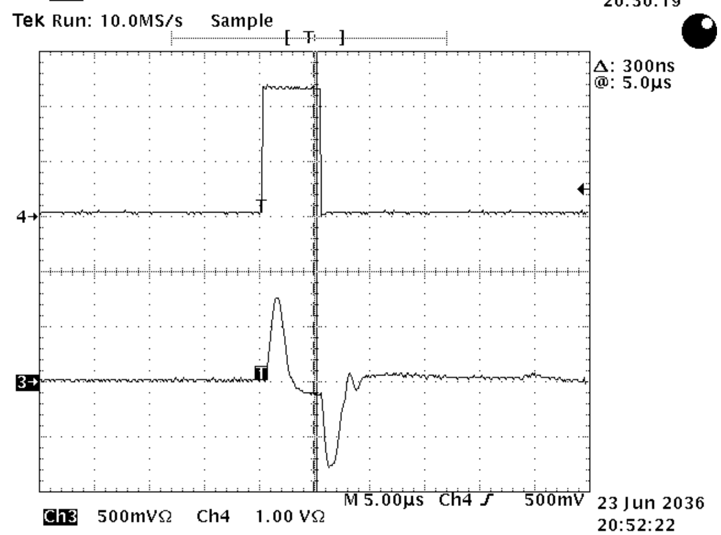
Bench Results, AC coupled diode network , 120 meter CAT 5 cable

- **diode non-conducting direction (upper left)** **diode conducting direction (upper right)**
  shorted load (lower left) **open load (lower right)**
  - vertical cursors show area of synchronous detection



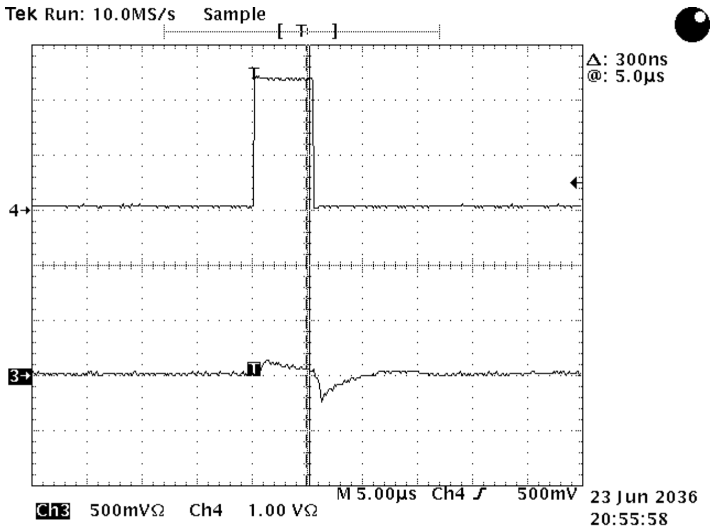


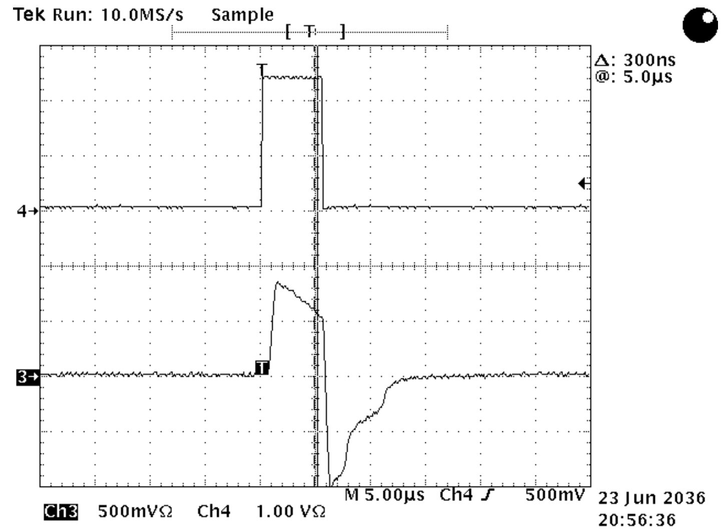


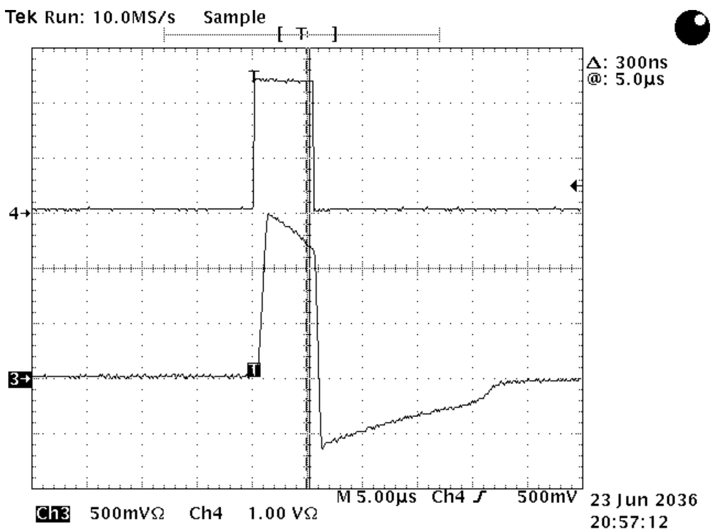


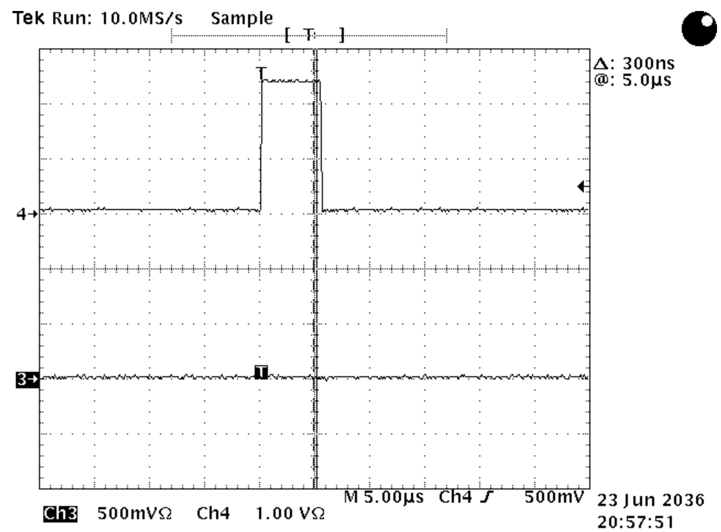
Bench Results, AC coupled diode network , 1 meter CAT 5 cable

- **diode non-conducting direction (upper left) shorted load (lower left)** **diode conducting direction (upper right) open load (lower right)**
  - vertical cursors show area of synchronous detection



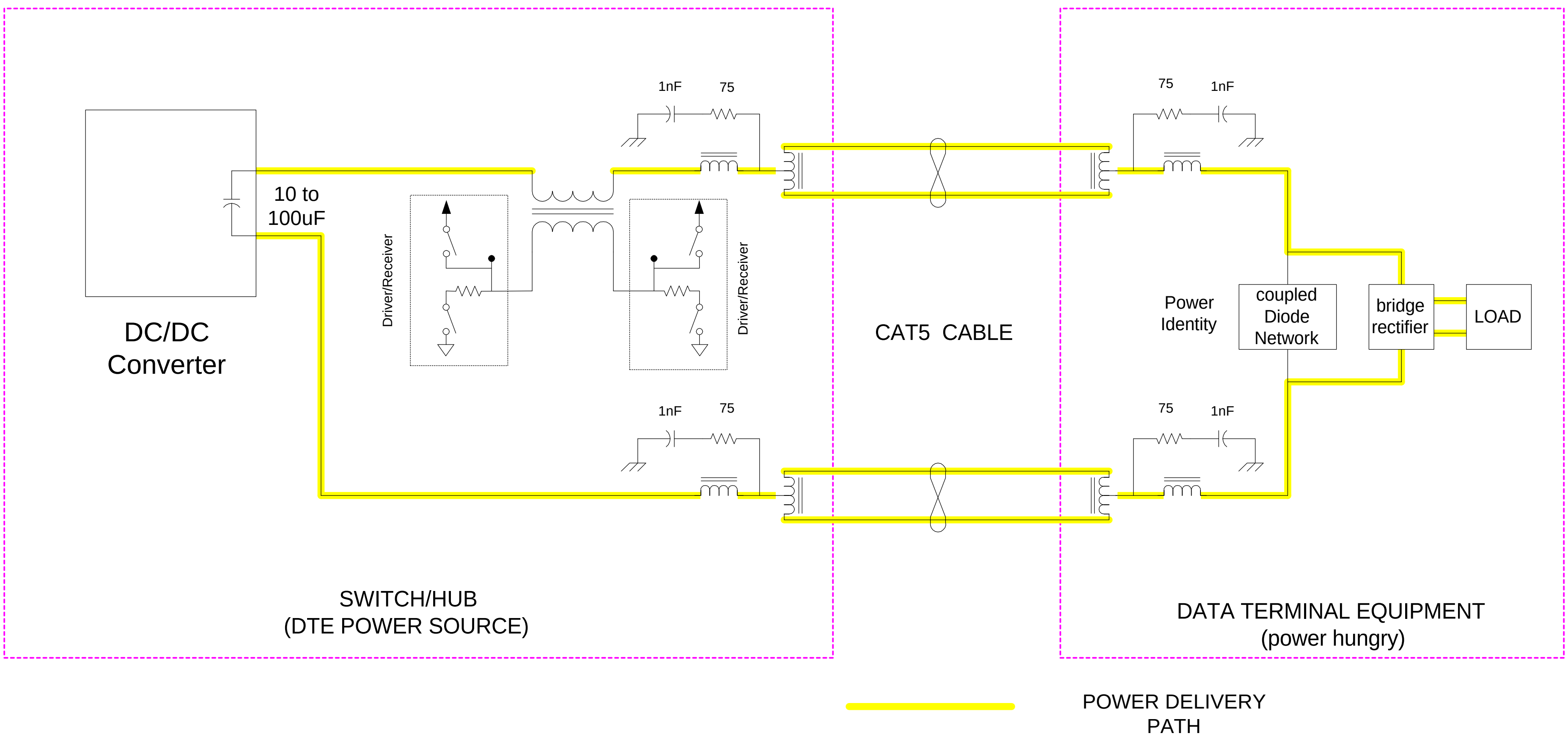






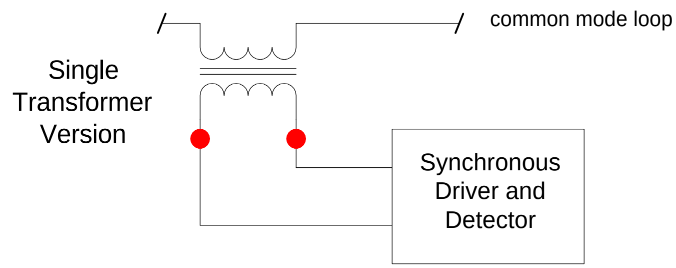
Future simplifications, common mode discovery

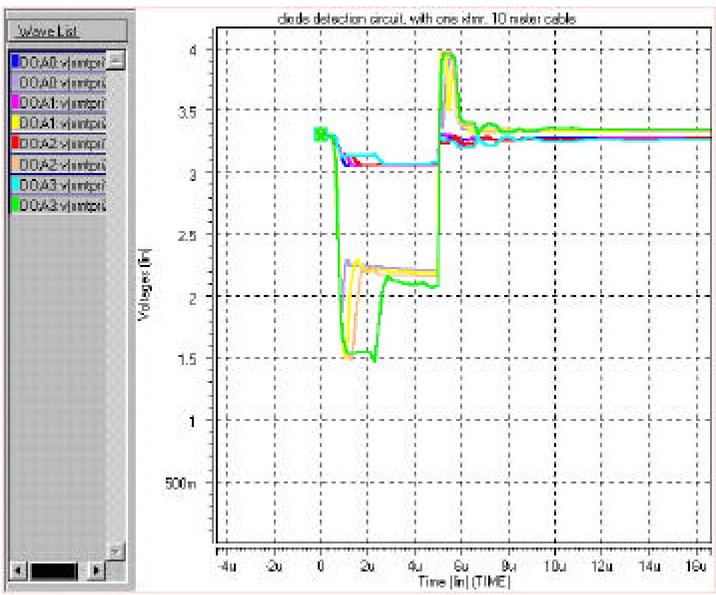
- **Lower parts count achieved by using a single transformer**
- **a bit more silicon area needed?**

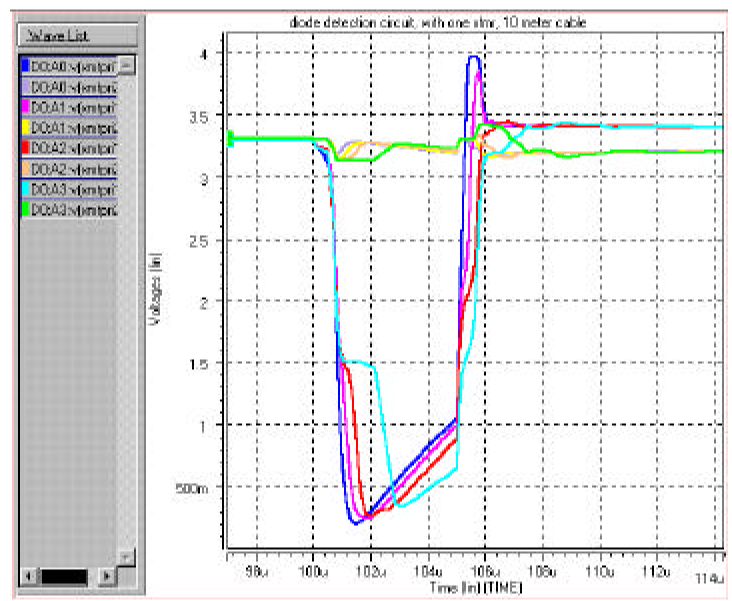


Spice Simulations,   single transformer common mode discovery

- Here is how detection can work with a single transformer for lower cost, less parts
- 10 meter, 40 meter, 80 meter, and 200 meter cables shown
- transformer primary pins, diode conducting (lower left), non-conducting (lower right)







Summary

- **neither differential, nor common mode discovery methods find all possible cable faults; no scheme is foolproof**
  - differential mode discovery does not find common shorts (but the power source will)
  - common mode does not find opens on redundant wires, this is probably acceptable
  - a combination of both discovery modes would provide higher coverage but with increased complexity and cost; it is probably not worth it
  - it's probably unrealistic to make a "network analyzer" finding any possible cable issue
- **the common mode AC coupled diode satisfies the basic requirements for discovery**
  - easy to implement, various ways to implement the concept
  - low cost
  - gentle to legacy devices, low voltage, low power
  - relatively robust, but not foolproof
  - independent of data delivery, multiple DTE power sources possible
- **common mode discovery probes the loop using the same mode (common mode) as the DTE power source will provide**

- **acknowledgements:**
  - Robert Muir, Level One
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