Voice Protection for ONTs Using ECL and Crowbar Devices

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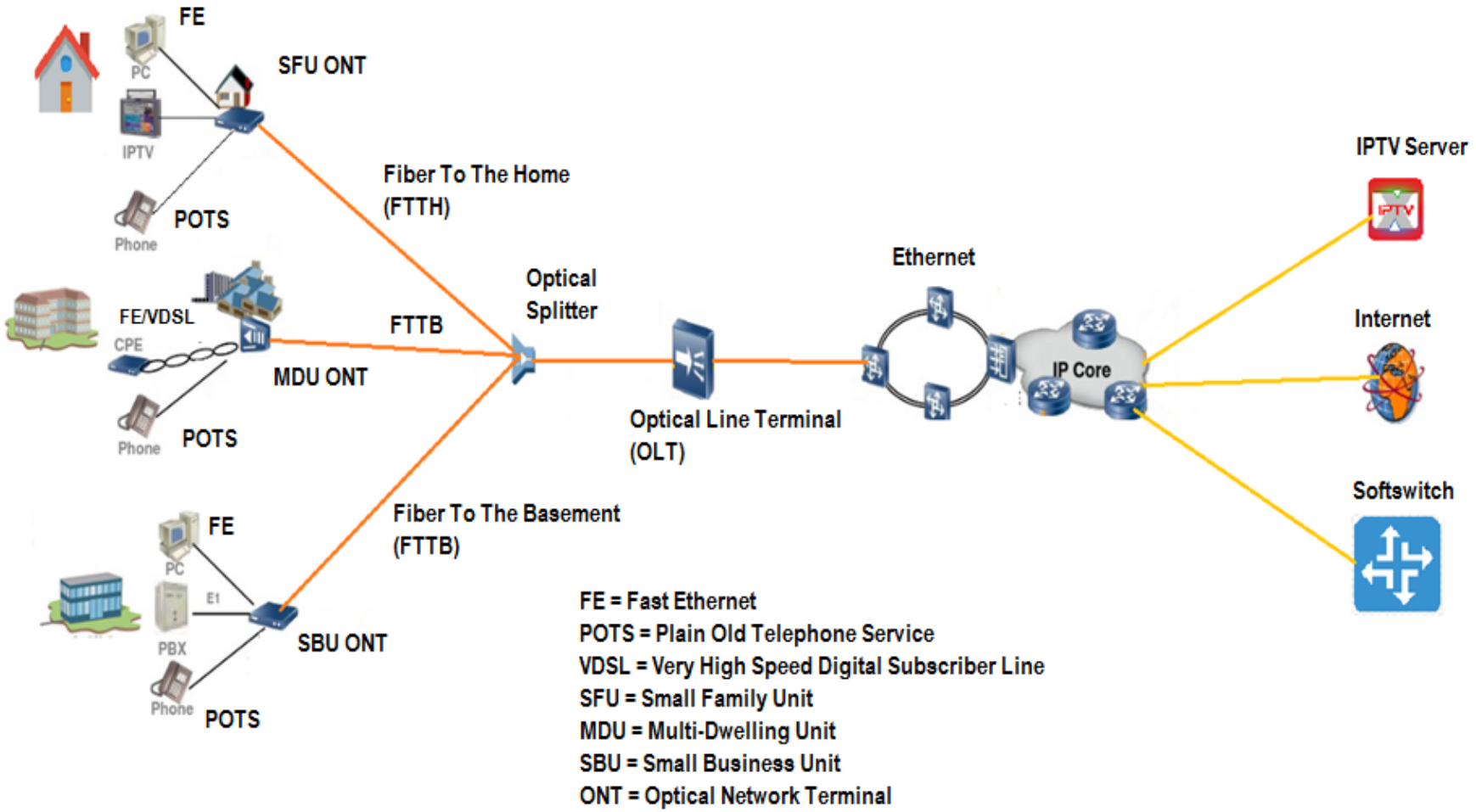
Agenda

- Overview of the Passive Optical Network (PON)
- Optical Network Termination (ONT) Protection standards
- Discuss **field failures** of **MDU ONTs'** voice ports
- Discuss protection **solutions using Electronic Current Limiters** (ECLs) and Example Applications

Passive Optical Network (PON)



Optical Network Terminal (ONT)

- The ONT receives a signal from the Optical Line Terminal (OLT) through a passive optical splitter
- The ONT provides POTS, broadband data, and video services to residential or business subscribers
- Different types of ONT based on location…
  - Single Family Unit (SFU), FTTH
  - Multiple Dwelling Unit (MDU), FTTB
- SFU - Voice port, FE/Gigabit Ethernet/PoE, WIFI
- MDU - Voice port, FE/Gigabit Ethernet/PoE, xDSL

Common SFU / MDU Features

- For SFUs, different combination of
  - Voice Ports (1 – 4 ch) , mainly 12 Vdc power
  - Ethernet Ports (1 – 8 ch FE/GE) + WIFI
- For MDUs, different combination of
  - Voice Ports (8 – 256 ch), mainly 48 Vdc, 110/220 Vac
  - Ethernet Ports (4 – 128 ch: FE/GE/PoE)
  - Digital Subscriber Lines (DSL), up to 128 ch
- Single/Dual power supply (i.e. SLIC supply voltage)
- Combo design (Voice and DSL on same board)
- Surge, power cross, power induction tests
- Clearance and creepage considerations

ITU and YDT test for MDU ONT

Test Items	Test level	Mode	K.45 / YDT1082	K.45 (With Primary Protector) / YDT1082
10/700 (lightning Surge)	Basic	Transverse	1.5 kV	4 kV
		Longitudinal		
	Enhanced	Transverse	1.5 kV	4 kV*
		Longitudinal		
Power Induction (50 Hz / 60 Hz)	Basic	Transverse	600V/600ohm/0.2s	600V/600ohm/1s
		Longitudinal		
	Enhanced	Transverse	600V/600ohm/0.2s	600V/600ohm/2s
		Longitudinal		
Power Contact (50 Hz / 60 Hz)	Basic	Transverse	230 Vrms 15 min	
		Longitudinal		
	Enhanced	Transverse		
		Longitudinal		

*6 kV if mutliple pairs are used.

ITU and YDT test for SFU ONT

Test Items	Test level	Mode	K.21 / YDT993	K.21 / YDT993 (With Primary Protector)
10/700 (lightning Surge)	Basic	Transverse	1.5 kV	4 kV
		Longitudinal		
	Enhanced	Transverse	1.5 kV	6 kV
		Longitudinal	6 kV	6 kV
Power Induction (50 Hz / 60 Hz)	Basic	Transverse	600V/600ohm/0.2s	600V/600ohm/1s
		Longitudinal		
	Enhanced	Transverse	600V/600ohm/0.2s	600V/600ohm/2s
		Longitudinal		
Power Contact (50 Hz / 60 Hz)	Basic	Transverse	230 Vrms 15 min	
		Longitudinal		
	Enhanced	Transverse		
		Longitudinal		

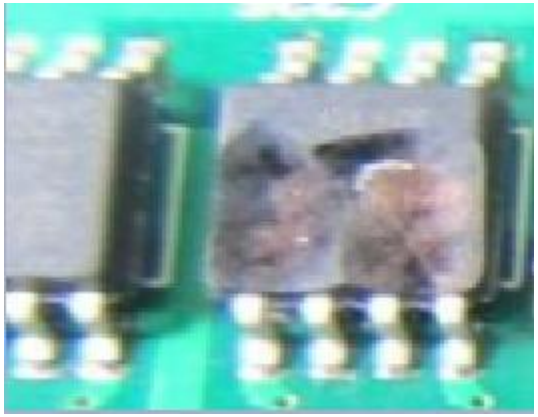
GR-1089-CORE Intra-building tests for SFU/MDU

Test Item	Port Type	Generator Voltage	Current Applied	Waveform	Test (configuration)
1*	4/4a	±800 V	100 A/conductor	2/10	A1-4
2*	4/4a	±1500 V	100 A/conductor	2/10	B
3	4a	1000 V	100 A/conductor	10/1000	A5-A6
4	4/4a	125 Vrms	25 Arms/conductor	50 or 60Hz	A

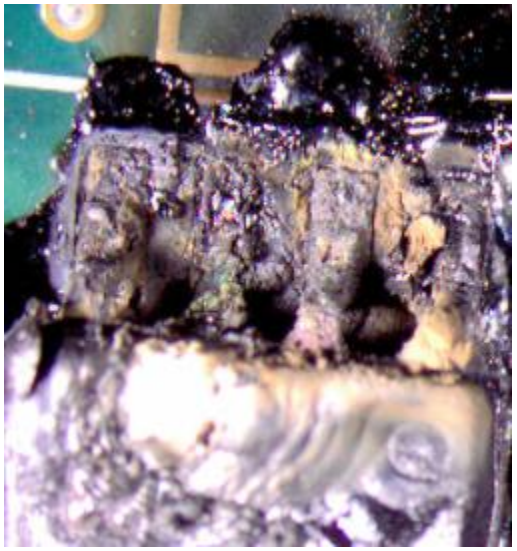
*For test items 1 or 2: 2/10 waveform can be replaced by 1.2/50 - 8/20 waveform, the test circuit and resistor value added list in below table for those tests.

Port type	Total Port no.	Test	Waveform (µs)	Voltage (V)	Resistance (Ω)	Port current (A)
4/4a	1 or 2	Transverse Longitudinal	2/10	±800	8	100
				±1500	15	100
4/4a	1 or 2	Transverse Longitudinal	8/20	±800	2 +6	100
			(1.2/50)	±1500	2 +10	125
4/4a	3 or 4	Transverse Longitudinal	8/20	±800	2 +6	100
			(1.2/50)	±1500	2+20	68
4/4a	>4	Transverse Longitudinal	8/20	±800	2+6	100
			(1.2/50)	±1500	2+40	35.7

Field failure cases in MDUs



Damage to Thyristor protector due to overstress



Dirty PCB and environmental factors caused burn

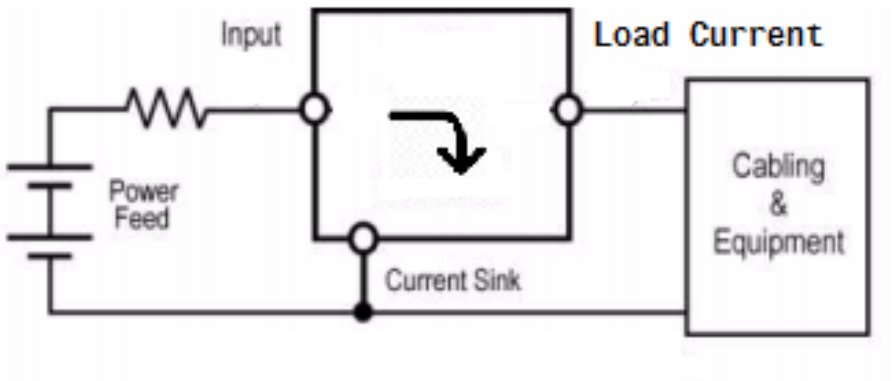
Damage to SLIC IC due to overstress

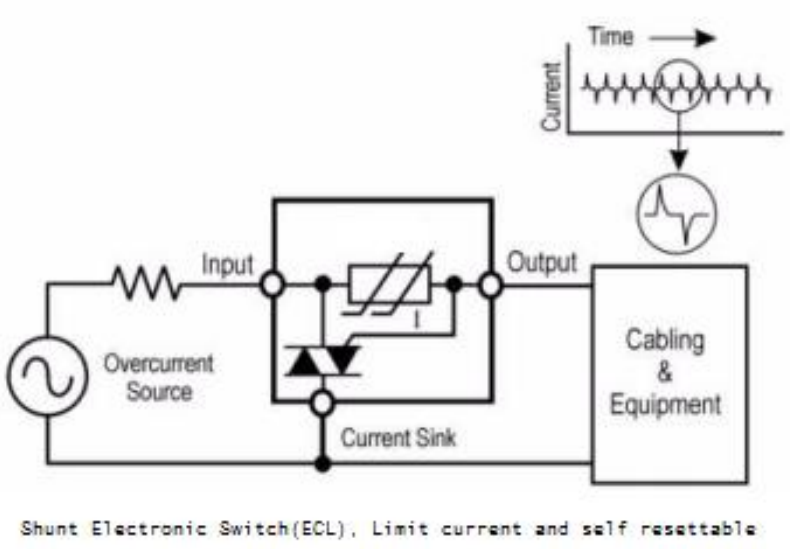
What is an Electronic Current Limiter (ECL)?

- A component based on transistor and related technology that automatically restricts the load current when it exceeds a predetermined threshold level. (ECL is defined in GR-3154-CORE).
- Two types of ECL
  - Shunt ECL (3 terminal device)
  - Series ECL (2 terminal device)

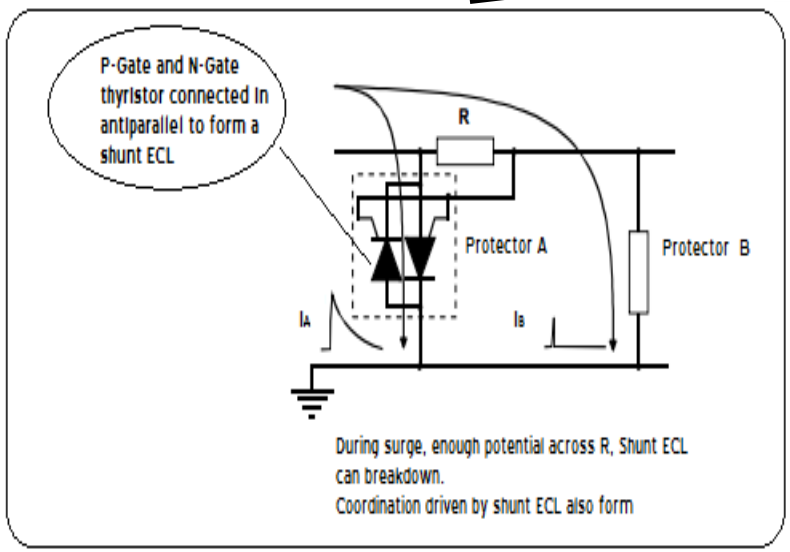
Shunt ECL

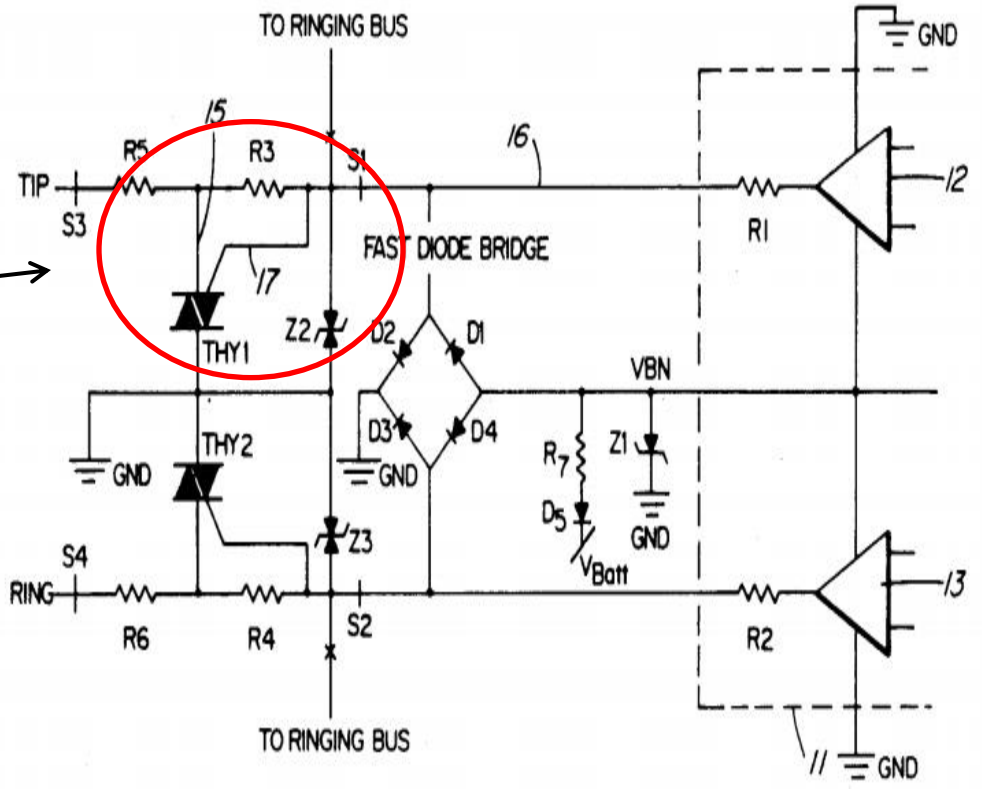
- Protects by diverting incoming surge currents to common/ ground.





Voice Protection by Shunt ECL



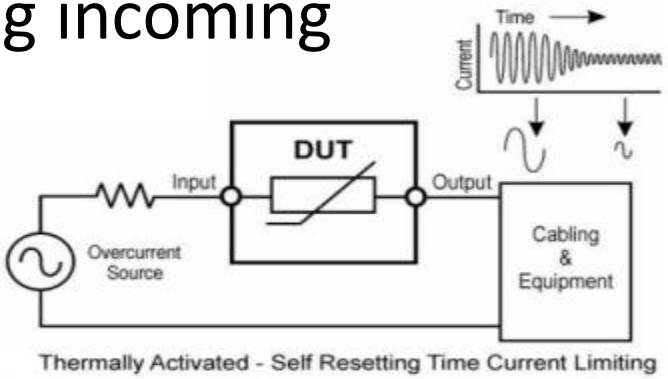


Series ECL

- Protects by blocking/restricting incoming surge currents.

(i) Limit to constant level and resettable

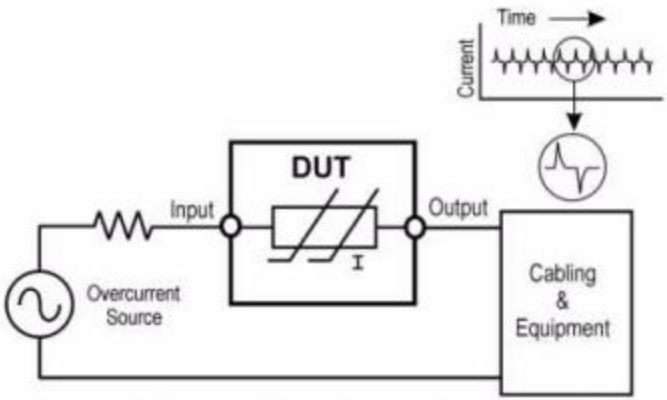
e.g. Ceramic or Polymeric Positive Temperature Coefficient Device (PTC)



Thermally Activated - Self Resetting Time Current Limiting

(ii) Re-entrant characteristics (Electronic Switch)

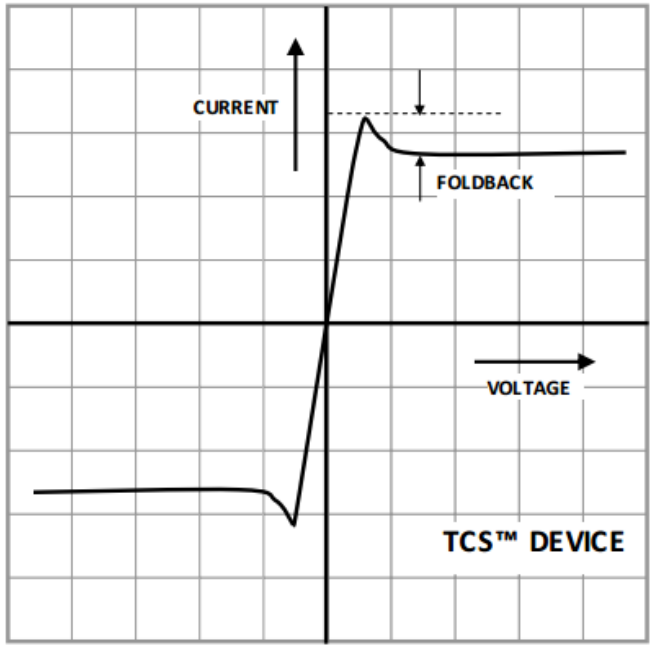
e.g. Transient Blocking Unit (TBU®)

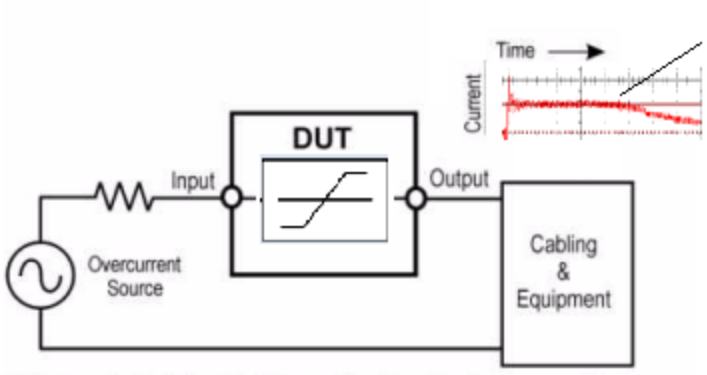


Electronic Switch - Self Resetting Amplitude Current Limiting

Series ECL

(iii) Constant current characteristics
e.g. Transient Current Suppressor (TCS™)





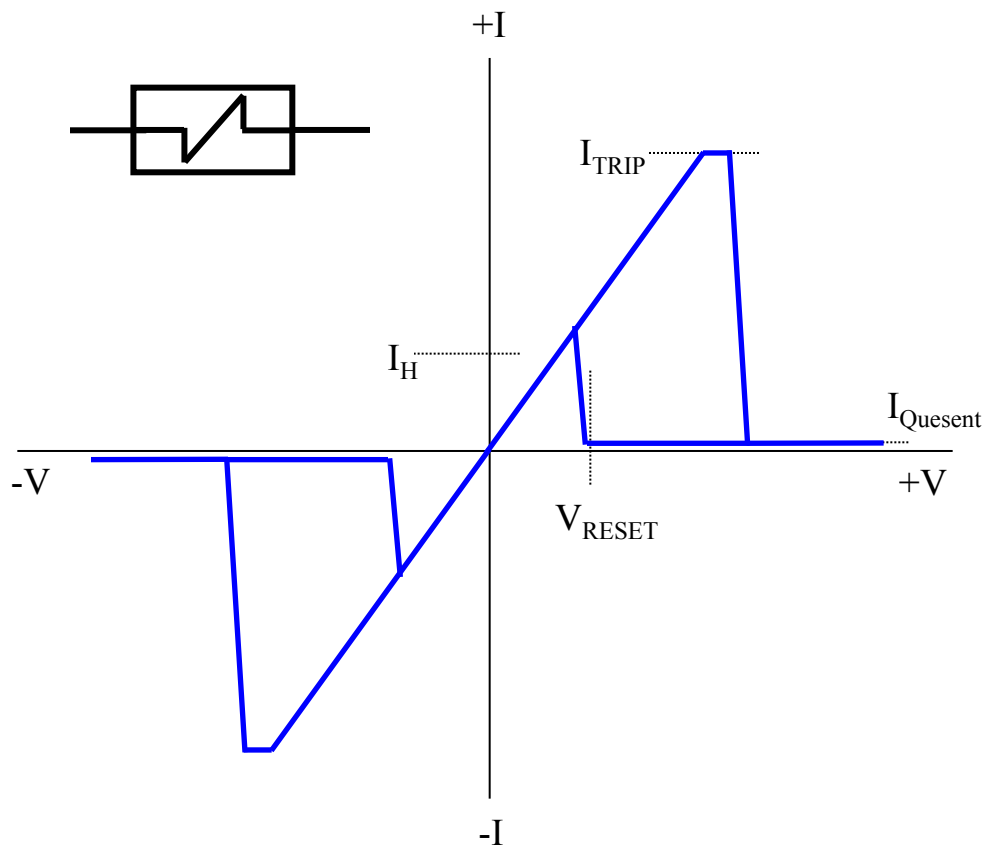
clamp and limited to almost constant value

Electronic current clamp- current clamp and limit to a constant

Series ECL / Electronic Switch

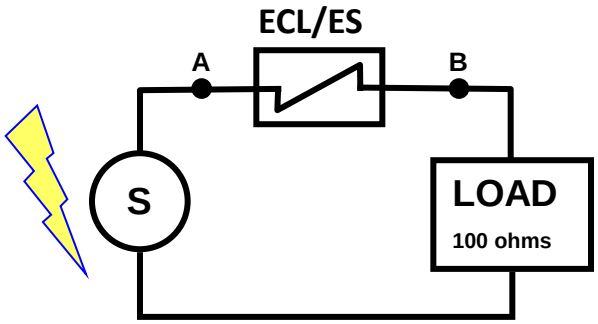
- Very high bandwidth up to 3 GHz
- High-speed protection (blocking in < 1 µs, re-entrant characteristic)
- Blocks both voltage and current
- Extremely low let-through energy
- Self-resetting (< Vreset or remove I quiescent)
- Easy coordination with crowbar, clamping device.

How an Electronic Switch Works

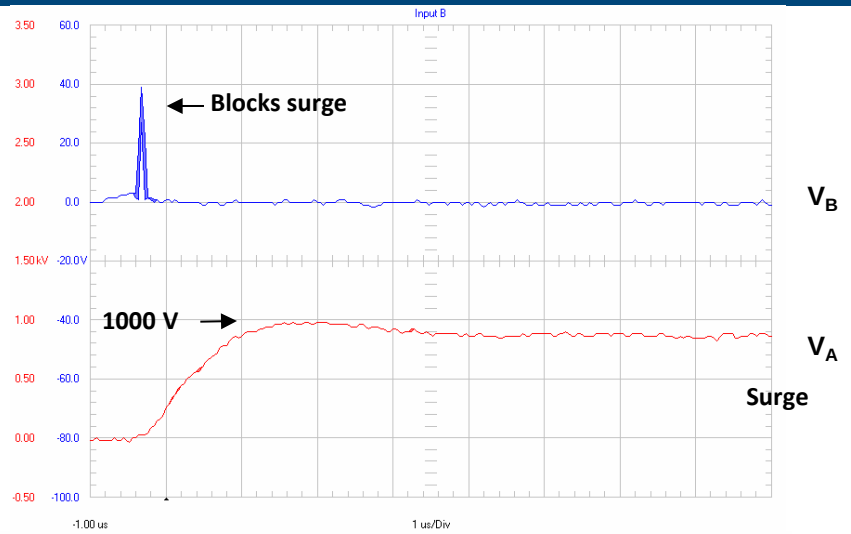


- ECL/ES maintains a stable low resistance until the current through it reaches it's I_{TRIP}
- ECL/ES switches into a high resistance state.
- ECL/ES remains in the high resistance state until the voltage across it drops below V_{RESET} or the quiescent current is removed.
- ECL/ES has a bi-directional characteristic – same reaction to negative voltages.

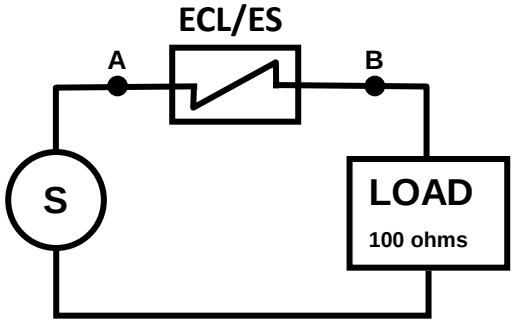
Blocks Surge



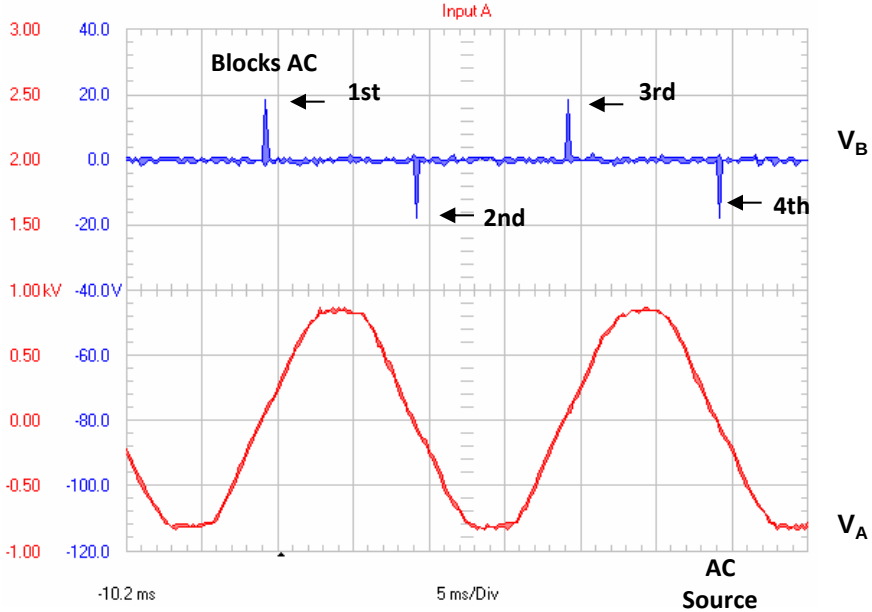
Surge – 1000 V, 1/50



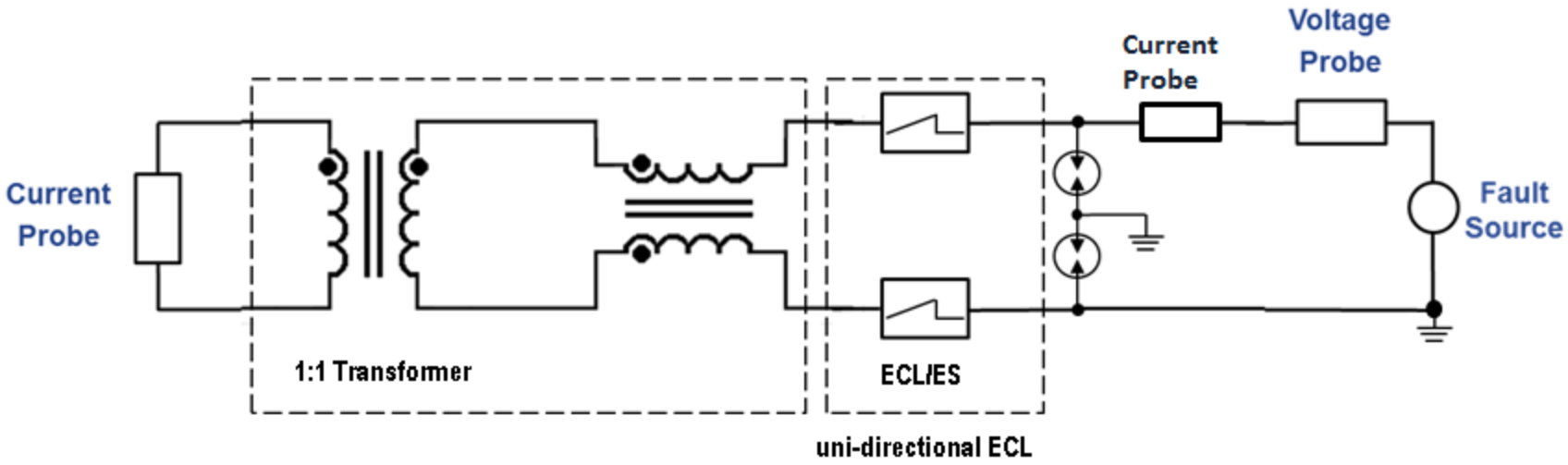
Blocks power cross



Voltage – 600 V_{ac}

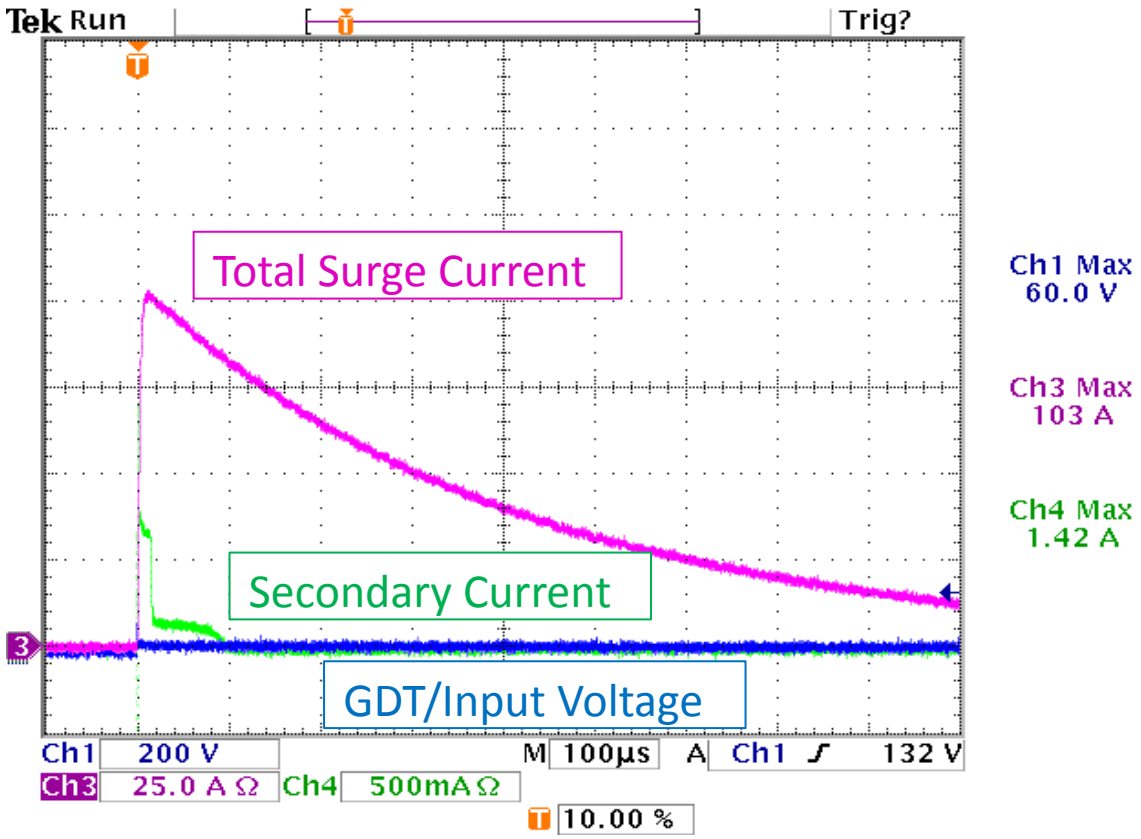


Serial ECL/ES in Gigabit Ethernet Application



Serial ECL in Gigabit Ethernet Application

4 kV, 10/700 Surge



Coordination of different ECLs

(1) GDT + ECL (CPTC) + Thyristor

(2) GDT + ECL (Electronic Switch)

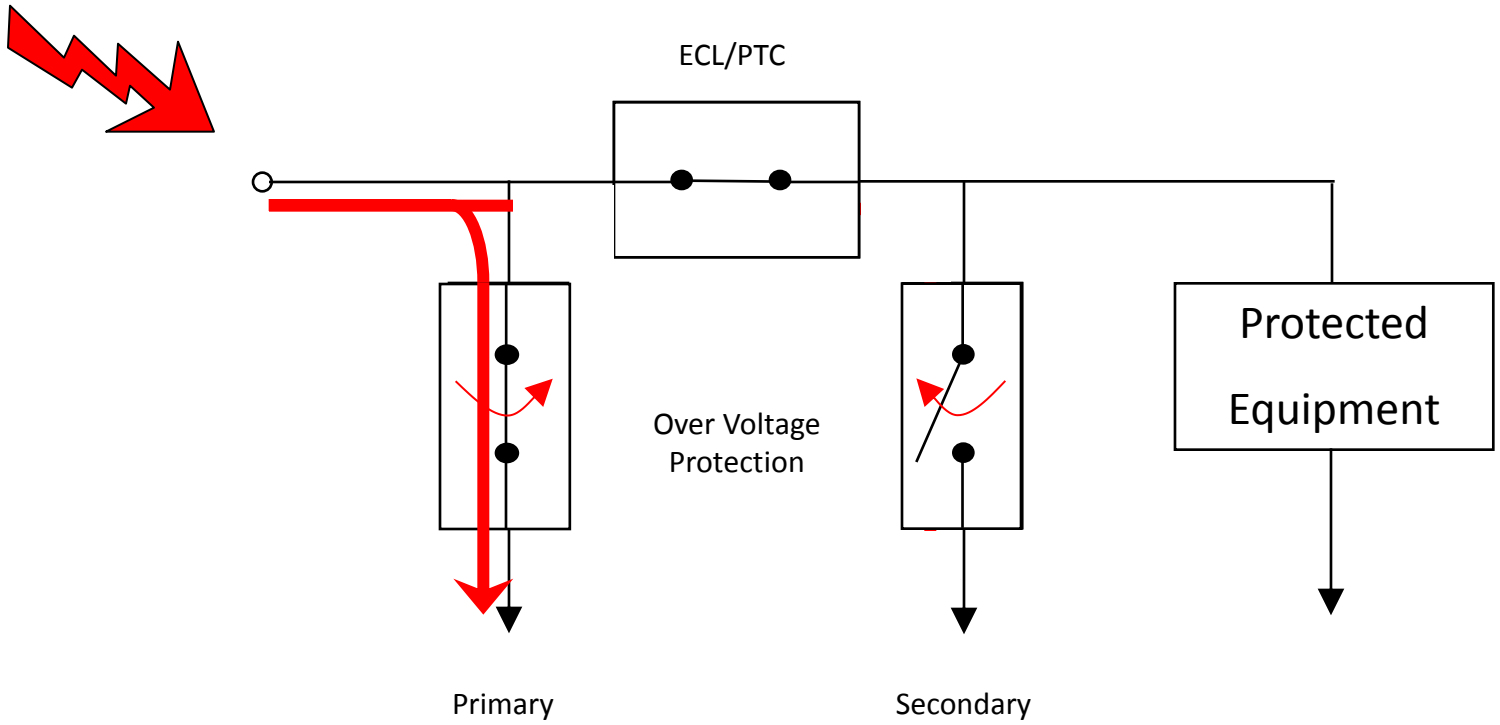
Example GR-1089-CORE Port Type 4a

10/1000 100 A (Using Ceramic PTC)

-230 V GDT with an impulse spark over of 650 V @ 5 kV/µs
-10/1000 30 A thyristor protector
-Coordination resistance at least =10*650/(1000-650)
=18.6 ohm
(according to pg. 5 of **ATIS-0600338.2010)**

=> If a CPTC is selected as the coordination element, a 55 ohm CPTC should be selected as the CPTC effective resistance drops approx. 50% during surge (75% in extreme cases).

Conventional Current Coordination by PTC



Example GR-1089-CORE Port Type 4a

10/1000 100 A (using Serial ECL/ES)

-230 V GDT with impulse spark over of 650 V@ 5 kV/us

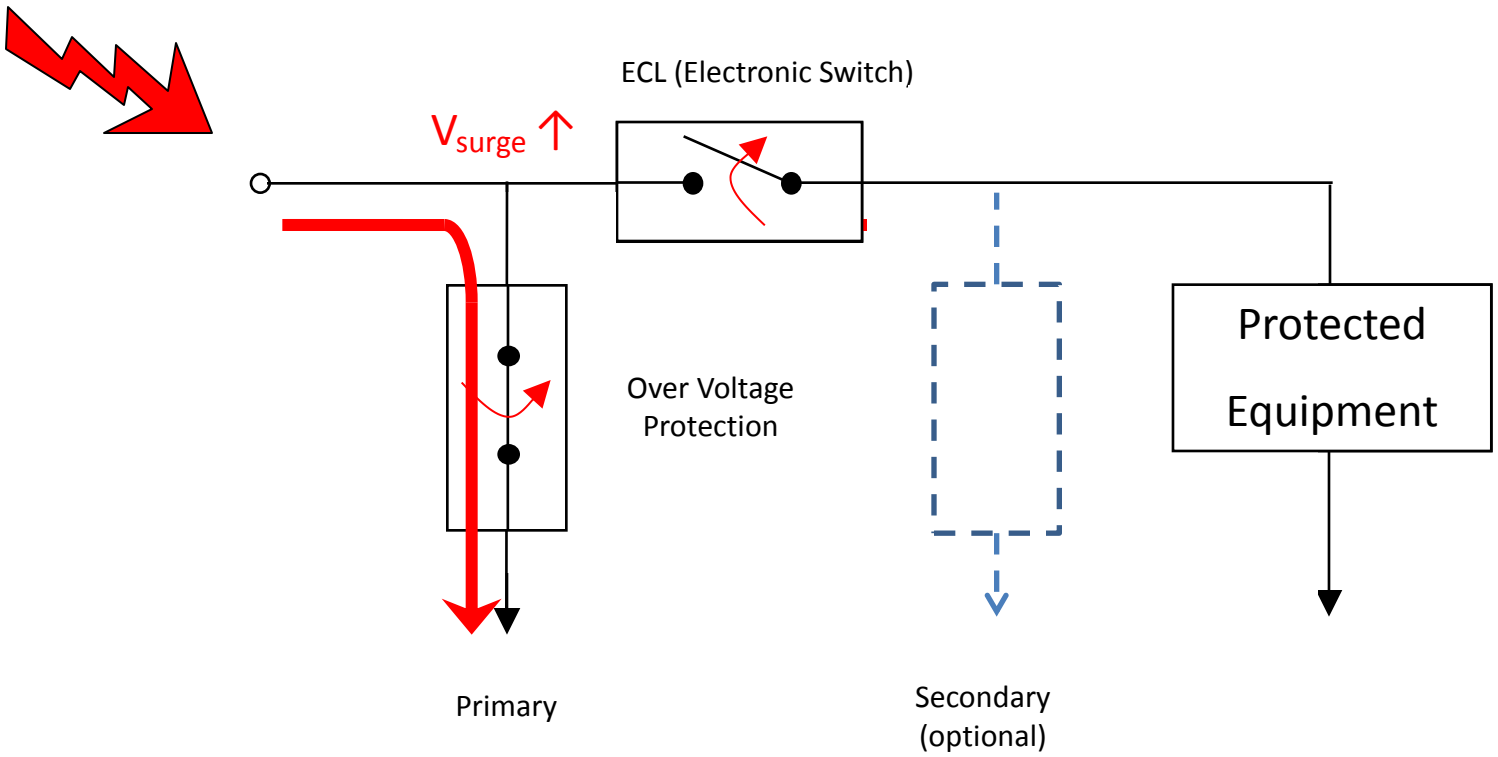
-200 mA series ECL/ES with 850 V max. impulse voltage rating

(Ensure the primary protector maximum impulse spark over rating is less than the ECL maximum impulse voltage rating.

=> The ECL/ES will inherently coordinate with the 230 V GDT during a surge

-The ECL/ES can coordinate with MOV, Thyristor, TVS

Inherent Coordination with Electronic Switch

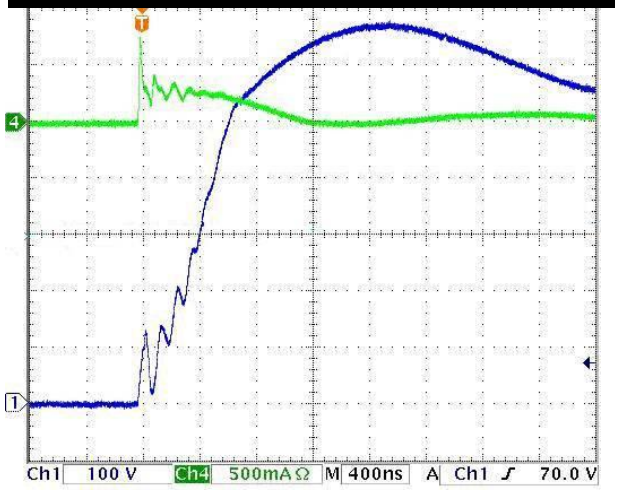


Series ECL/ES Specific to SLIC Protection

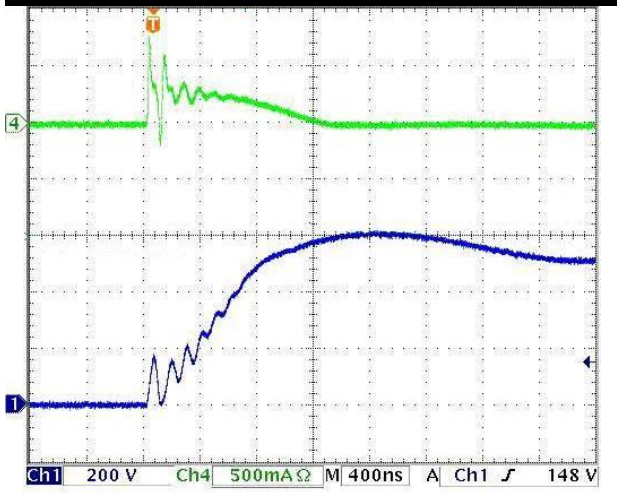
- Effectively blocks both impulse surge currents and power faults
- ECL with internal voltage comparator with programmable voltage triggering function (-ve side)
  - Positive trigger by current, negative trigger by voltage for SLIC port
- Inherent coordination with both clamping and crowbar devices (MOV, GDT, Thyristor)

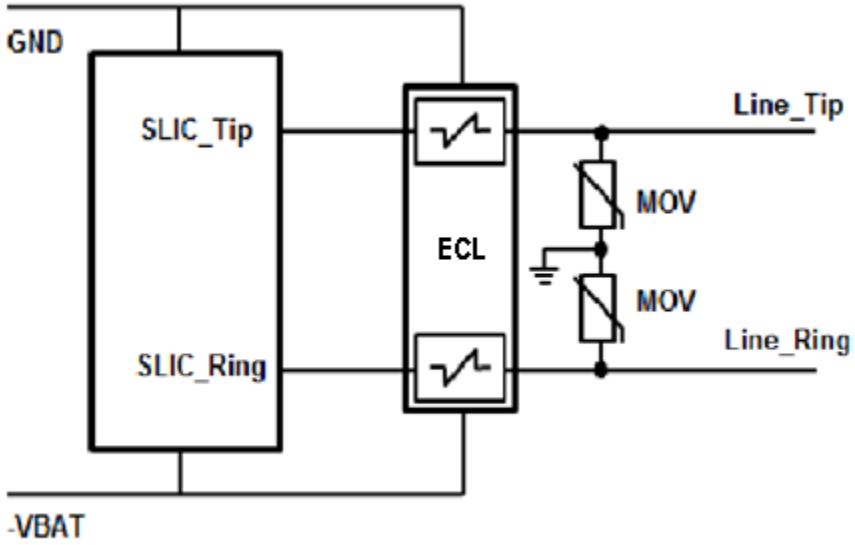
Impulse Surge test results

Lightning: 2/10 µs, 2.5 kV, 500 A



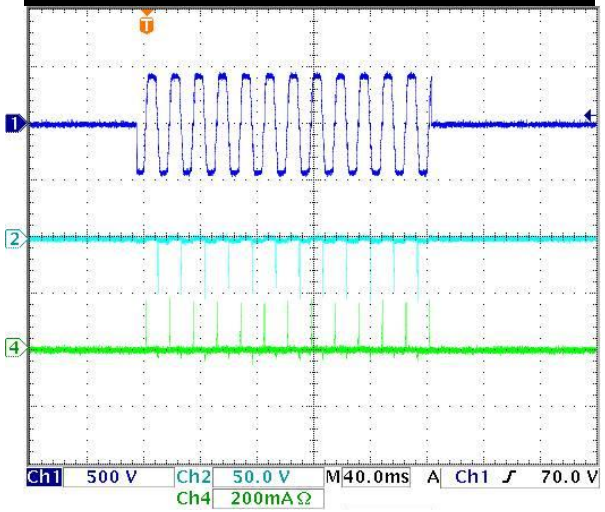
Lightning: 10/700 µs, 6 kV, 150 A



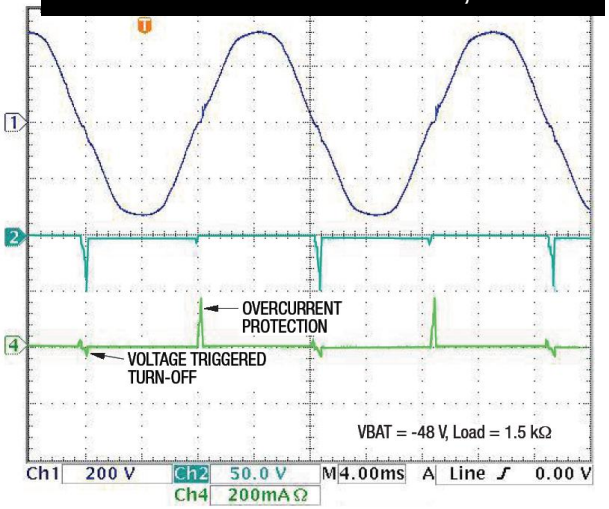


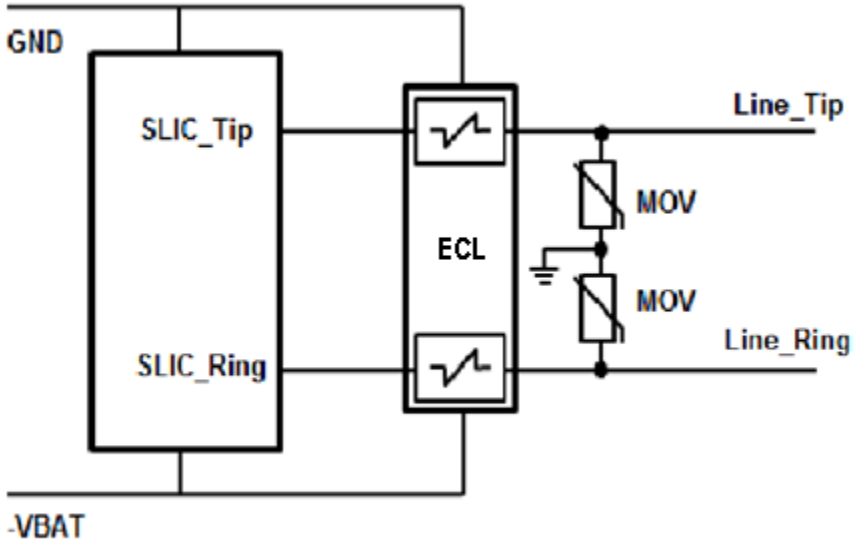
Power Fault test results

Power Ind.: 600 V, 600 Ω, 0.2 s



Power Fault: 230 Vrms, 25 A



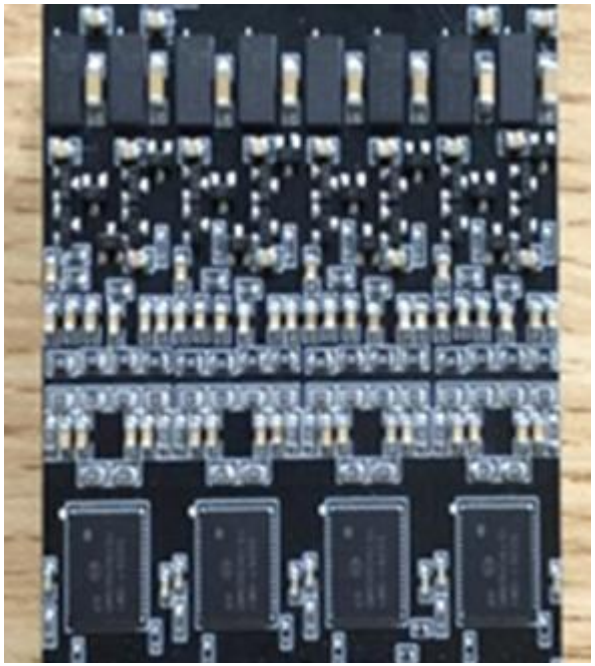


Design consideration for Voice Port for MDU (1)

Q: How to make all devices SMT, while protecting against power fault?

A: SMT Thyristors + SMT ECL/ES

Series ECL/ES can handle the power fault to GR-1089-CORE port type 4/4a and ITU K.45 enhanced level requirements.



7cm x 6 cm board design with Thyristors + ECL/ES

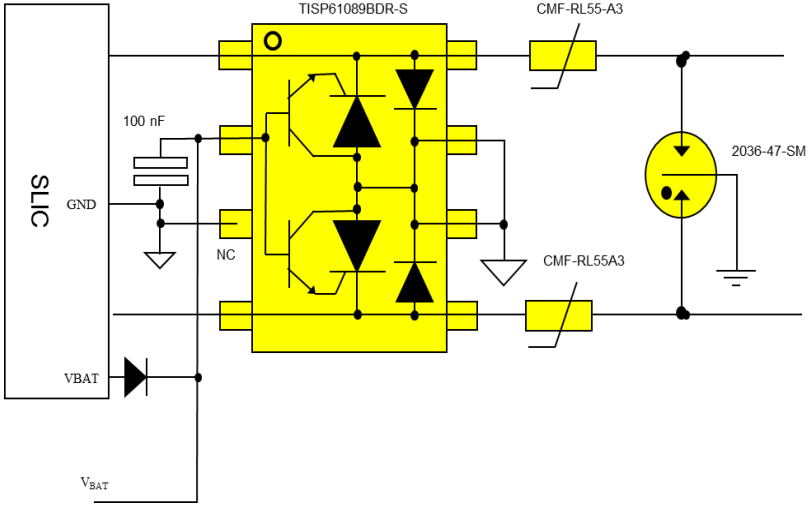
Design consideration for Voice Port for MDU (2)

Q: How to protect ITU K.45 10/700 4 kV on board when Main Distribution Frame cannot be installed in building ?

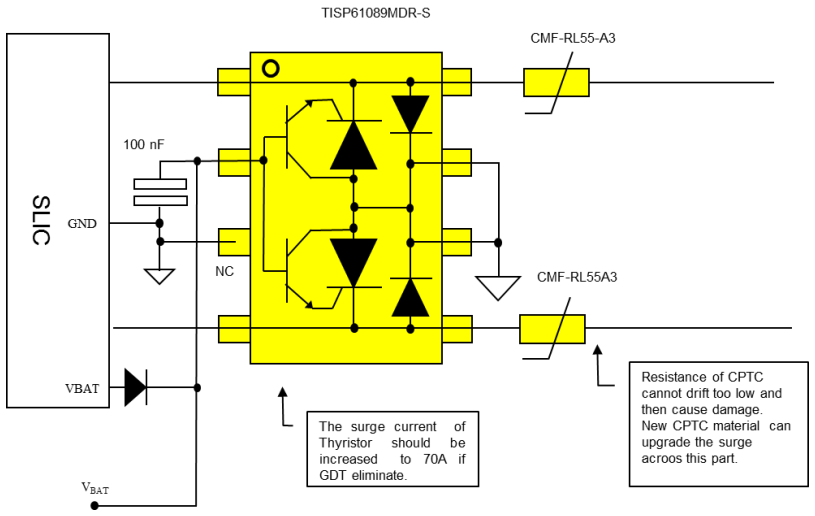
Solution 2:

*4 kV CPTC + higher current rating of gated thyristor (5/310 70 A)

Solution 1:



GDT+CPTC+Thyristor (5/310 40 A)



High Voltage CPTC+ high current rating Thyristor (5/310 70 A)

Summary

- MDU ONTs require robust voice port protection, evidenced by field failures.
- Electronic Current Limiters, as defined in GR-3154-CORE, can offer practical solutions, and are commonly applied in voice port protection.
- New ECLs and crowbar devices used in the latest designs for Asian markets reduce size and cost and improve production efficiencies.