# DTE Power via MDI Discovery Process

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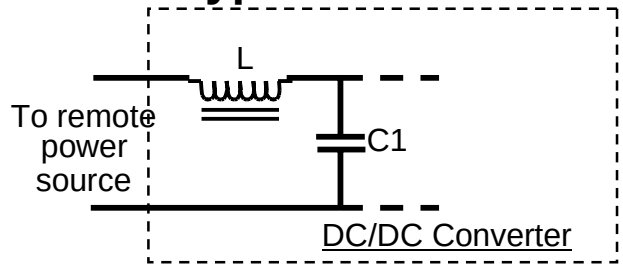
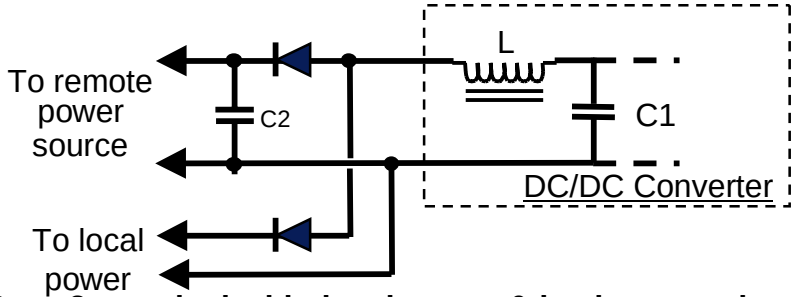
# Economic and technical feasibility : PD side

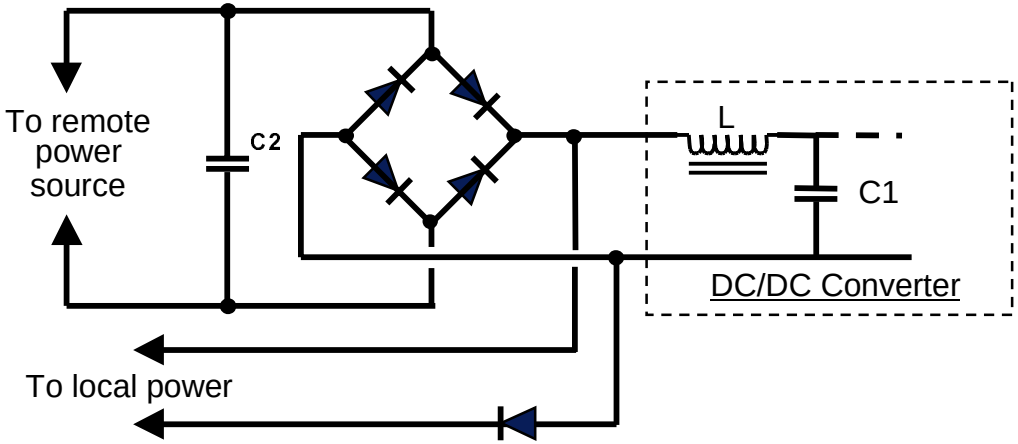
## Three types of such terminations :




**Case 1: terminal without local power source**




**Case 2- terminal with local power & basic protection**

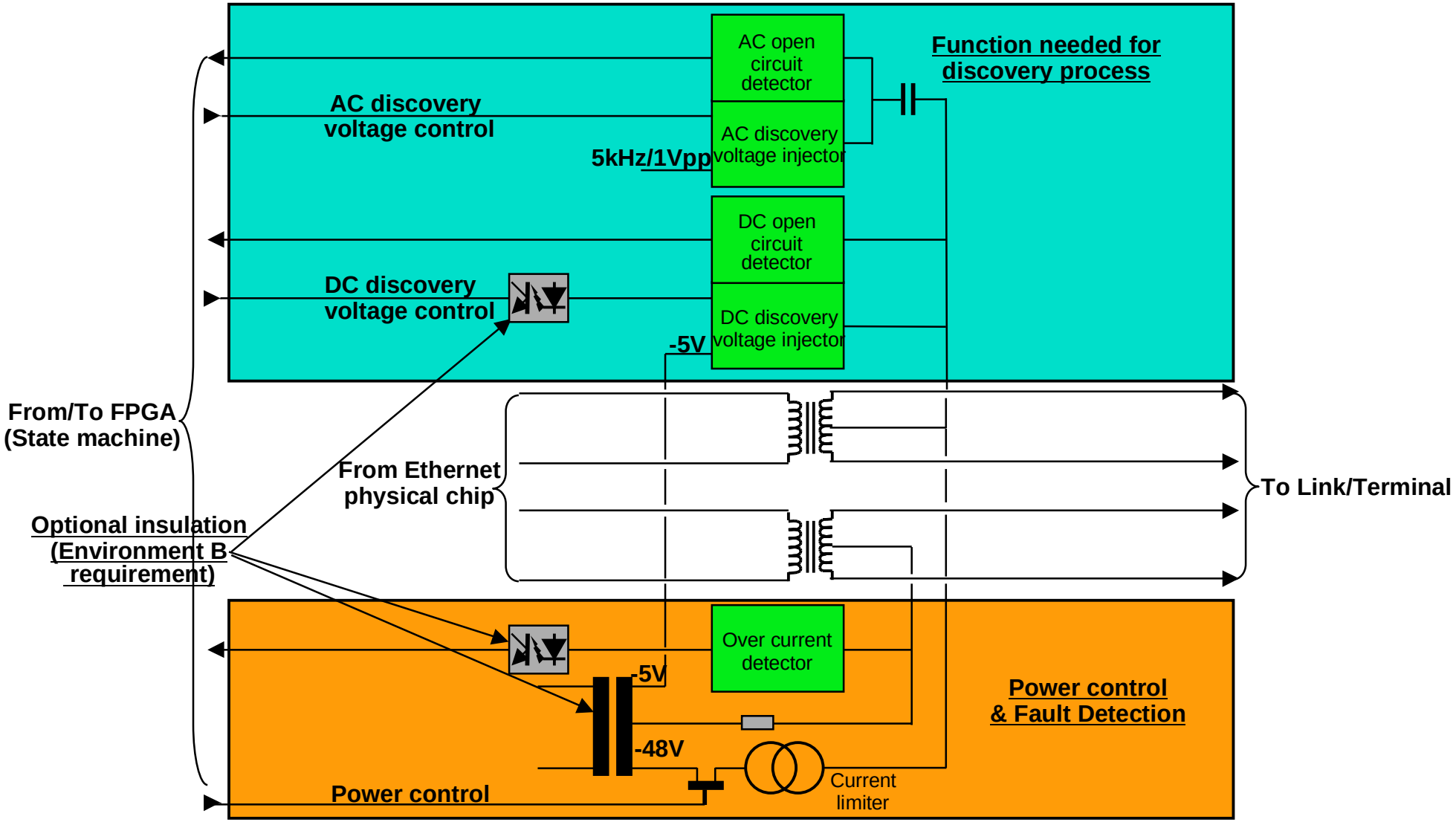



**Case 3- terminal with local power & protection including possible reverse polarity of the remote power**

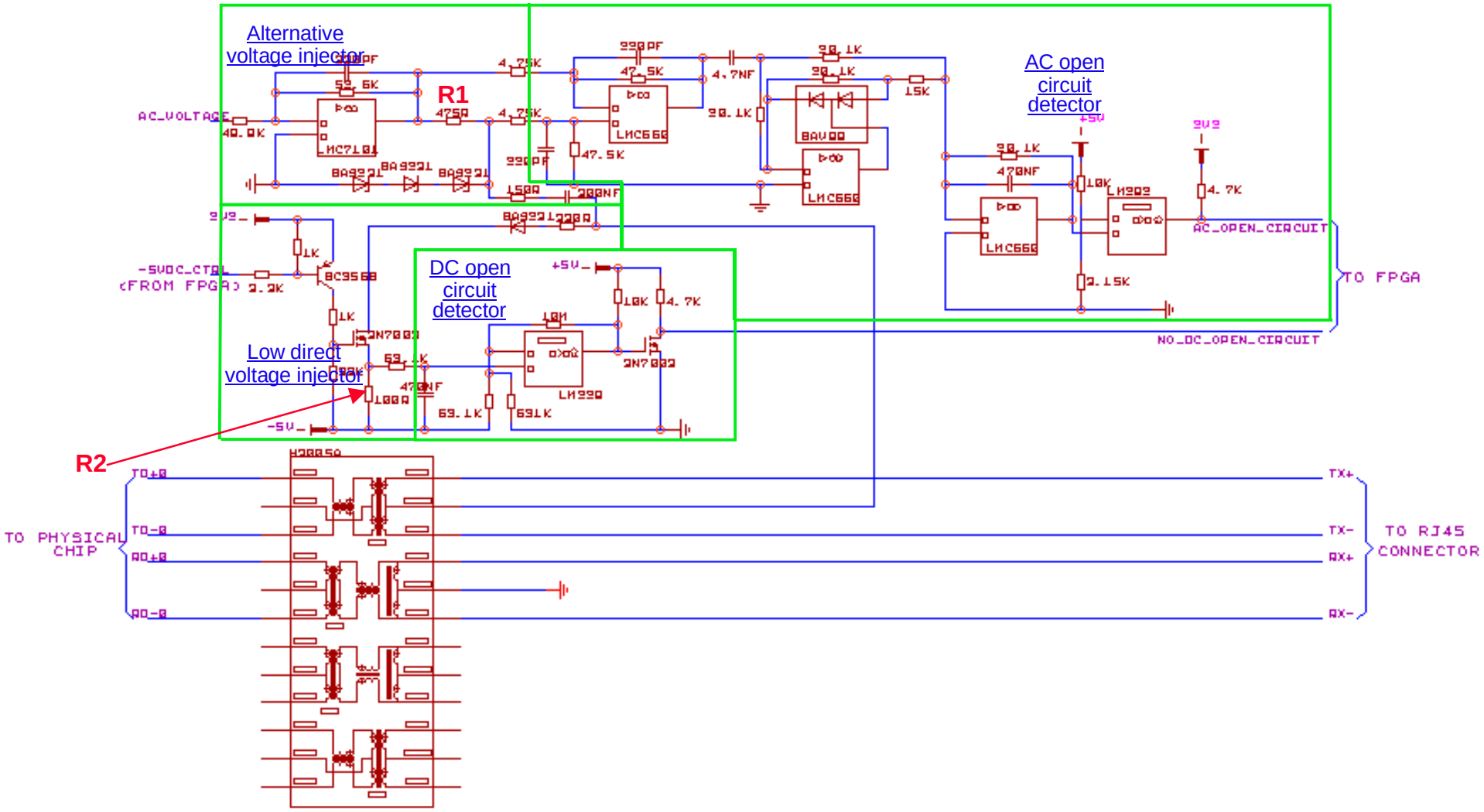
## C1 is the capacitor naturally present at terminal DC/DC converter input

## Only one requirement C2 ≥ 200nF

# Economic and technical feasibility : PSE side (block diagram)



# Economic and technical feasibility : PSE side (mock-up used for tests)



# Economic and technical feasibility : PSE side (BOM of one possible implementation)

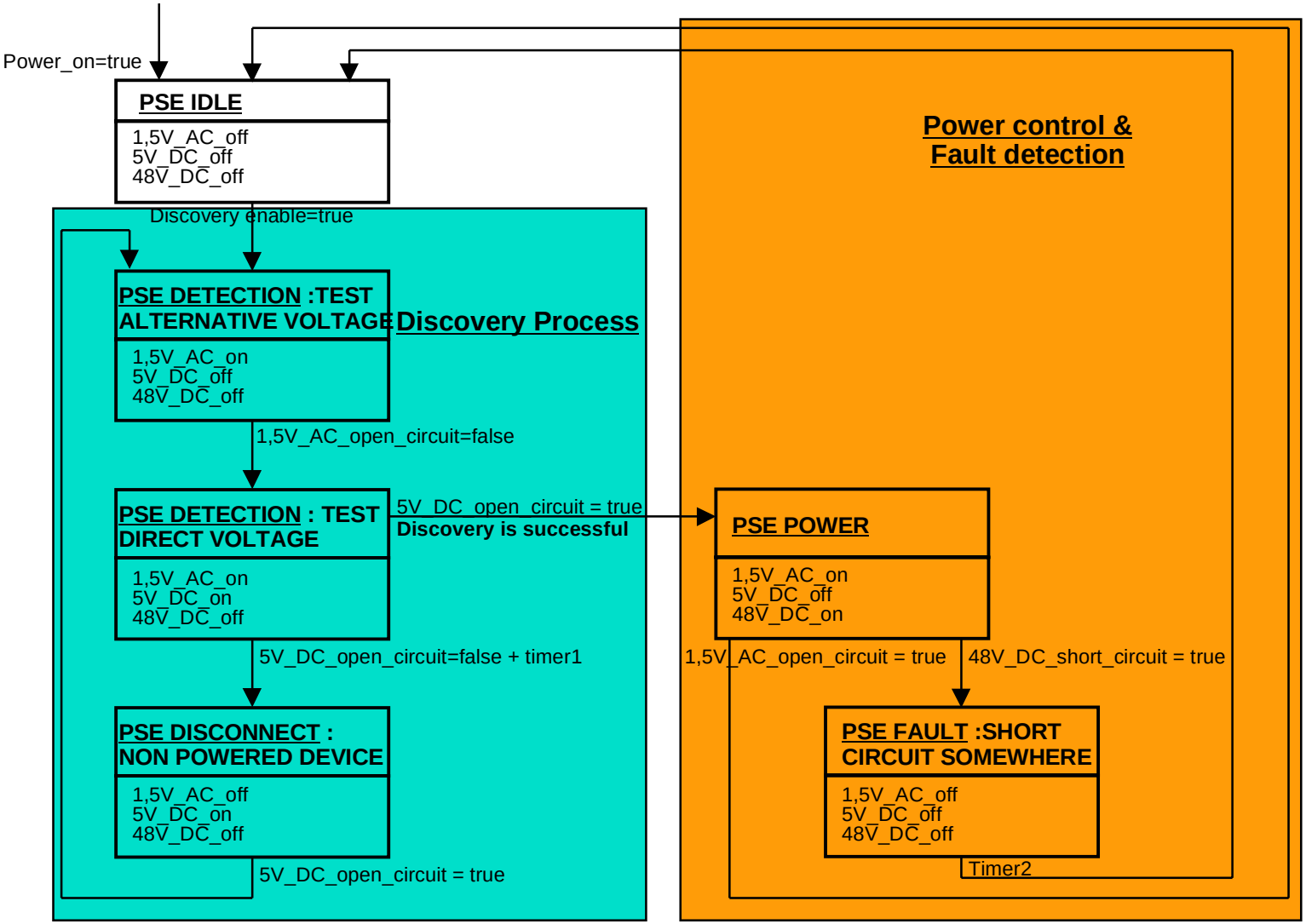
| Functions | Component types | Number | Cost |
|---|---|---|---|
| AC discovery voltage injector | Resistor | 4 | 0,3US$ |
| | Capacitor | 2 | |
| | Diode | 3 | |
| | Op Amp | 1 | |
| | | | |
| AC open circuit detector | Resistor | 12 | 0,5US$ |
| | Capacitor | 4 | |
| | Diode | 2 | |
| | Op Amp | 3/4 Quad | |
| | | | |
| DC discovery voltage injector | Resistor | 6 | 0,06US$ |
| | Transistor | 2 | |
| | Diode | 1 | |
| | | | |
| DC open circuit detector | Resistor | 6 | 0,06US$ |
| | Capacitor | 1 | |
| | Transistor | 1 | |
| | Op Amp | 1/4 Quad | |
| | | | |
| State machine | 1/16 of a XCS20 | 25 CLB | 0,37US$ |

- **Globally there are 46 small SMD components for the discovery part : 28 resistors, 7 capacitors, 3 transistors, 6 diodes, and 2 OP Amp chips.**

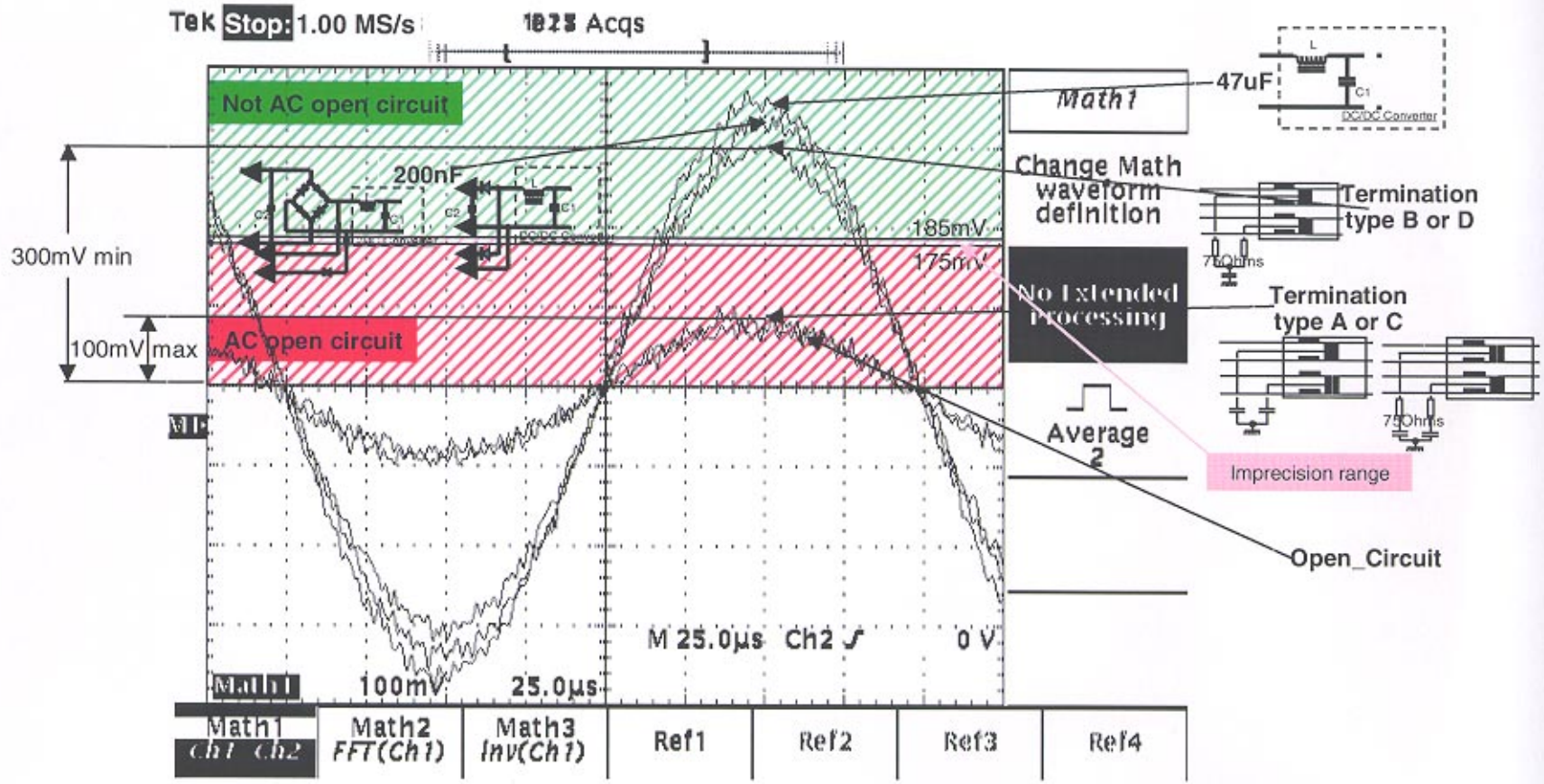
# Economic and technical feasibility : Manageability

- **Items manageable :**
  - **Enable/disable output power**
  - **Level of deliverable current**
- **Items available :**
  - **Power status (power sent or not)**
  - **Fault at PSE output**
  - **Level of delivered current**

# Robustness : state machine

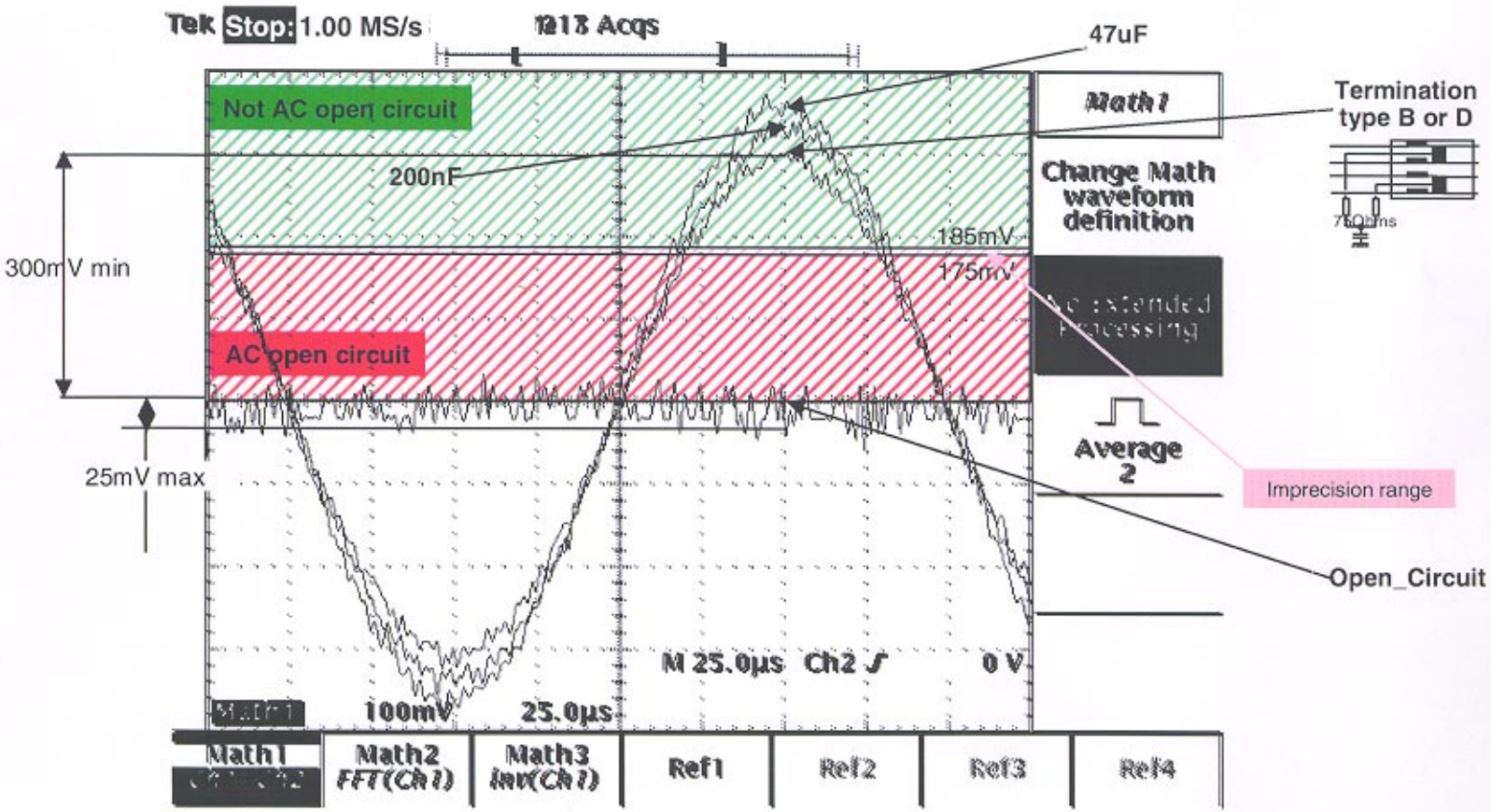


# Robustness : measurements with AC voltage at end of a 120m cable.



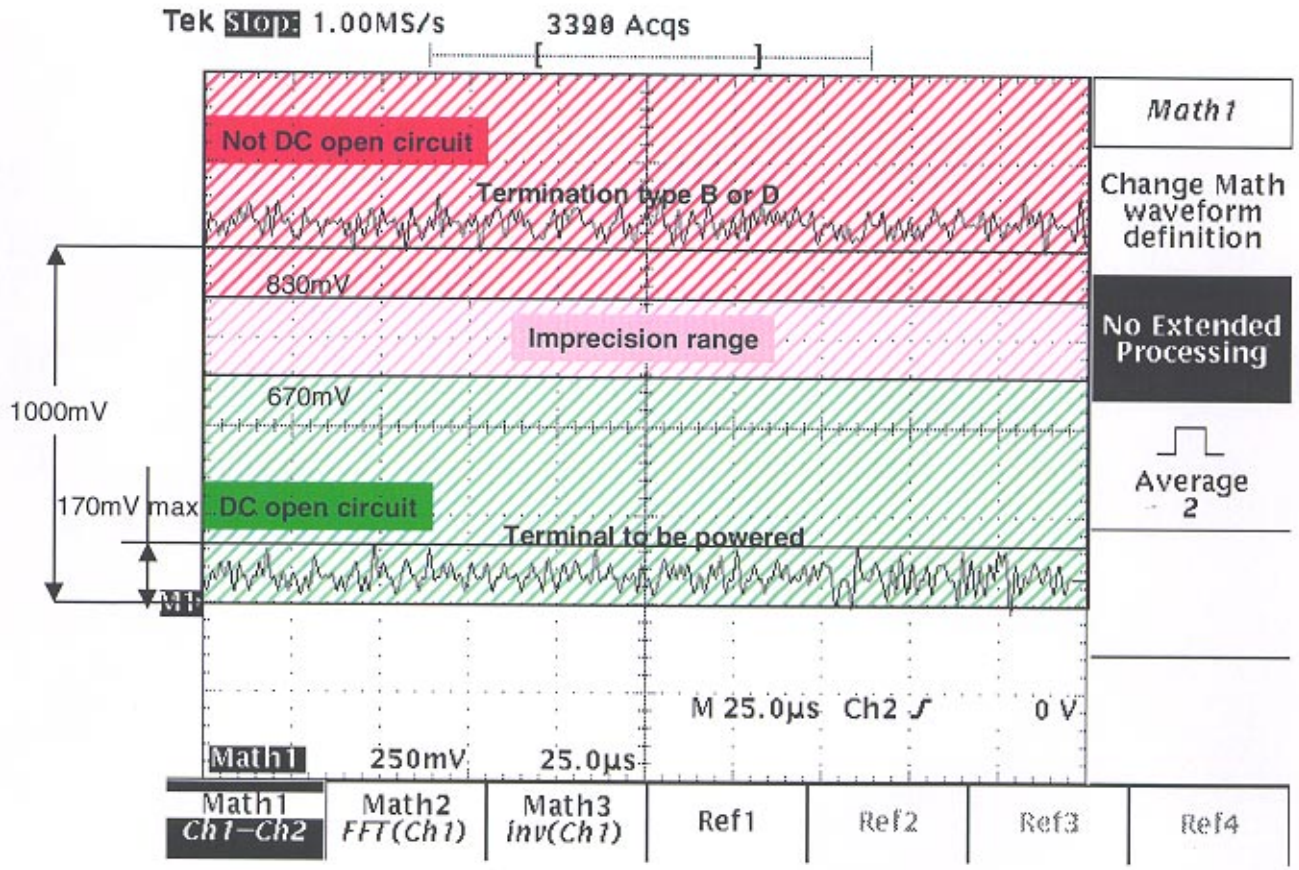

- **Voltage ratio between open_circuit and non-open_circuit = 3. Conclusion can be done without any ambiguity. Measurements are done at R1 extremities.**

# Robustness : measurements with AC voltage at end of a 0m cable.



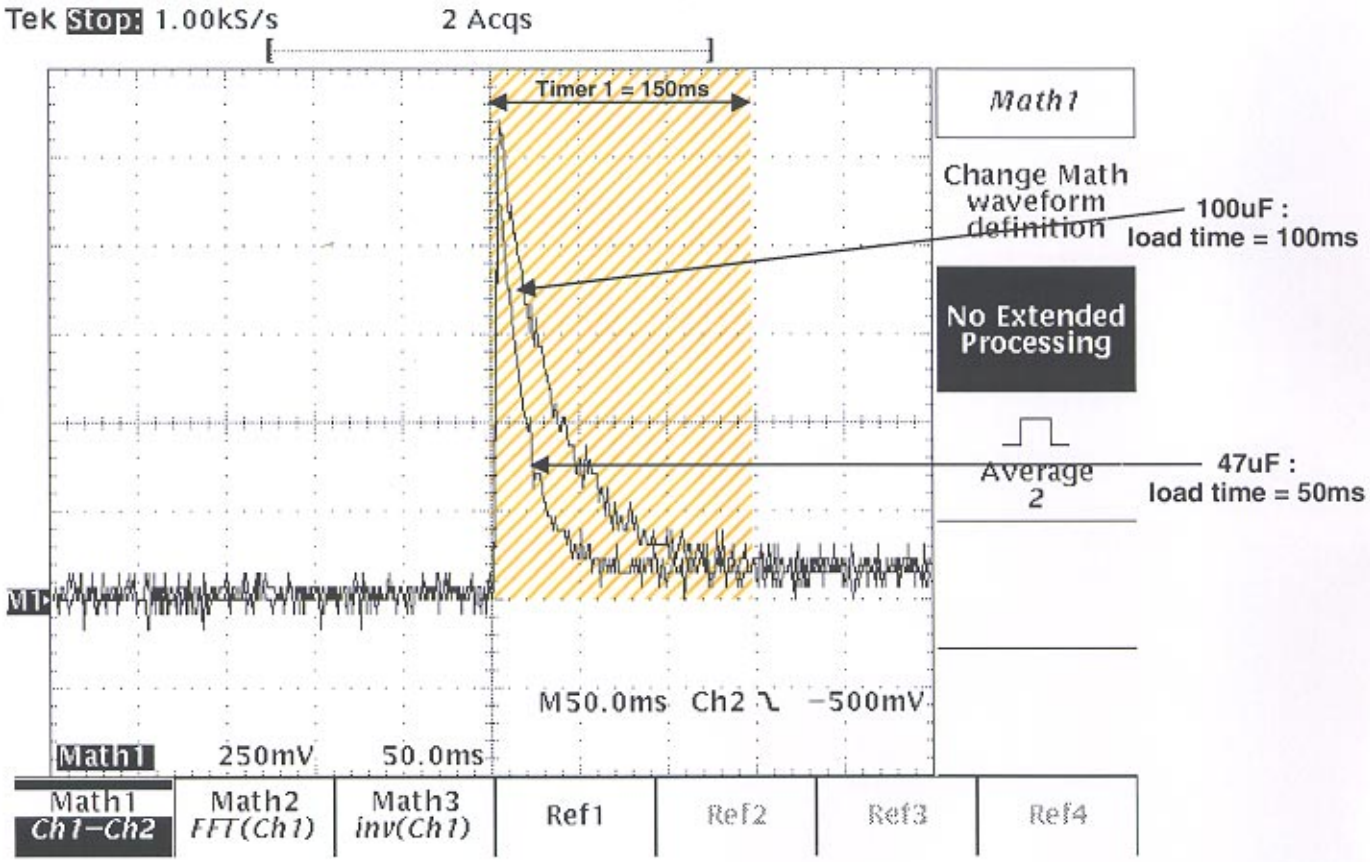

- **Voltage ratio between open_circuit and non-open_circuit = 12. Conclusion can be done without any ambiguity. Measurements are done at R1 extremities.**

# Robustness : measurements under DC voltage




- **Voltage ratio between a terminal not to be powered and a terminal to be powered = 6. Conclusion can be done without any ambiguity. Measurements are done at R2 extremities.**

# Robustness : load time for capacitor




- **Peak load current = 15mA**

# Robustness = Based on solution simplicity

- To decide to send power two events are necessary :
  - Detect a non open-circuit under alternative voltage
  - Detect an open circuit under direct voltage after a timer less than 150ms.
- If these two events do not occur then power is not sent.
- While power is sent, it will be switch off if, and only if, an AC open circuit is detected.
- Consequences :
  - If a short is present on the link during the discovery processing, power will not be sent (since there is not AC open circuit but there is not DC open circuit too).
  - If a legacy terminal (not to be powered) is present on the link, even in parallel with another to be powered, power will not be sent (since there is not AC open circuit but there is not DC open circuit too).
  - If a terminal to be powered is detected on the link, power will be sent and held whatever its local power status is. Therefore no extra power will be spent without necessity.

# Solutions comparison : discovery efficiency

| Features | Type of solution | | | |
|---|---|---|---|---|
| | Diode | Resistor | Capa & DC analysis | Capa & AC/DC analysis |
| Solution usable on both pair sets | Yes | Yes | ? | Yes |
| PD detected ==> Power sent | Yes | Yes | Yes | Yes |
| No PD detected ==> Power not sent | Yes | Yes | Yes | Yes |
| PD disconnection | Power stopped | Power stopped | Power stopped | Power stopped |
| Power sent when short present | No | No | No | No |
| Power sent when mixed terminal types in parallel | ? | No | ? | No |
| Power sent and held when PD locally powered | No | No | No | Yes |

- **Major point : A PD locally powered must be powered from PSE. This is the current case in PBX and end-user does not want to change that.**
- **The three first solutions are not able to solve naturally this problem. It is necessary to spend unused power to hold the power feeding toward a PD locally powered.**

# Solutions comparison : needed hardware

| Functions | | Type of solution | | | |
|---|---|---|---|---|---|
| | | Diode | Resistor | Capa & DC analysis | Capa & AC/DC analysis |
| At PSE side | Power current analyzer | X | X | X | |
| | Low DC voltage or ramp injector | | X | X | X |
| | DC voltage or current analyzer | | X | X | X |
| | AC voltage or pulse injector | X | | | X |
| | AC voltage or return pulse analyzer | X | | | X |
| At PD side | Signature (additional components) | 2resistors, one diode, one capacitor | One resistor | None | One capacitor |
| | Hardware to hold power to a PD locally powered | X | X | X | |
| Total number of functions | | 4 | 4 | 4 | 4 |
| Necessary nb of gates to do, at PSE side, one channel state machine | | ? | ? | ? | 1250 (25 CLB) |

- All solutions need globally the same number of functions.
- Concerning our proposal, notice the state machine simplicity (25 CLB).

## Hazard matrix

| Equipment | Power status | Signal pairs (1,2/3,6) | | Spare pairs (4,5/7,8) | | Power via MDI |
|---|---|---|---|---|---|---|
| | | DC voltage test | AC voltage test | DC voltage test | AC voltage test | |
| | | | | | | |
| Terminals | | | | | | |
| Compaq Armada | OFF | 1V | 300mV | 1V | 300mV | Not Sent |
| M700 | ON | 1V | 300mV | 1V | 300mV | |
| Compaq Deskpro | OFF | 1,1V | 300mV | 1,1V | 300mV | |
| DP4000 | ON | 1,1V | 300mV | 1,1V | 300mV | |
| Sun Ultra 5 | OFF | 0,9V | 280mV | 0,9V | 280mV | |
| | ON | 0,9V | 280mV | 0,9V | 280mV | |
| | | | | | | |
| Tests Equipments | | | | | | |
| Wandel & Golderman | OFF | 0V | 50mV | 0V | 360mV | Sent on spare pairs |
| DA30C | ON | 0V | 50mV | 0V | 350mV | but w/o damage |
| Microtest MT350 | OFF | 0V | 50mV | 0V | 50mV | Not Sent |
| Scanner | ON | 0V | 50mV | 0V | 50mV | |
| Microtest Injector | OFF | 0V | 50mV | 0,16V max | 50mV | |
| | ON | 0V | 50mV | 0,6V max | 50mV | |
| | | | | | | |
| Legacy Equipments | | | | | | |
| 3Com Hub8/TPO | OFF | 0V | 50mV | 0V | 50mV | Not Sent |
| | ON | 0V | 50mV | 1,2V | 50mV | |
| Accton Fast Switch | OFF | 0,93V | 380mV | 0,94V | 390mV | |
| | ON | 0,93V | 380mV | 0,94V | 390mV | |
| Shiva LanRover/Eplus | OFF | 0,93V | 380mV | 0,94V | 390mV | |
| (Token Ring) | ON | 0,93V | 380mV | 0,94V | 390mV | |

# Hazard matrix (cont'd)

| Equipment | Power status | Signal pairs (1,2/3,6) | | Spare pairs (4,5/7,8) | | Power via MDI |
|---|---|---|---|---|---|---|
| | | DC voltage test | AC voltage test | DC voltage test | AC voltage test | |
| Alcatel | | | | | | |
| Omnistack 6024 | OFF | 0V | 20mV | 0,94V | 380mV | Not sent |
| | ON | 0V | 20mV | 0,94V | 380mV | |
| Omnistack 5024 | OFF | 0,93V | 360mV | 0,94V | 380mV | |
| | ON | 0,93V | 360mV | 0,94V | 380mV | |
| OmniStack 4024 | OFF | 0V | 20mV | 0,94V | 380mV | |
| | ON | 0V | 20mV | 0,94V | 380mV | |
| OmniSwitch (EFX board) | OFF | 0,93V | 380mV | 0,94V | 380mV | |
| | ON | 0,93V | 380mV | 0,94V | 380mV | |
| OmniStack (Olmd version) | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| LSS210 | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| BayNetwork | | | | | | |
| BayStack 101 | OFF | 0V | 20mV | 0V | 20mV | Not Sent |
| | ON | 0V | 20mV | 0V | 20mV | |
| 810M | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| EtherSpeed Board | OFF | 0V | 50mV | 0V | 20mV | |
| | ON | 0V | 50mV | 0V | 20mV | |
| 5308PS Board | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| LattisNet 3308A board (Synoptics) | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| BayStack 350 | OFF | 1,05V | 390mV | 0,94V | 370mV | |

# Hazard matrix (cont'd)

| Equipment | Power status | Signal pairs (1,2/3,6) | | Spare pairs (4,5/7,8) | | Power via MDI |
|---|---|---|---|---|---|---|
| | | DC voltage test | AC voltage test | DC voltage test | AC voltage test | |
| BayNetwork (cont'd) | | | | | | |
| LattisNet 2800 (Synoptics) | OFF | 0V | 10mV | 0V | 10mV | Not Sent |
| | ON | 0V | 10mV | 0V | 10mV | |
| 5505 Board (Token Ring) | OFF | 0V | 10mV | 0V | 10mV | |
| | ON | 0V | 10mV | 0V | 10mV | |
| TokenSpeed Board | OFF | 0V | 10mV | 0V | 390mV | Sent on spaire pairs but w/o damage |
| | ON | 0V | 10mV | 0V | 390mV | |
| Cisco | | | | | | |
| Cisco 4000 mono10bT | OFF | 0V | 50mV | 0V | 20mV | Not Sent |
| | ON | 0V | 50mV | 0V | 20mV | |
| Cisco 2600 10/100bT | OFF | 0,93V | 370mV | 0,93V | 370mV | |
| | ON | 0,93V | 370mV | 0,93V | 370mV | |
| Cisco 2600 10bT | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| Cisco 1603 | OFF | 0V | 10mV | 0V | 10mV | |
| | ON | 0V | 10mV | 0V | 10mV | |
| Cisco 4500M 6Eth ports board | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| Cisco 4500M DualEth ports board | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| Cisco 2507 | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| LattisNet 3308A board (Synoptics) | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |

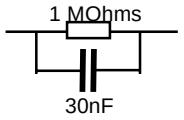
## Hazard matrix (cont'd)

| Equipment | Power status | Signal pairs (1,2/3,6) | | Spare pairs (4,5/7,8) | | Power via MDI |
|---|---|---|---|---|---|---|
| | | DC voltage test | AC voltage test | DC voltage test | AC voltage test | |
| Cisco (cont'd) | | | | | | |
| Catalyst 2800 | OFF | 0V | 10mV | 0V | 10mV | Not Sent |
| | ON | 0V | 10mV | 0V | 10mV | |
| Catalyst 2926 | OFF | 0V | 20mV | 0,94V | 370mV | |
| | ON | 0V | 20mV | 0,94V | 370mV | |
| Catalyst 3000 (WorkGroup Stack) | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| Catalyst 5500 : Fast Ethernet Module | OFF | 0,93V | 360mV | 0,94V | 370mV | |
| | ON | 0,93V | 360mV | 0,94V | 370mV | |
| Catalyst 5500 : WSX5225 board | OFF | 0V | 20mV | 0,93V | 370mV | |
| | ON | 0V | 20mV | 0,93V | 370mV | |
| Catalyst 5500 : TokenRing Switching Module | OFF | 0V | 20mV | 0V | 100mV | |
| | ON | 0V | 20mV | 0V | 100mV | |
| Cisco 2507 | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |
| ISDN | | | | | | |
| Cisco4000 ISDN Board | OFF | 0V | 20mV | 0V | 20mV | Not Sent |
| | ON | 0V | 20mV | 0V | 20mV | |
| Alcatel 2824 ISDN Phone Set | N/A | 0V | 10mV | 0V | 10mV | |
| Alcatel TTN2 ISDN Phone set | N/A | 0V | 10mV | 0V | 10mV | |
| Alcatel PBX Basic and Primary ISDN Accesses | OFF | 0V | 20mV | 0V | 20mV | |
| | ON | 0V | 20mV | 0V | 20mV | |

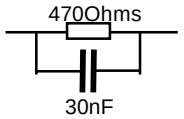
**Besides this solution is able to detect very efficiently a set of different types of terminal (PD or not PD) connected in parallel on the link and not to send the power whether only one of them is a not to be powered terminal.**

## Test fixture schematic

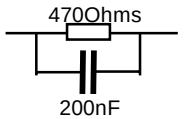
- Following dipole corresponds to a Cat3 cable without terminal at its end; There is an AC open circuit ==> state machine stays in PSE detection "Test alternative voltage" state. Power is not sent



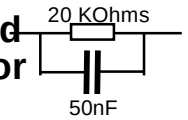

- Following dipole corresponds to a cable with a legacy terminal at its ends (a factor 3 as safety margin is taken into account for the resistor value) : There is no AC open circuit but there is no DC open circuit ==> state machine reaches the "PSE disconnect : Non powered device" state. Power is not sent.




- Following dipole corresponds to the case where two different types of terminal (To be powered and not to be powered; a factor 3 as safety margin is taken into account for the resistor value) are plugged in parallel at the PSE outputs. Power is not sent.




- Following dipole corresponds to the case where only one terminal to be powered is plugged at the ends of the link. A factor 4 is taken into account about capacitor value. Power is sent (Eureka!)



# Testing (cont'd)

- Cables
  - The type of cable does not have any influence on the solution robustness since the alternative voltage used is at a low frequency.

## EMI, ESD immunity

- The capacitor, at PD side, needed by this solution participates efficiently to these immunities

# Conclusions

- **Solution advantages :**
  - **Able to detect very safely all cases of miss or right connections**
  - **Simple to carry out**
  - **Usable on both set of pairs**
  - **Economic especially  in term of silicon (very simple state machine)**
  - **No power spent unnecessarily**