Beam Interlock System
SPS CIBU Connection Review

Christophe Martin
TE/MPE

Outline:

- CIBU distribution in SPS
- “Conform connection” definition
- Commissioning Tool
- “non-conform connection” in SPS
- Open issues

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Location	Channel Nb	Used	Short Name	Additional info	Groupe
BA1	1	YES	Vacuum LSS1 +TT10		TE-VSC-ICM
BA1	2	YES	MKD		TE-ABT-EC
BA1	3	YES	Q KICKER		TE-ABT-EC
BA1	4	NO	WIC	New Input	TE-MPE-MS
BA1	8	YES	BLM LSS1		BE-BI-BL
BA1	9	YES	Beam Position		BE-BI-SW
BA1	10	YES	BLM Ring		BE-BI-BL
BA2	1	YES	Vacuum LSS2		TE-VSC-ICM
BA2	2	NO	WIC	New Input	TE-MPE-MS
BA2	8	YES	BLM LSS2+TT20+Spl		BE-BI-BL
BA2	9	YES	TBSE TT21		EN-STI-ECE
BA2	10	YES	TED TT20		EN-STI-ECE
BA2	11	YES	Vacuum TT20		TE-VSC-ICM
BA2	12	YES	ZS Electronic system		TE-ABT-EC
BA2	13	YES	ZS Spark		TE-ABT-EC
BA3	1	YES	Vacuum LSS3		TE-VSC-ICM
BA3	2	YES	ACCESS Chain-1		GS-ASE-SSE
BA3	3	YES	Operators Buttons		TE-MPE-EP
BA3	4	YES	MPS Dipoles		TE-EPC-MPC
BA3	5	YES	MPS Quadripoles		TE-EPC-MPC
BA3	6	YES	MPS Sextupoles		TE-EPC-MPC
BA3	7	NO	WIC	New Input	TE-MPE-MS
BA3	8	NO	SPS Eco	New Input	BE-OP-SPS
BA3	9	YES	BCT		BE-BI-SW
BA3	10	YES	RF		BE-RF-FB
BA3	11	YES	Vacuum TT80		TE-VSC-ICM
BA3	12	YES	ROCS interlock		TE-EPC-CCS
BA3	13	NO	WIC Ring Line	New Input	TE-MPE-MS

Location	Channel Nb	Used	Short Name	Additional info	Groupe
BA4	1	YES	Vacuum LSS4		TE-VSC-ICM
BA4	2	NO	WIC	New Input	TE-MPE-MS
BA4	3	YES	MKE4 Status		TE-ABT-EC
BA4	8	YES	BLM LSS4		BE-BI-BL
BA4	9	YES	BCT		BE-BI-SW
BA5	1	YES	Vacuum LSS5		TE-VSC-ICM
BA5	2	NO	WIC	New Input	TE-MPE-MS
BA5	8	YES	Collimators		EN-STI-ECE
BA5	9	YES	BLM LSS5		BE-BI-BL
BA5	10	YES	UA9 Collimators		EN-STI-ECE
BA6	1	YES	Vacuum LSS6		TE-VSC-ICM
BA6	2	NO	WIC	New Input	TE-MPE-MS
BA6	3	YES	MKE6 Status		TE-ABT-EC
BA6	8	YES	BLM LSS6		BE-BI-BL
BA6	9	YES	Turn by turn Interlock		BE-BI-QP

For the SPS, 43 CIBU in total

- 35 CIBU in operation before LS1
- 8 new CIBU installed during LS1

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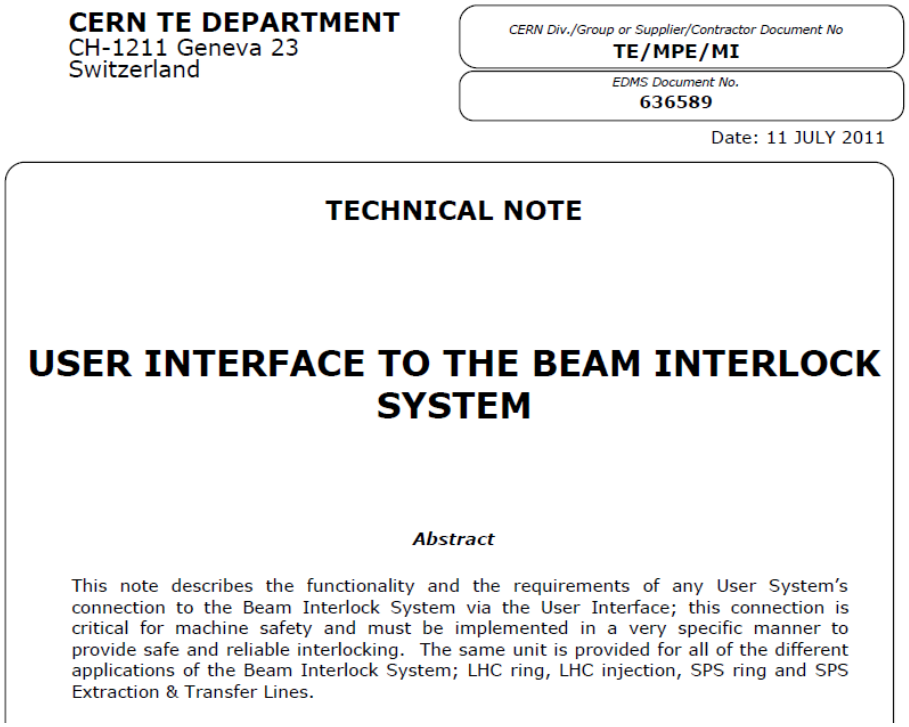
CIBU User manual



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CERN Div./Group or Supplier/Contractor Document No
TE/MPE/MI

EDMS Document No.
636589

Date: 11 JULY 2011

TECHNICAL NOTE

USER INTERFACE TO THE BEAM INTERLOCK SYSTEM

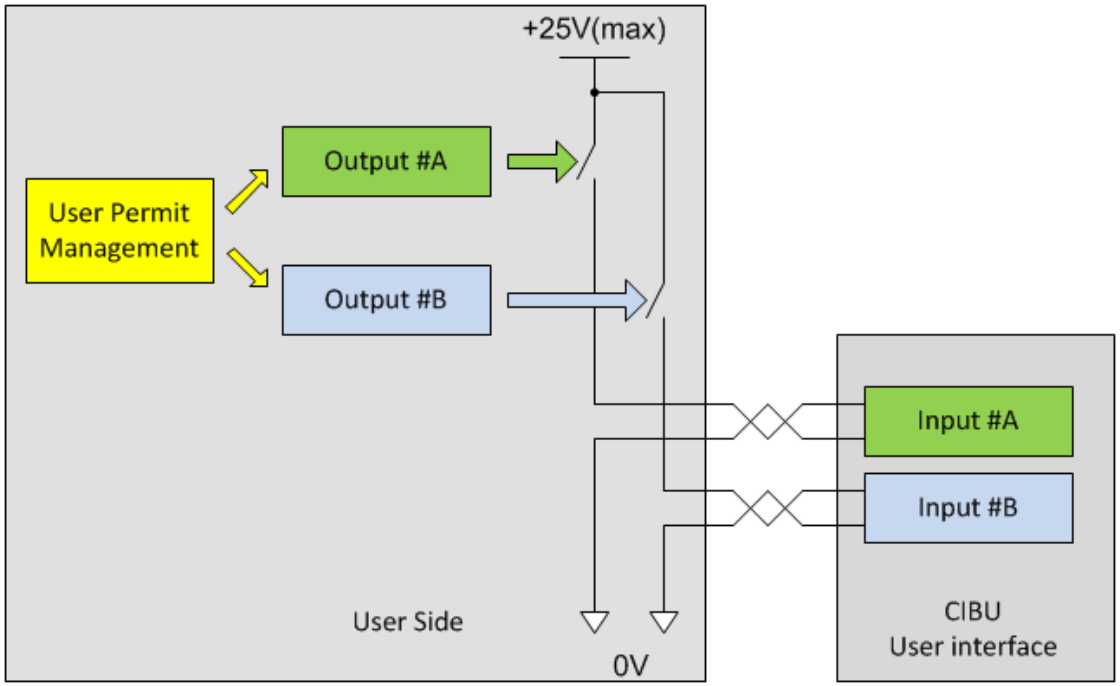
Abstract

This note describes the functionality and the requirements of any User System's connection to the Beam Interlock System via the User Interface; this connection is critical for machine safety and must be implemented in a very specific manner to provide safe and reliable interlocking. The same unit is provided for all of the different applications of the Beam Interlock System; LHC ring, LHC injection, SPS ring and SPS Extraction & Transfer Lines.

- EDMS 636589

The reference document used to qualify a CIBU connection is the CIBU user manual 1V51

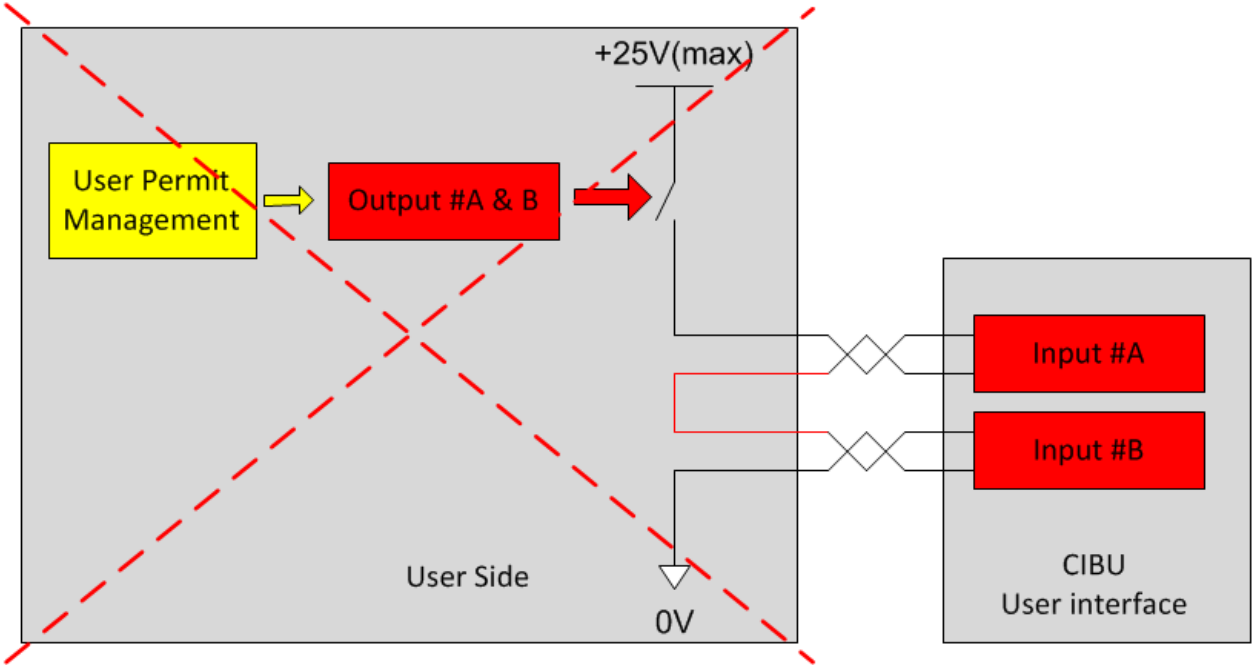
CIBU redundant signals



Distinct connection ✓ OK

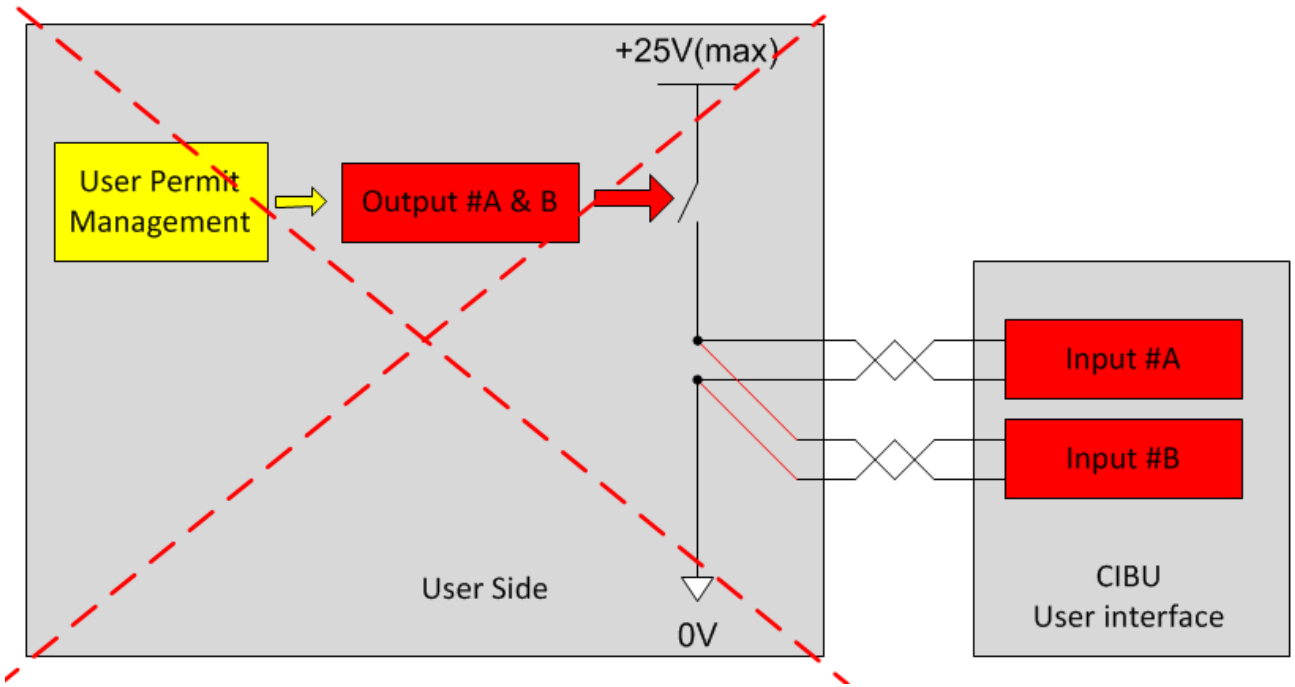
- The redundancy is applied at least at the “Output stage” of the User electronic

CIBU redundant signals



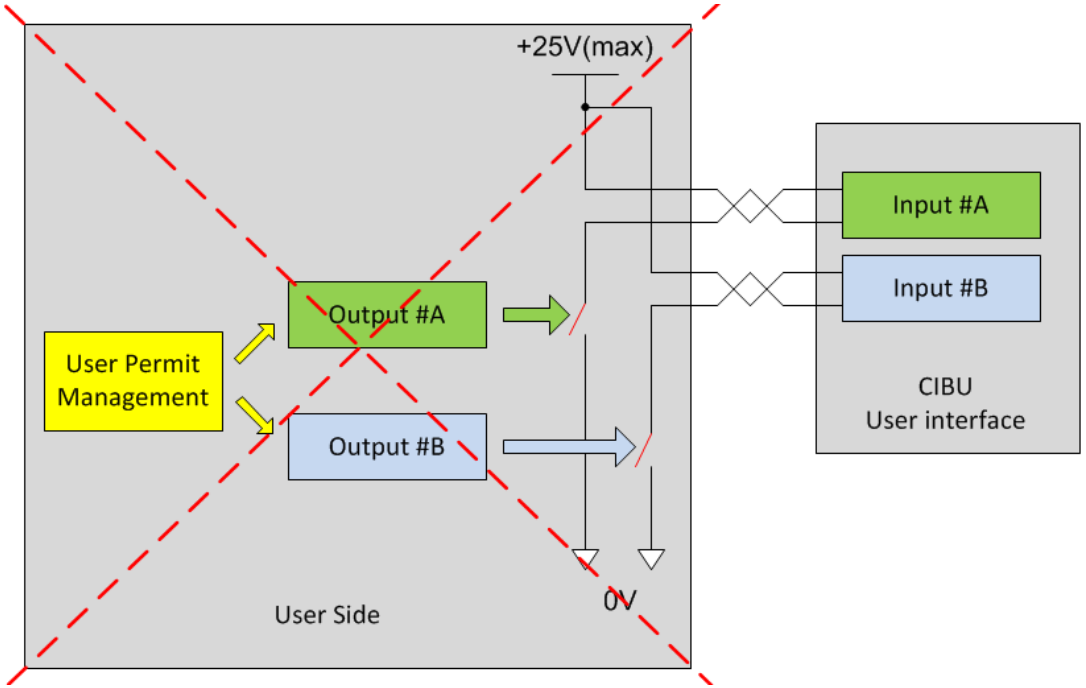
Serial connection NON-CONFORM !

CIBU redundant signals



Parallel connection NON-CONFORM !

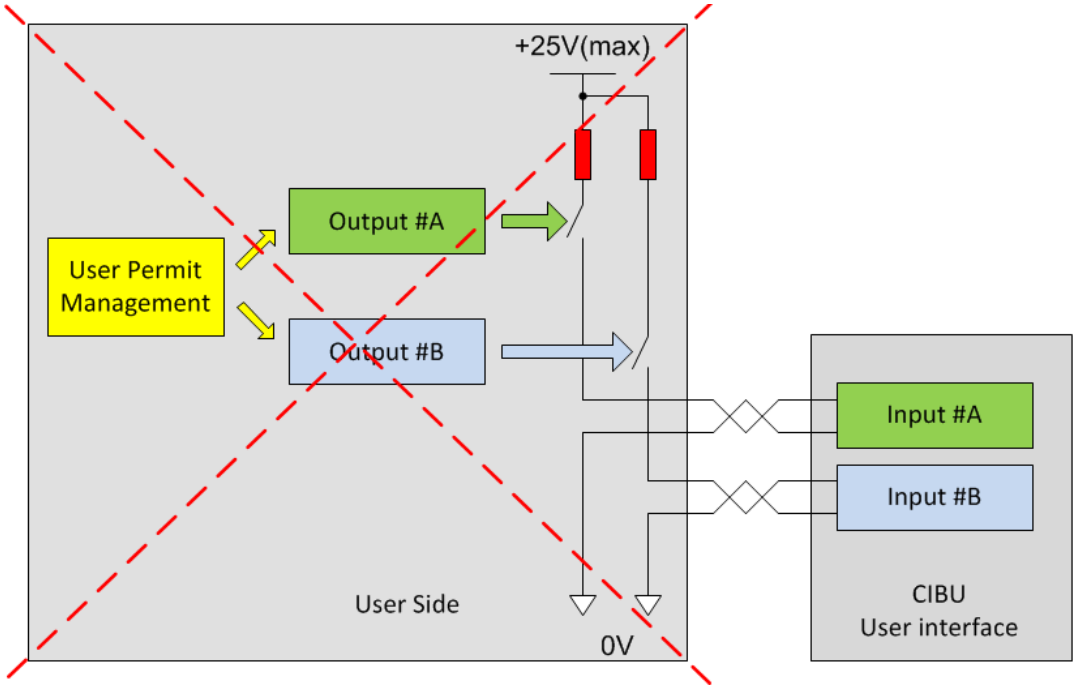
CIBU Switches position



Wrong switches position NON-CONFORM !

- This schematic was the recommended implementation in the CIBU user manual 1V4 up to 2009 !!!
- Following the presentation “CIBU Connection Review” of Benjamin Todd of December 2008, this schematic has been reported as “non-conform”

User output impedance



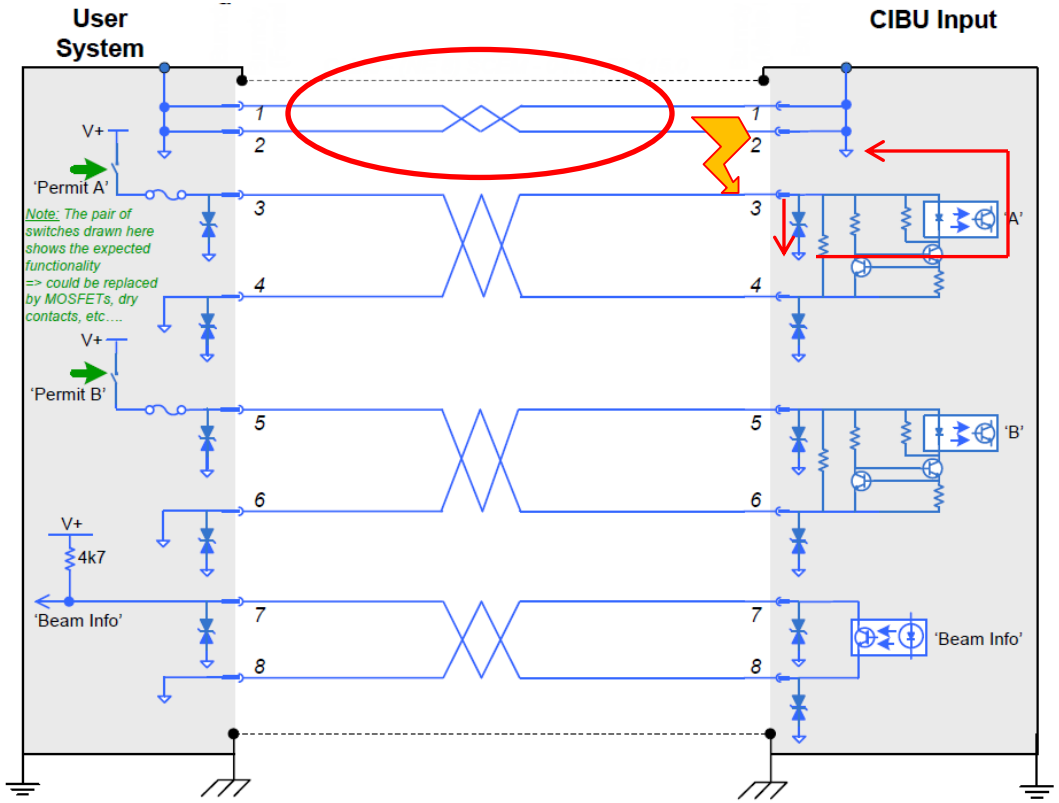
Serial resistor

NON-CONFORM !

- In the CIBU user manual 1V4 up to 2009 a misinterpretation can lead the users to provide a current into the CIBU.

The current loop is inside the CIBU, the user has to provide a voltage !

CONNECTION DETAILS BETWEEN THE USER SYSTEMS AND THE CIBU



- If wire "1" and "2" are not connected, the cabling is not conform
  (No return path for the CIBU voltage suppressor in case of over voltage)

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EMC COMPLIANCE INTERCONNECTION

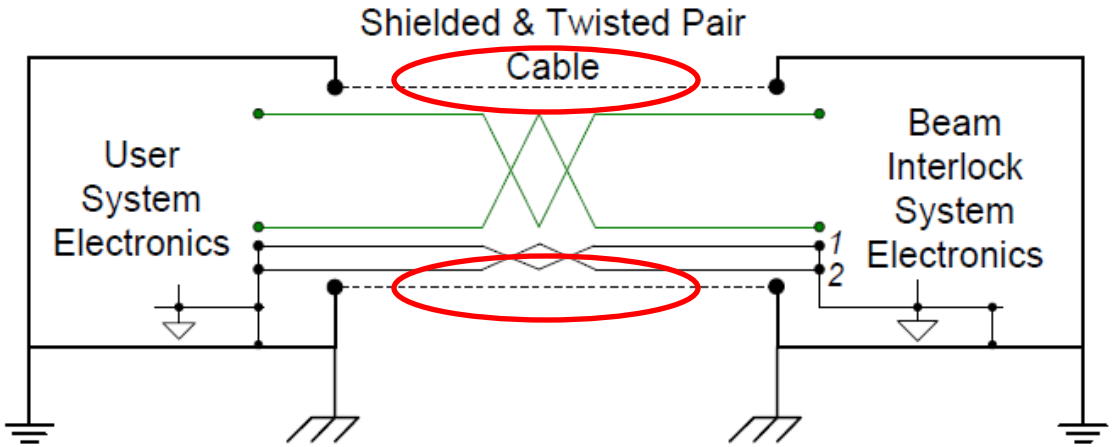

Figure 11: Principle of Interconnection for Complete EMC Compliance

- The shielding must be present on the connection cable (visual control)

Reminder: The interconnection cable between the User electronics and the CIBU is under the responsibility of the user!

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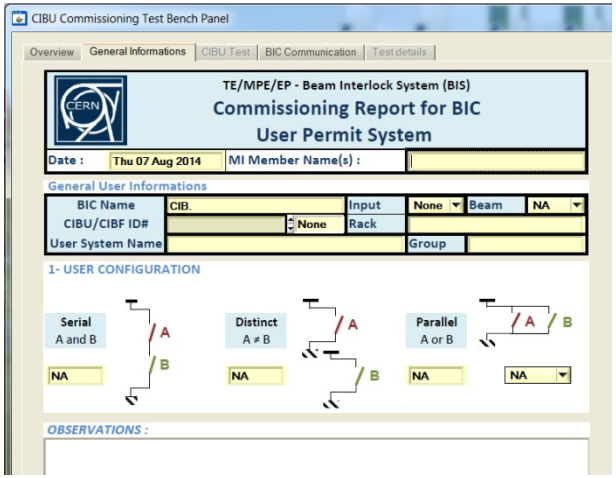
NEW CIBU COMMISSIONING TOOL

BIS Handheld tester

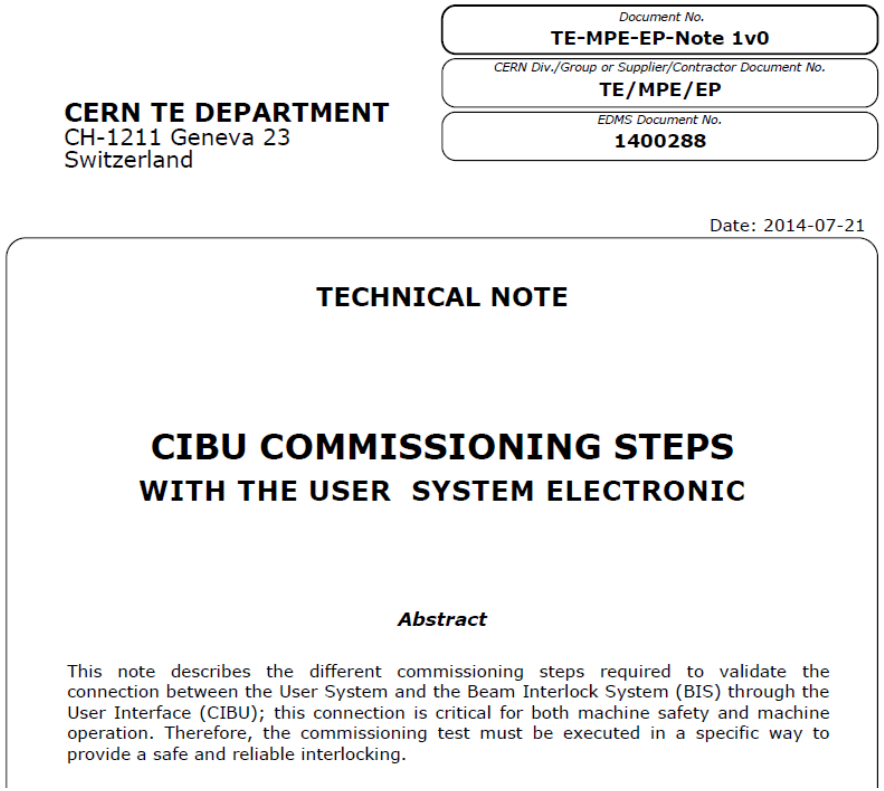


NI CVI remote application on Windows PC

Main features:

- Checks the voltage applied on both user permit (A+, A- & B+, B-)
- Checks the User Output impedance (A & B)
- Checks the current drawn by the CIBU (A & B)
- Checks the redundancy of user permit A & B (serial connections are detected)
- Checks the ground connection (pin 1 & 2)
- Automatically generates an Excel report (Bluetooth connection with a windows PC)

COMMISSIONING TEST SEQUENCE



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TE/MPE/EP
EDMS Document No.
1400288

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Date: 2014-07-21

TECHNICAL NOTE

CIBU COMMISSIONING STEPS
WITH THE USER SYSTEM ELECTRONIC

Abstract

This note describes the different commissioning steps required to validate the connection between the User System and the Beam Interlock System (BIS) through the User Interface (CIBU); this connection is critical for both machine safety and machine operation. Therefore, the commissioning test must be executed in a specific way to provide a safe and reliable interlocking.

- EDMS 1400288

- In order to efficiently realise the commissioning test, the owner of the system can find in this document all details related to the test sequence.

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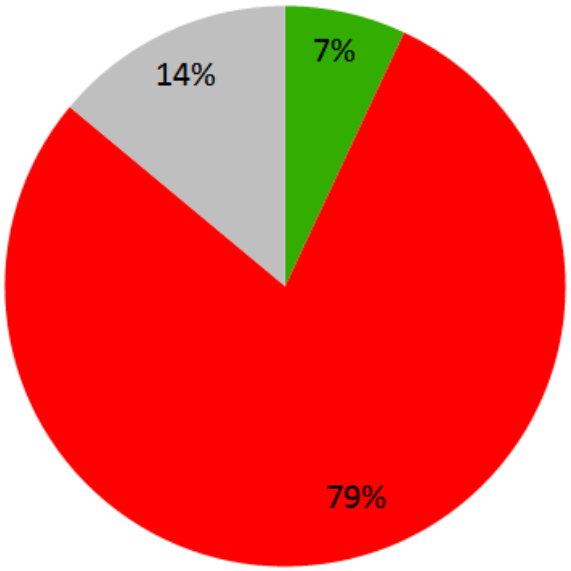
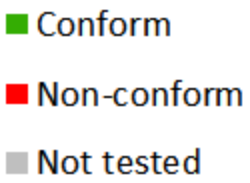
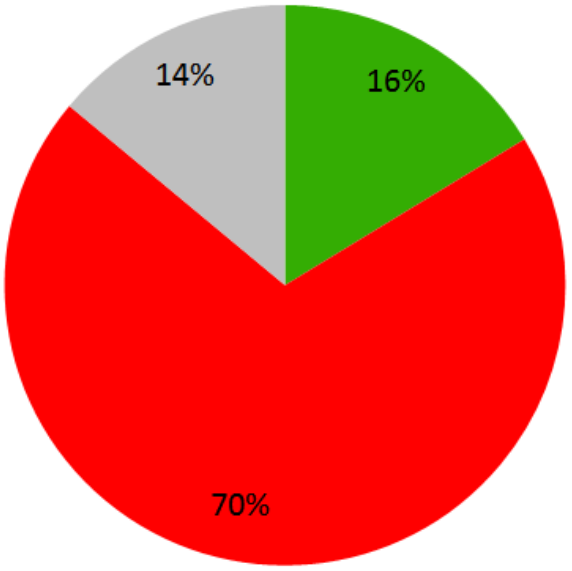
SPS CIBU CONNECTION STATUS



As found in June





After User improvement

SPS NON-CONFORMITY DETAILS

Systems	Number of CIBU	Resistor in series	Seial connection	Parallel connection	Switch on GND	No GND	GND On CIBU connector
BLM	6	X		X		X	
BCT	2				X		
RF	1				X		
Collimators	3				X		
Turn by turn	1				X		
MKD	1		X			X	
MKE6	1		X			X	
Q Kicker	1		X			X	
MKE4	1		X				
SPS operator switches	1					X	
WIC	7					X	
Beam Position	1			X		X	
Vacuum	8			X		X	

Total non-conformity 34

As found in June

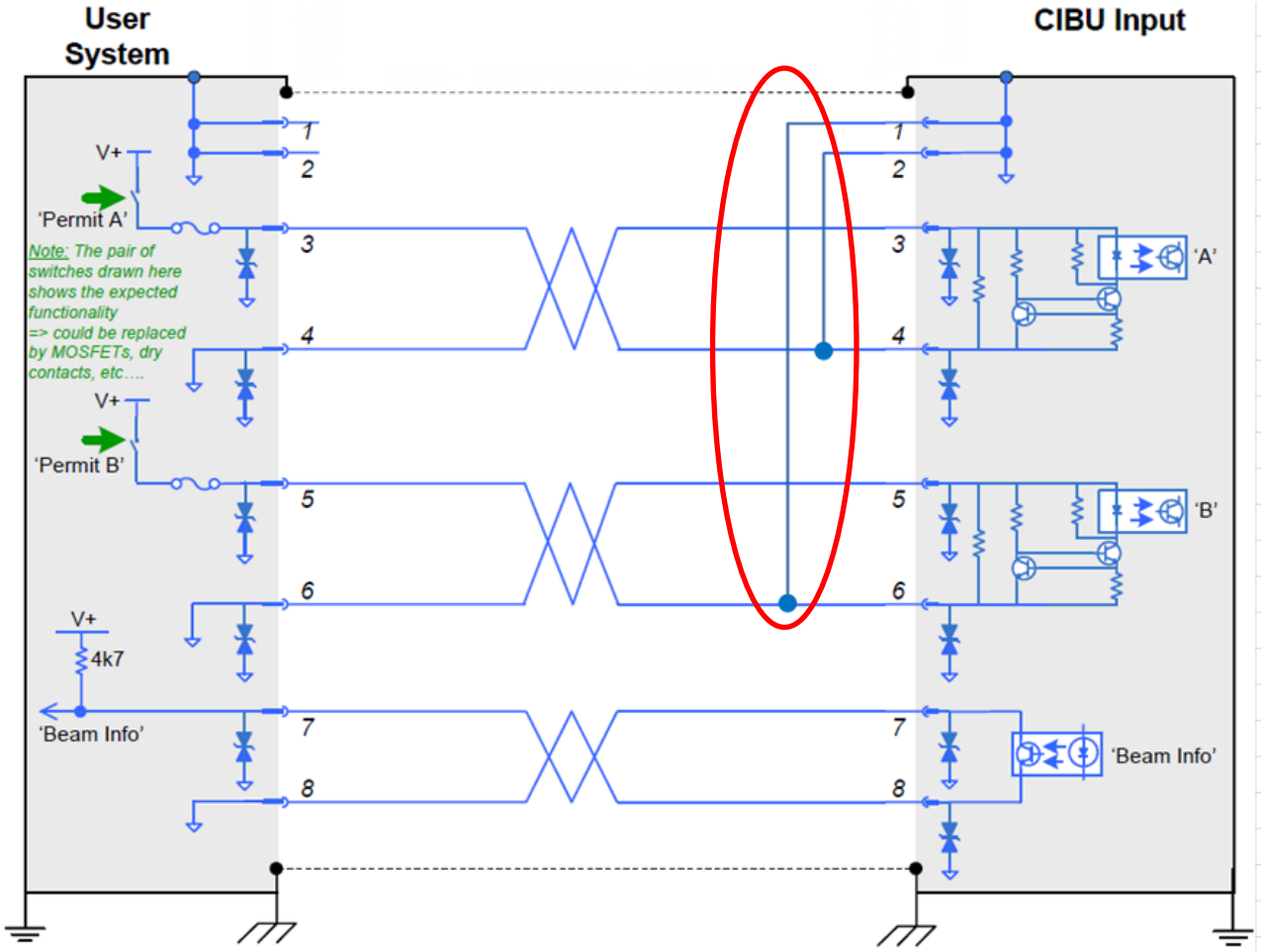
SPS NON-CONFORMITY DETAILS

Systems	Number of CIBU	Resistor in series	Seial connection	Parallel connection	Switch on GND	No GND	GND On CIBU connector
BLM	6	X		X		X	
BCT	2				X		
RF	1				X		
Collimators	3				OK		
Turn by turn	1				X		
MKD	1		X			X	
MKE6	1		X			X	
Q Kicker	1		X			X	
MKE4	1		X				
SPS operator switches	1					OK	
WIC	7					OK	→ X
Beam Position	1			X		X	
Vacuum	8			X		OK	

Total non-conformity 30

After User improvement

GND ON CIBU CONNECTOR



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NOT TESTED CIBU IN THE SPS

Currently, the following systems have been not yet tested:

Location	Short Name	Group
BA3	ACCESS Chain-1	GS-ASE-AC
BA2	ZS Spark	TE-ABT-EC
BA3	ROCS interlock	TE-EPC-CCS
BA3	MPS Dipoles	
BA3	MPS Quadripoles	TE-EPC-MPC
BA3	MPS Sextupoles	

Not tested CIBU: 6

Note: the test of the CIBU "ACCESS Chain 1" is foreseen on the 27/09 during the DSO tests

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- Many connections in the SPS are reported as “non-conform”.
  What will we do with these connections ???

- We needed more or less 2 months for testing 34 CIBU in the SPS

  - LHC => 152 CIBU
  - Extraction => 108 CIBU
  - Injection => 37 CIBU

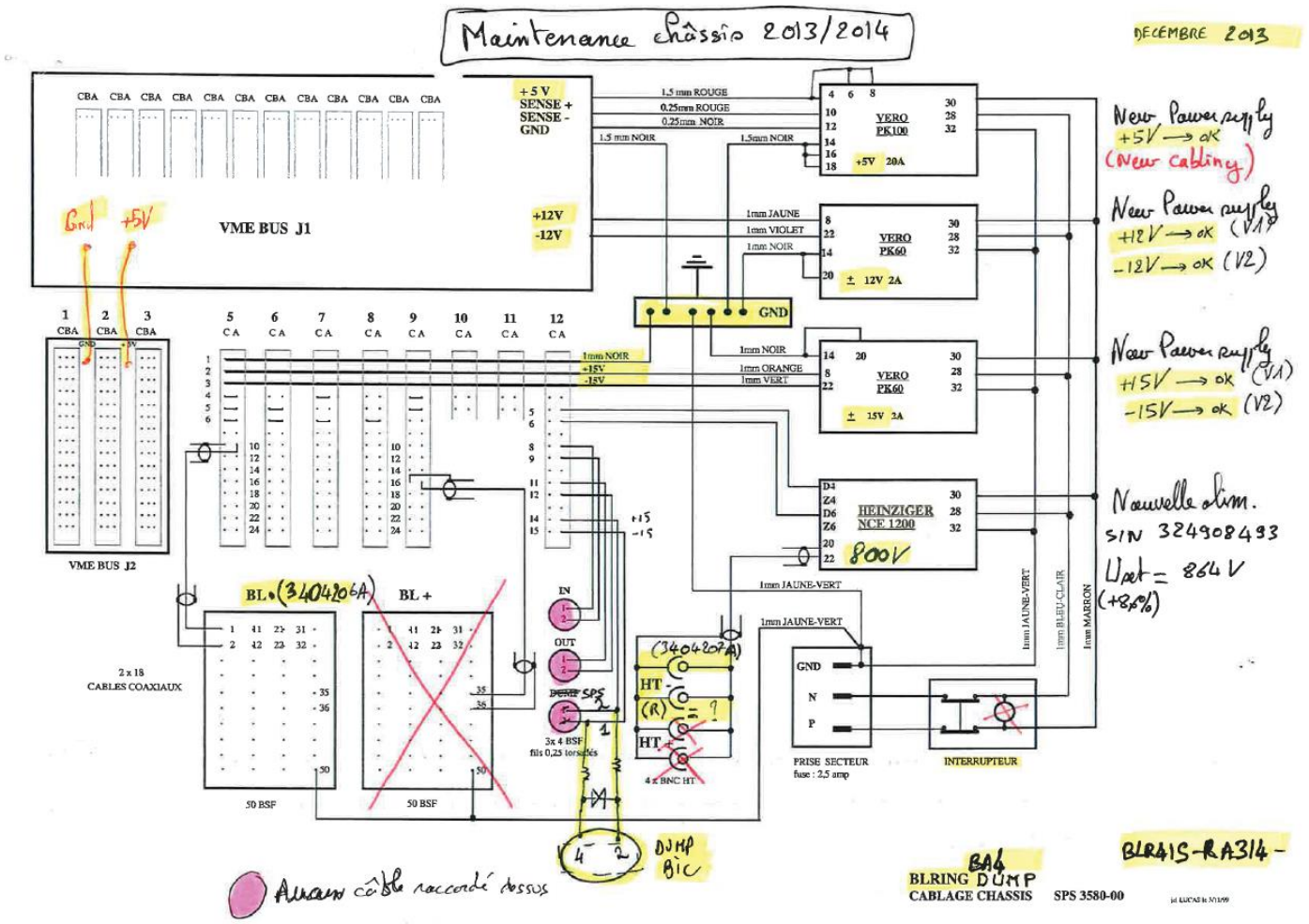
  Total => 297 CIBU !!!

We can assume that a lot of time will be required if we have to re-test all these CIBU

Thanks for your attention

Spare slides

BLM DETAIL CONNECTION



Timescale

7th August 2008

No Beam In the Machine
Final Commissioning Vacuum System to Beam Interlock System

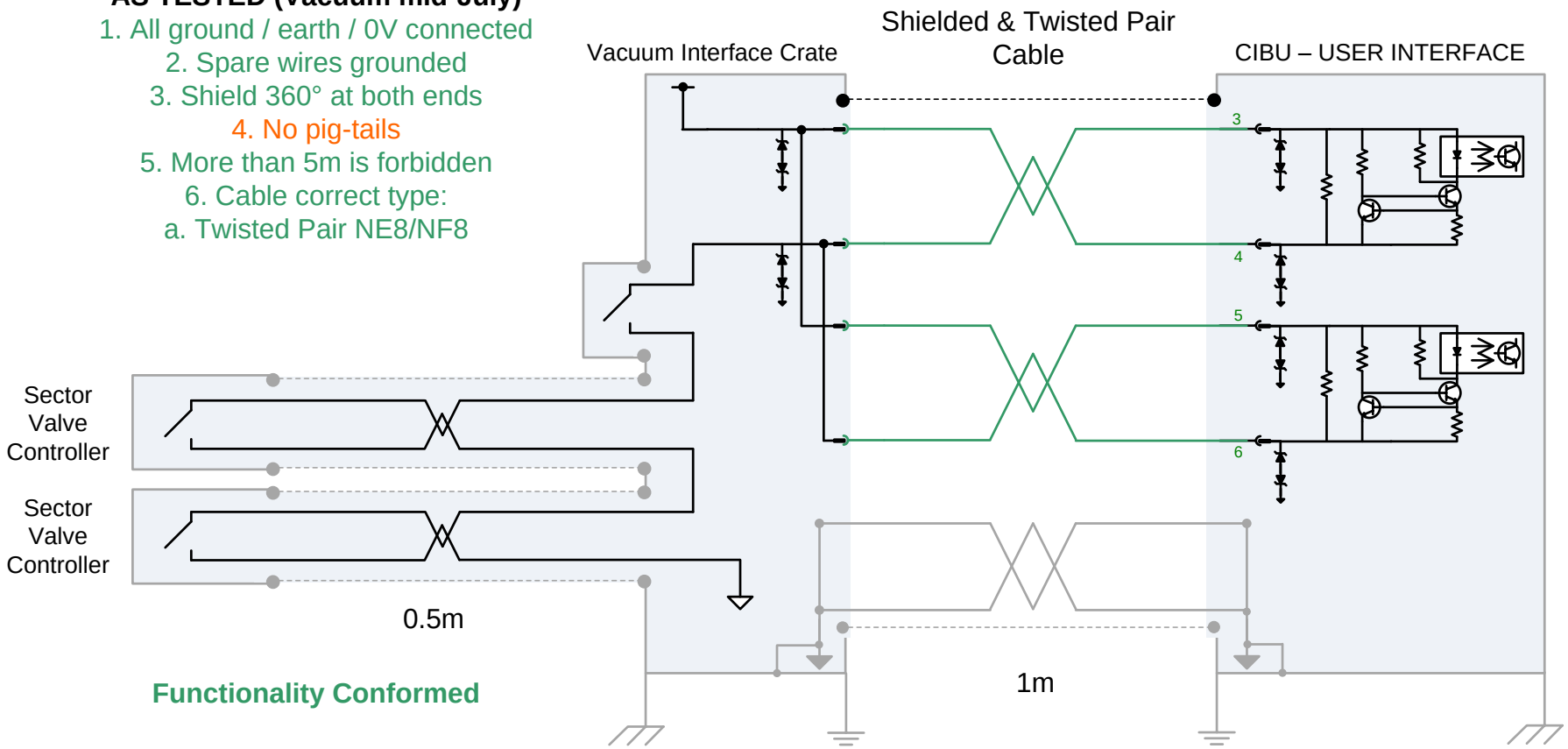
1. Vacuum Valves moved IN around IR3
2. Vacuum UJ33 USER_PERMIT_A stayed TRUE
3. Vacuum UJ33 USER_PERMIT_B stayed TRUE
4. BIC Test Mode showed ALL OK

Commissioning Fail

As Tested July 08

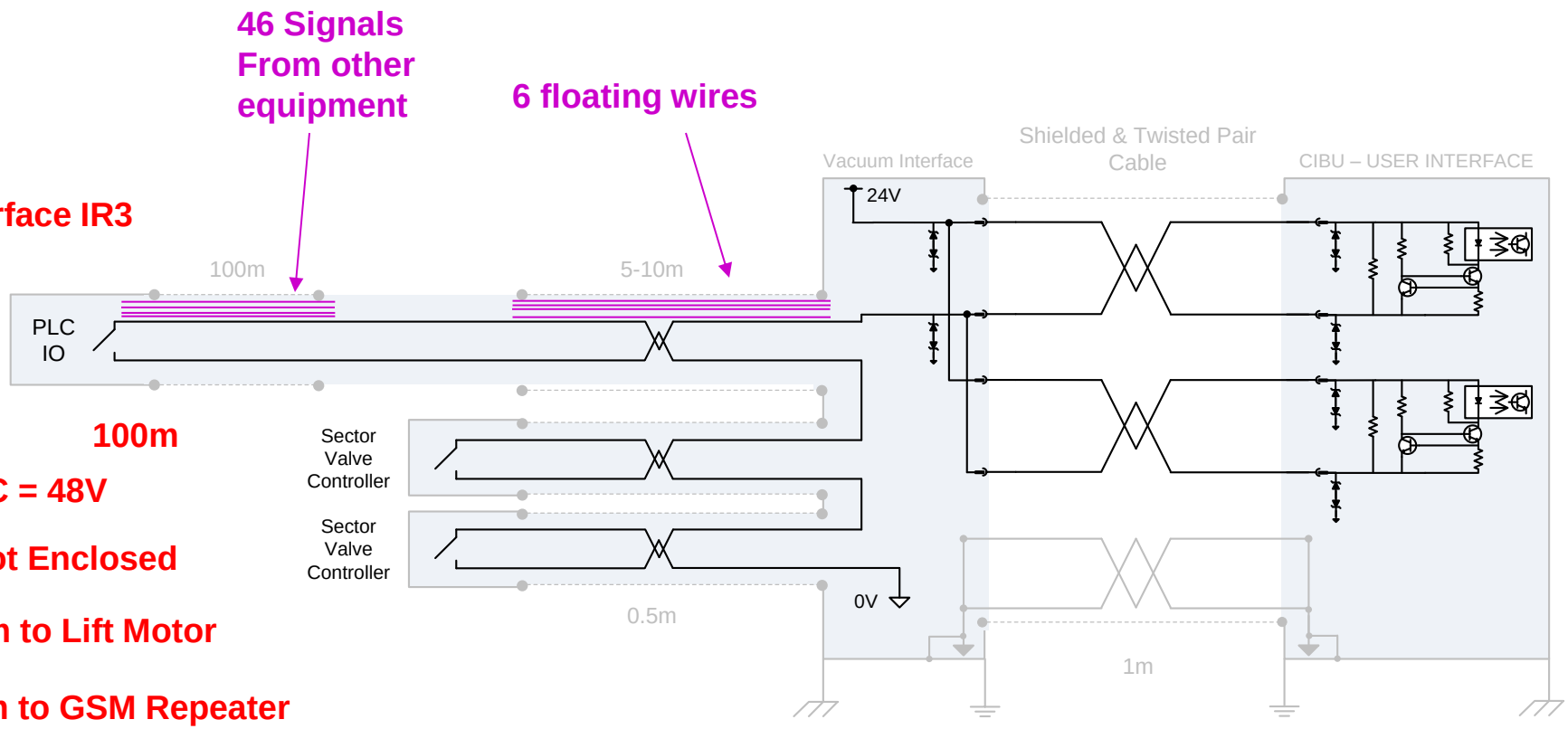
AS TESTED (Vacuum mid-July)

1. All ground / earth / 0V connected
2. Spare wires grounded
3. Shield 360° at both ends
4. No pig-tails
5. More than 5m is forbidden
6. Cable correct type:
   a. Twisted Pair NE8/NF8



Functionality Conformed

August 08 - After Incident



PLC = 48V

Not Enclosed

2m to Lift Motor

1m to GSM Repeater

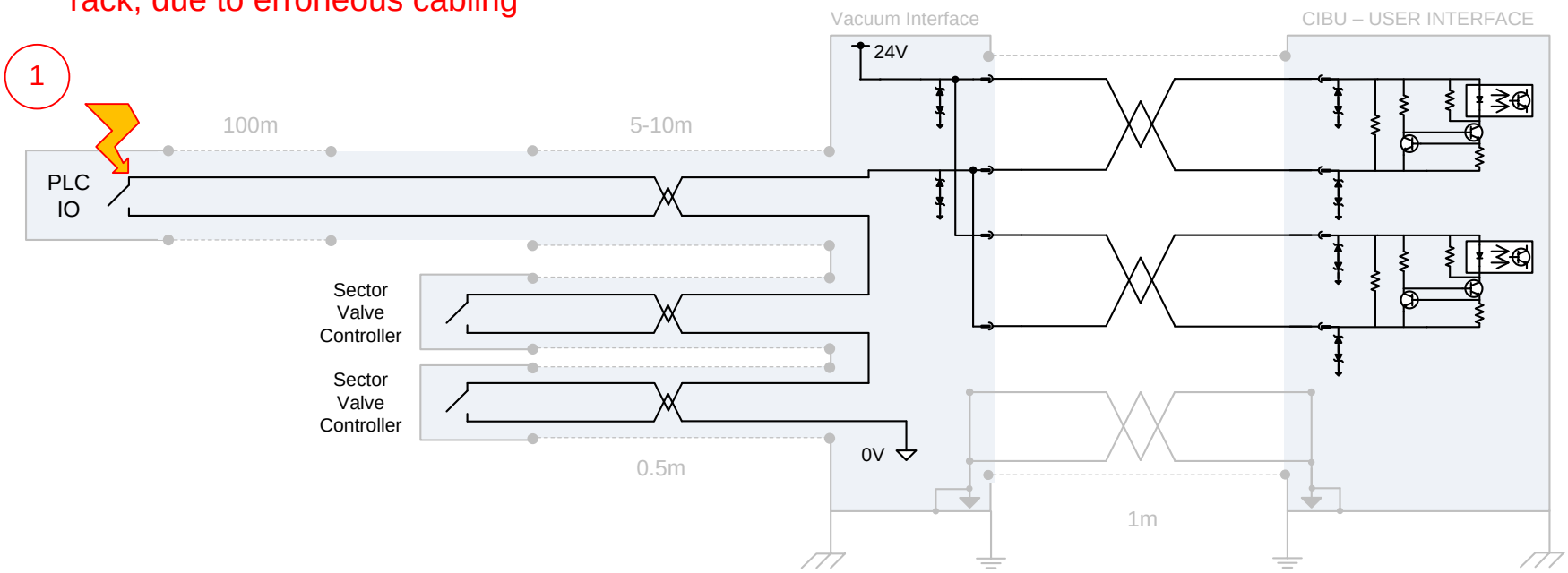
WHEN CONNECTED CIBU ALWAYS TRUE (next slides)

What was the mechanism?

Presumed Failure

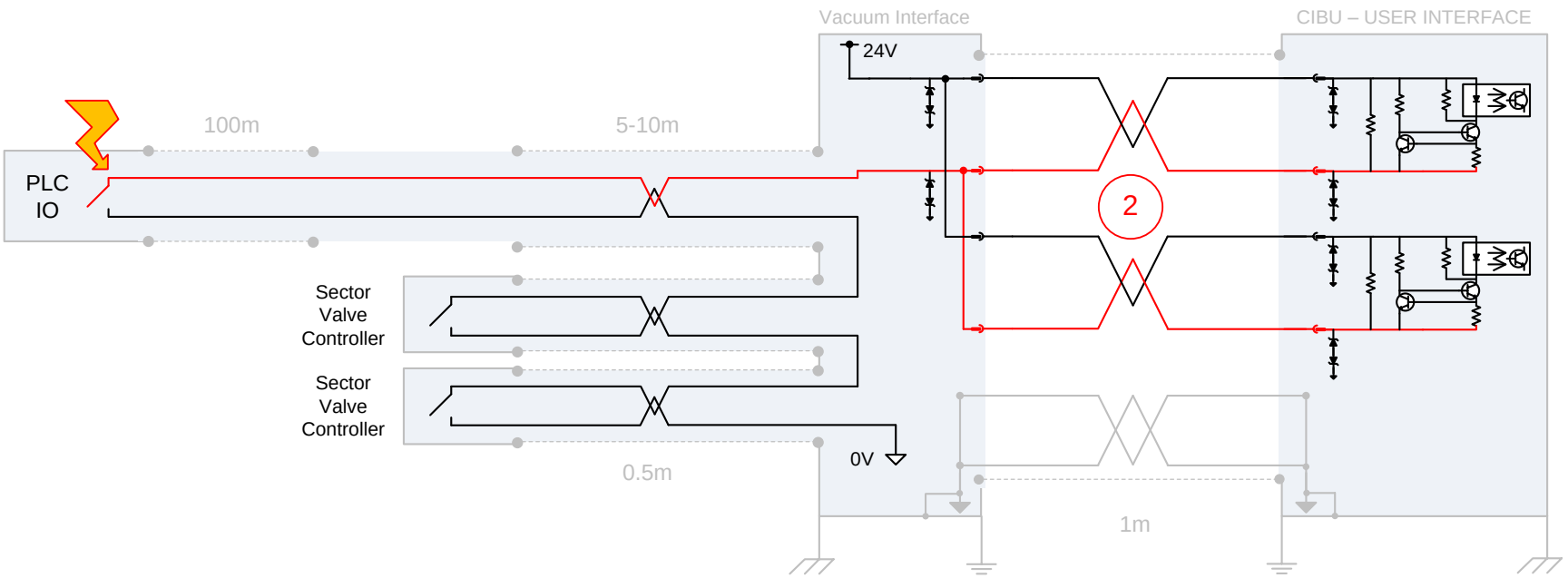
1. Excessive Voltage

Is applied in the Access System PLC rack, due to erroneous cabling

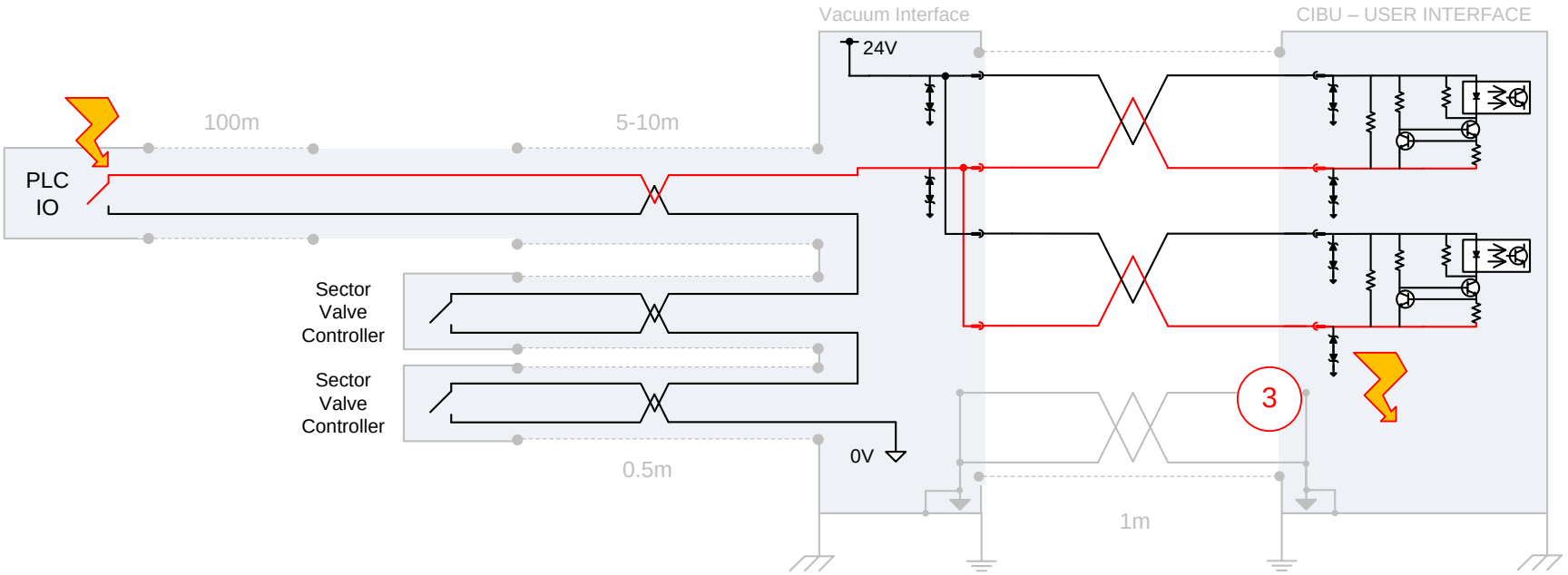


What was the mechanism?

2. This subjects the CIBU negative current loop to an excessive voltage (48V)



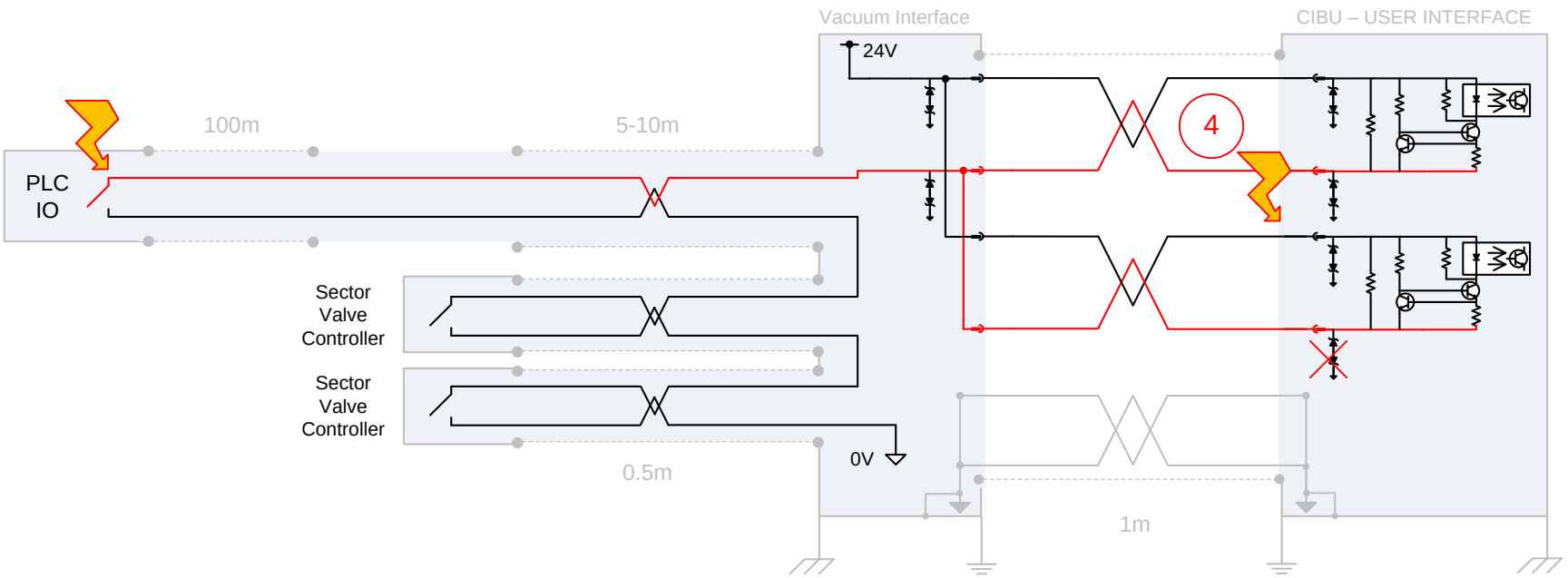
What was the mechanism?



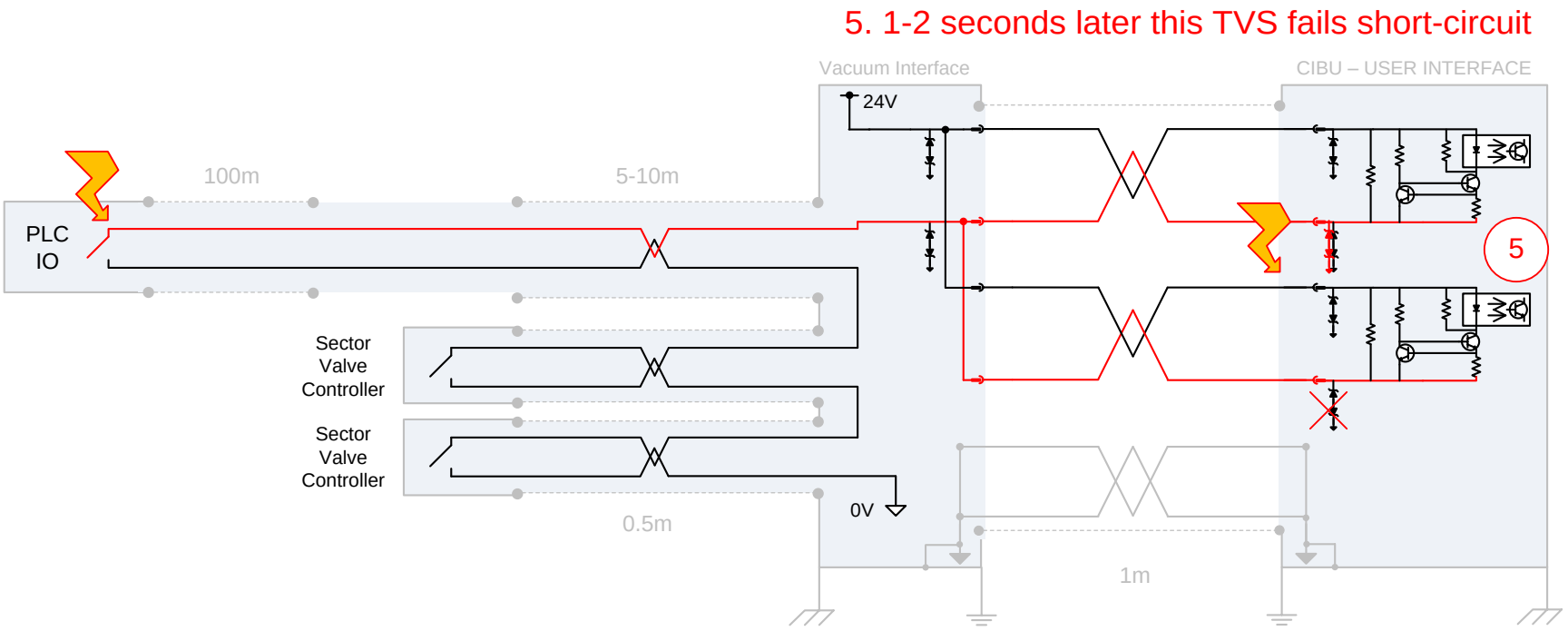
3. The Transient Voltage Supressor (SM6T30CA) Clamps the voltage and dissipates the energy

What was the mechanism?

4. Experiments show that after 1-2 seconds the TVS will fail, this TVS fails open-circuit The ‘A’ loop TVS now absorbs the excess

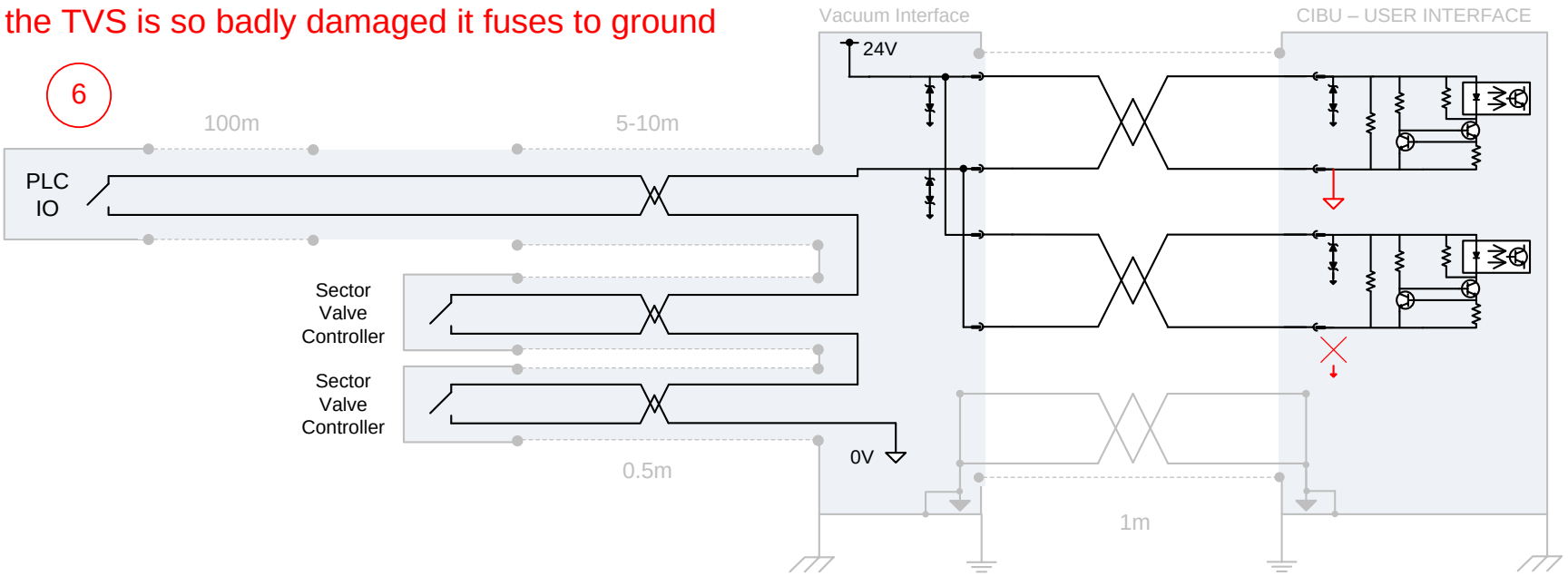


What was the mechanism?



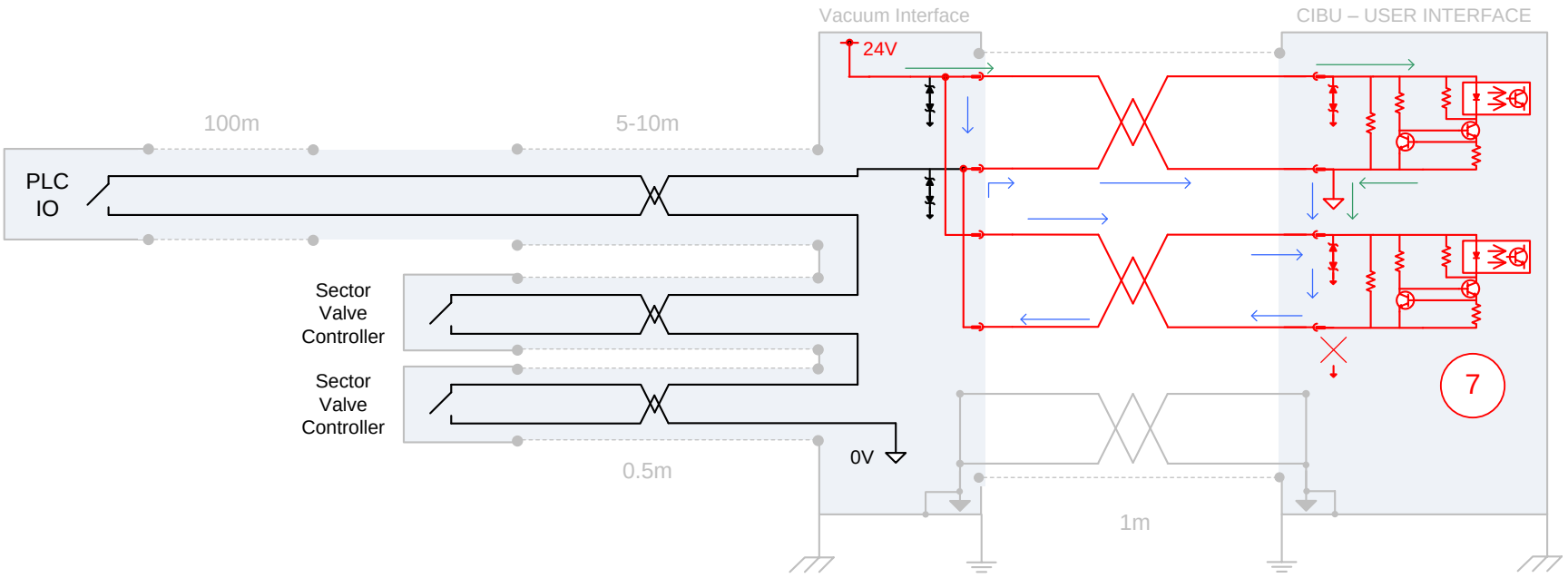
What was the mechanism?

6. The fault is discovered in the ACCESS system and is removed
But the TVS is so badly damaged it fuses to ground



What was the mechanism?

7. At this point both USER PERMIT A and B are stuck TRUE as current flows to ground through A (green) and B (blue) using the damaged TVS



In Summary

Several events = complete Blind Failure

1. Two Equipment systems sharing the same channel
2. PLC Voltage against rules
3. TVS Blocked Short-Circuit
4. Inputs were not redundant
5. Not re-commissioned by MI after a significant change

In addition…

a) Cable length against rules
b) EMC would have been a show-stopper anyway!