

# MPP meeting #199:

### WIC delay for switching off equipment for the PS

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### Introduction

The WIC system is a generic solution (originally) designed for the protection of resistive magnets

It is a PLC based system (Siemens)

It was first implemented in the SPS-LHC transfer lines, the LEIR and the LHC in 2004-2005

It is now deployed in the whole CERN accelerator complex

- It collects inputs from thermo-switches, flow switches, internal PC faults

- It provides Permits to the power converter and beam interlock system



Recently, we added inputs from other systems: PLCs, vacuum gages...



# The principle

### In case of a magnet overheating, the WIC will:

- 1. Request a Beam Dump to the BIS (circular acc.) or Inhibit the next beam (transfer lines)
- 2. After a configurable delay (typically 1,2s), remove the "Power Permit" to the power converters

### In case of a PC failure, the WIC will:

1. Request a Beam Dump to the BIS

This delay between the beam dump and removing the "Power Permit" was introduced to allow a clean beam extraction before ramping down the magnets

The response time of the WIC is not an issue for the protection of resistive magnets

This delay is common to all circuits connected to a given WIC



# **Extension to other equipment**

### Since 2016 (ELENA project), other types of equipment are protected by the WIC

### This trend increased during LS2

No BIS connection

Machine	Eq. type	Machine	Eq. type	Eq. name	Machine	Eq. type	Eq. name
ELENA	Septum (TE-ABT)	PSB	Septum (TE-ABT)	BI.SMV10	PS	Septum (TE-ABT)	PE.SMH16
ELENA	Ion switch (TE-ABT)	PSB	Bumper (TE-ABT)	BI.BSW	PS	Septum (TE-ABT)	PE.SMH57
ELENA	Electron Cooler (BE-BI) ?	PSB	Septum (TE-ABT)	BE.SMH15L1	PS	Septum (TE-ABT)	PE.SMH61
ELENA	Electrostatic ?	PSB	Septum (TE-ABT)	BT1.SMV10	PS	Bumper (TE-ABT)	PE.BSW57.61
		PSB	Septum (TE-ABT)	BT4.SMV10	PS	Septum (TE-ABT)	PI.SMH26
Machine	Ea type	PSB	Septum (TE-ABT)	BT2.SMV20	PS	Septum (TE-ABT)	PI.SMH42
LHC	Beam Beam Compensation Wires (BE-BI)		Other cas	ses ?	Identifie (high cur	d as critical /	



# Standardized interface for all Septa and Bumpers



The TS and FS signals are received directly from the tunnel and connected, in parallel, to:

- ABT's control PLC
- The WIC

by means of safety relays

=> ABT's control PLC is NOT introducing any extra delay.



# **Special case of the PE.SMH57**



The Irms max of this septum is 5 kA when the power converter can deliver 10 kA in continuous mode.

A dedicated "Fast Interlock system" was put in place (ABT) that measures the voltage and the current to calculate its internal temperature.

It sends an interlock signal at the end of a pulse to avoid switching off the PC during a pulse.



### PS duty cycle: 600ms plateau @ 10kA

SMH57 THIN SEPTUM MAGNET FAST INTERLOCK SYSTEM by Roger Barlow



# **Special case of the PE.SMH57**

Because of its high current density, the response time of the WIC becomes an issue.

A general rule of thumb is to assume that the PLC could take as long as twice the maximum cycle time to respond. But this assumption is not correct !

#### The response time of a PLC depends on 3 parameters:

1.	PLC cycle time	=> btw 117 and 131 ms
2.	Profibus cycle time	=> btw 5,8 and 28,1 ms
3.	I/Os sampling rate	=> btw 3 to 5 ms

This gives a response time for the PS WIC : btw 140 ms and 340 ms

#### Adding the 1.2 s delay is problematic for TE-ABT

Therefore, we made an exception in the PS and removed this delay

But this affects also all other circuits of the PS (next slide)







### List of power converters connected to the "PS\_Aux" WIC

PR.RODN PE.RBSW12 PR.RDHZ05.OC PE.RBSW14 PR.RNA0 PE.RBSW20 PR.RBGI84MAIN PE.RBSW22 PR.RBGI82MAIN PE.RBSW23 PR.RDHZ60.OC PE.RBSW23 PR.RDHZ60.OC PI.RBSW26 PR.RDVT02 PI.RBSW26 PR.RDVT04 PI.RBSW40 PI.RSM426 PR.RDVT04 PI.RBSW41 PI.RBSW42 PR.RDVT08 PI.RBSW42 PR.RDVT20 PI.RBSW42 PR.RDVT20 PI.RBSW43	Bldg. 355	Bldg. 365	
PR.RDH205.0CPE.RBSW14PR.RBG184MAINPE.RBSW20PR.RBG184MAINPE.RBSW22PR.RBG184MAINPE.RBSW22PR.RBG182TRIMPE.RBSW57PR.RBG182TRIMPE.RQKE16PR.RDVT02PI.RBSW46PR.RDVT04PI.RBSW46PR.RDVT05PI.RBSW42PR.RDV108PI.RBSW42PR.RDV12PI.RBSW42PR.RDV120PI.RBSW43PR.RDV121PI.RBSW44PR.RDV122PI.RBSW44PR.RDV124PI.RBSW44PR.RDV124PI.RBSW44PR.RDV133PE.RDH218.0CPR.RDV134PR.RDH218.0CPR.RDV138PR.RDN039PR.RDV138PR.RQN055PR.RDV144PR.RQN055PR.RDV154PR.RQTRDB.APR.RDV164PR.RQTRDB.APR.RDV170PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.BPR.RDV174PR.RQTRDB.APR.RDV174PR.RQTRDB.APR.RDV1780PR.RXNO39PR.RDV1780PR.RXNO55PR.RDV1780PR.RXNO55PR.RDV1780PR.RXN	PR.RODN	PE.RBSW12	
PR.RNO   PE.RBSW20     PR.RBGI84MAIN   PE.RBSW22     PR.RBGI84TRIM   PE.RBSW23     PR.RBGI82TRIM   PE.RQKE16     PR.RDVT02   PI.RBSW40     PR.RDVT02   PI.RBSW40     PR.RDVT04   PI.RBSW41     PR.RDVT02   PI.RBSW42     PR.RDVT02   PI.RBSW42     PR.RDVT02   PI.RBSW44     PR.RDVT20   PI.RBSW44     PR.RDVT21   PI.RBSW43     PR.RDVT22   PI.RBSW44     PR.RDVT24   PI.RBSW44     PR.RDVT24   PI.RBSW44     PR.RDVT24   PI.RDSW44     PR.RDVT34   PR.RONO39     PR.RDVT34   PR.RONO39     PR.RDVT64   PR.RQTRDB.A     PR.RDVT64   PR.RQTRDB.A     PR.RDVT64   PR.RQTRJ.R.A     PR.RDVT64   PR.RQTRJ.R.A     PR.RDVT65   PR.RDVT60     PR.RDVT80   PR.RXNO39     PR.RDVT88   PR.RXNO55     PR.RDVT88   PR.RXNO55	PR.RDHZ05.OC	PE.RBSW14	
PR.RBGI84MAIN   PE.RBSW22     PR.RBdi84TRIM   PE.RBSW23     PR.RDH260.OC   PE.RBSW57     PR.RDH260.OC   PE.RBSW57     PR.RDH260.OC   PI.RBSW26     PR.RDVT02   PI.RBSW40     PR.RDV104   PI.RBSW40     PR.RDV104   PI.RBSW42     PR.RDV12   PI.RBSW42     PR.RDV12   PI.RBSW43     PR.RDV12   PI.RBSW44     PR.RDV12   PI.RBSW44     PR.RDV124   PI.RBSW44     PR.RDV125   PI.RBSW44     PR.RDV126   PE.RSMH57     PR.RDV127   PI.RBSW44     PR.RDV128   PE.RSM57     PR.RDV130   PI.RQLB   PE.RSW57     PR.RDV134   PR.RON039   PE.RSMH61     PR.RDV138   PR.RON055   PE.RSMH61     PR.RDV174   PR.RQTRDB.A   PE.RSMH61     PR.RDV176   PR.RQTRDB.A   PE.RSM16     PR.RDV176   PR.RQTRDB.A   PE.RSM16     PR.RDV174   PR.RQTRDB.A   PE.RSM16     PR.RDV176   PR.RQTRDB.A   PE.RSM16     PR.RDV176   PR.RQTRDB.B   PR.RDV176 <td>PR.RXNO</td> <td>PE RBSW20</td> <td></td>	PR.RXNO	PE RBSW20	
PR.RBGB4TRIM   PE.RBSW23     PR.RBGB2MAIN   PE.RBSW23     PR.RBGB2MAIN   PE.RBSW57     PR.RBGB2TRIM   PE.RQKE16     PR.RDVT02   PI.RBSW26     PR.RDVT04   PI.RBSW40     PR.RDVT05   PI.RBSW41     PR.RDVT08   PI.RBSW41     PR.RDVT08   PI.RBSW42     PR.RDVT20   PI.RBSW43     PR.RDVT21   PI.RBSW43     PR.RDVT22   PI.RBSW44     PR.RDVT24   PI.RQLB     PR.RDVT38   PR.RDH218.0C     PR.RDVT38   PR.RON039     PR.RDVT38   PR.RON039     PR.RDVT44   PR.RON055     PR.RDVT64   PR.RQTRDB.A     PR.RDVT70   PR.RQTRDB.B     PR.RDVT74   PR.RQTRJ.R.A     PR.RDVT76   PR.RQTRJ.R.A     PR.RDVT780   PR.RXN039     PR.RDVT80   PR.RXN039     PR.RDVT84   PR.RXN055     PR.RDVT94   PR.RXN055	PR.RBGI84MAIN	PE RBSW22	
PR.RbD/260.0C   PE.RbSW57     PR.RbBGI82TRIM   PE.RQKE16     PR.RbD/702   PI.RbSW26     PR.RbD/702   PI.RbSW40     PR.RbD/703   PI.RbSW41     PR.RbD/704   PI.RbSW42     PR.RbD/705   PI.RbSW42     PR.RbV/702   PI.RbSW42     PR.RbV/720   PI.RbSW44     PR.RbV722   PI.RbSW44     PR.RbV724   PI.RBSW44     PR.RbV730   PI.RCLB     PR.RbV734   PE.RSMH57     PR.RbV734   PR.RON039     PR.RbV734   PR.RON039     PR.RbV744   PR.RQN055     PR.RDV754   PR.RQTRDB.A     PR.RDV770   PR.RQTRDB.A     PR.RDV776   PR.RQTRJ.R.A     PR.RDV780   PR.RXN039     PR.RDV788   PR.RXN039     PR.RDV788   PR.RXN039     PR.RDV789   PR.RXN039	PR.RBGI84TRIM	PE RBSW23	
PR.RBGI82MAIN   PE.R.NDW07     PR.RDVT02   PI.RBSW26     PR.RDVT04   PI.RBSW40     PR.RDVT08   PI.RBSW41     PR.RDVT12   PI.RBSW42     PR.RDVT20   PI.RBSW42     PR.RDVT21   PI.RBSW43     PR.RDVT22   PI.RBSW44     PR.RDVT24   PI.RBSW44     PR.RDVT34   PR.RDHZ18.OC     PR.RDVT34   PR.RON039     PR.RDVT38   PR.RON039     PR.RDVT54   PR.RQSE     PR.RDV754   PR.RQTRDB.A     PR.RDV776   PR.RQTRDB.A     PR.RDV776   PR.RQTRJ.TR.A     PR.RDV780   PR.RXN039     PR.RDV780   PR.RXN039     PR.RDV780   PR.RXN039     PR.RDV780   PR.RXN055	PR.RDHZ60.OC	DE DRSW57	
PR.RBG/B21RIMPE.RQ/T04PE.RSM/16PE.RSM/16PR.RDVT02PI.RBSW26PI.RSM/26PR.RDVT04PI.RBSW40PI.RSM/26PR.RDVT12PI.RBSW41PI.RSM/42PR.RDV720PI.RBSW42PE.RSM/47PR.RDV722PI.RBSW43+PR.RDVT24PI.RBSW44PR.RDVT30PI.RQLBPR.RDV730PR.RDHZ18.OCPR.RDV738PR.RON039PR.RDV738PR.RON055PR.RDV744PR.RQN55PR.RDV754PR.RQSEPR.RDV764PR.RQTRDB.APR.RDV776PR.RQTRJ.TR.APR.RDV780PR.RQTRJ.TR.APR.RDV780PR.RQTRJ.TR.BPR.RDV780PR.RXN039PR.RDV780PR.RXN055PR.RDV780PR.RXN055PR.RDV780PR.RXN055PR.RDV780PR.RXN055PR.RDV780PR.RXN055	PR.RBGI82MAIN		
PR.RDV102 PI.RBSW20 PR.RDV708 PI.RBSW40 PR.RDV708 PI.RBSW41 PR.RDV712 PI.RBSW42 PR.RDV720 PI.RBSW43	PR.RBGI821RIM		PE.RSMH16
PR.RDV104PI.R5W40PI.R5WH20PR.RDVT08PI.RBSW41PI.RSMH42PR.RDVT12PI.RBSW42PI.RSMH42PR.RDVT20PI.RBSW43+PR.RDVT22PI.RBSW44PE.RSMH57PR.RDVT34PR.RDHZ18.OCPE.RBSW57PR.RDVT38PR.RON039PE.RSMH61PR.RDVT44PR.RON055PE.RSMH61PR.RDVT54PR.RQTRDB.APR.RQTRDB.APR.RDV764PR.RQTRDB.BPR.RQTRDB.APR.RDV770PR.RQTRDB.BPR.RQVT74PR.RDV774PR.RQTRJ.TR.APR.RQTRJ.TR.APR.RDV780PR.RXN039PR.RQTRJ.TR.BPR.RDV780PR.RXN039PR.RXN055PR.RDV794PR.RXN055PR.RXN055	PR.RDV102	PI.RBSW20	
PR.RDVT00PI.RBSW41PI.RSMH42PR.RDVT20PI.RBSW42PR.RDVT22PI.RBSW43PR.RDVT24PI.RBSW44PR.RDVT30PI.RQLBPR.RDVT34PR.RDHZ18.OCPR.RDVT38PR.RONO39PR.RDVT34PR.RONO55PR.RDVT44PR.RQSEPR.RDVT54PR.RQTRDB.APR.RDVT64PR.RQTRDB.APR.RDVT70PR.RQTRDB.BPR.RDVT76PR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.APR.RDVT80PR.RXNO39PR.RDVT84PR.RXNO39PR.RDV784PR.RXNO39PR.RDV764PR.RQTRJ.TR.BPR.RDV776PR.RQTRJ.TR.BPR.RDV780PR.RXNO39PR.RDV794PR.RXNO39PR.RDV794PR.RXNO39		PI.RBSW40	PI.RSMH26
PR.RDVT20PI.RBSW42PR.RDVT22PI.RBSW43Image: Pi.RBSW47PR.RDVT24PI.RBSW44PE.RSMH57PR.RDVT30PI.RQLBPE.RBSW57PR.RDVT34PR.RDHZ18.OCPE.RSMH61PR.RDVT38PR.RON039PE.RSMH61PR.RDVT44PR.RON055PE.RSMH61PR.RDVT54PR.RQSEPR.RQTRDB.APR.RDVT70PR.RQTRDB.BPR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.APR.RQTRJ.TR.APR.RDVT80PR.RQTRJ.SCPI.RZN039PR.RDVT80PR.RXN035PR.RXN055PR.RDVT94PR.XN055PR.RXN055PR.RDVT94PR.XN055PR.RXN055	PR RDV/T12	PI.RBSW41	PI.RSMH42
PR.RDVT22PI.RBSW43PE.RSMH57PR.RDVT24PI.RBSW44PR.RDVT30PI.RQLBPR.RDVT34PR.RDHZ18.OCPR.RDVT38PR.RON039PR.RDVT44PR.RON055PR.RDVT54PR.RQSEPR.RDVT64PR.RQTRDB.APR.RDVT70PR.RQTRDB.BPR.RDVT74PR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.BPR.RDVT88PR.RXN039PR.RDVT88PR.RXN055PR.RDVT94PR.RXN055	PR RDVT20	PI.RBSW42	1
PR.RDVT24PI.RBSW44PR.RDVT30PI.RQLBPE.RBSW57PR.RDVT34PR.RDHZ18.OCPE.RSMH61PR.RDVT38PR.RON039PE.RSMH61PR.RDVT44PR.RON055PR.RQVT54PR.RDVT54PR.RQTRDB.APR.RQTRDB.APR.RDVT70PR.RQTRDB.BFR.RQVT74PR.RDVT76PR.RQTRJ.TR.APR.RDVT88PR.RXN039PR.RDVT88PR.RXN055PR.RDVT94PR.RXN055	PR.RDVT22	PI.RBSW43	PE.RSMH57
PR.RDVT30PI.RQLBPE.RBSW57PR.RDVT34PR.RDHZ18.OCPE.RSMH61PR.RDVT38PR.RON039PE.RSMH61PR.RDVT44PR.RON055PR.RQSEPR.RDVT54PR.RQTRDB.APR.RQTRDB.APR.RDVT70PR.RQTRDB.BPR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.APR.RQTRJ.TR.BPR.RDVT88PR.RXN039PR.RXN055PR.RDVT94PR.RXN055PR.RXN055	PR.RDVT24	PI.RBSW44	
PR.RDVT34PR.RDHZ18.OCPE.RSMH61PR.RDVT38PR.RON039PE.RSMH61PR.RDVT44PR.RON055PR.RDVT54PR.RQSEPR.RDVT64PR.RQTRDB.APR.RDVT70PR.RQTRDB.BPR.RDVT74PR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.BPR.RDVT80PR.RXN039PR.RDVT94PR.RXN055PR.RDVT94PR.RXN055	PR.RDVT30	PI.RQLB	PE.RBSW57
PR.RDVT38PR.RON039PE.ROM01PR.RDVT44PR.RON055PR.RDVT54PR.RQSEPR.RDVT64PR.RQTRDB.APR.RDVT70PR.RQTRDB.BPR.RDVT74PR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.BPR.RDVT80PR.RXN039PR.RDVT94PR.RXN055PR.RDVT94PR.RXN055	PR.RDVT34	PR.RDHZ18.OC	
PR.RDVT44PR.RON055PR.RDVT54PR.RQSEPR.RDVT64PR.RQTRDB.APR.RDVT70PR.RQTRDB.BPR.RDVT74PR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.BPR.RDVT80PR.RXNO39PR.RDVT94PR.RXN055PR.RDVT94PR.RXN055	PR.RDVT38	PR.RONO39	PE.KSIVIHOT
PR.RDVT54PR.RQSEPR.RDVT64PR.RQTRDB.APR.RDVT70PR.RQTRDB.BPR.RDVT74PR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.BPR.RDVT80PR.RXNO39PR.RDVT94PR.RXNO55PR.RDVT94PR.RXNO55	PR.RDVT44	PR.RONO55	
PR.RDVT64PR.RQTRDB.APR.RDVT70PR.RQTRDB.BPR.RDVT74PR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.BPR.RDVT80PR.RXNO39PR.RDVT94PR.RXNO55PR.RDVT09PR.RXNO55	PR.RDVT54	PR.RQSE	
PR.RDVT70PR.RQTRDB.BPR.RDVT74PR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.BPR.RDVT80PR.RXNO39PR.RDVT94PR.RXNO55PR.RDVT09PR.RXNO55	PR.RDVT64	PR.RQTRDB.A	
PR.RDV174PR.RQTRJ.TR.APR.RDVT76PR.RQTRJ.TR.BPR.RDVT80PR.RXNO39PR.RDVT94PR.RXNO55PR.PDVT08PR.RXNO55	PR.RDVT70	PR.RQTRDB.B	
PR.RDV176PR.RQTRJ.TR.BPR.RDVT80PR.RXNO39PR.RDVT94PR.RXNO55PR.PDVT08PR.PXSE	PR.RDVT74	PR.RQTRJ.TR.A	
PR.RDVT88 PR.RXNO39 PR.RDVT94 PR.RXNO55 PR.RDVT99 PR.RXNO55		PR.RQTRJ.TR.B	
PR.RDVT94 PR.RXNO55		PR.RXNO39	
		PR RXNO55	
	PR RD\/T98	PRRXSE	



# **Conclusions and discussion**

The delay of 1.2 s between the beam dump and removing the "Power Permit" was implemented by default for all WIC systems

• Even for installations with no BIS connection

### Recently, this delay was removed for the WIC installation in the PS, on request of TE-ABT

- Remains the WIC reaction time (140 ms to 340 ms)... Is it acceptable for the PE.SMH57 ?
- Is it an issue for the other circuits connected to this same WIC?
- If we switch off an "AUX" power converter during a pulse (which was the case before with a delay)?

### It is technically feasible to set different values for each WIC (all machines) considering:

- Whether it's a circular machine or a transfer line
- If they protect any sensitive equipment (Ex: ELENA)
- Is there a need for this ?



## Thank you for your attention



### **Proton chain**

Machine:	Nb. of PLCs	BIS connection
LHC	8	Yes
LHC-SPS transfer lines	4	Yes
SPS	7	Yes
TT10	1	Yes
PS – TT2	2	No
PSB ejection lines	1	Yes
PSB rings	4	Yes
PSB injection lines	1	Yes
Linac 4 + TL	2	Yes



### lon chain

Machine:	Nb. Of PLCs	BIS connection
Leir	1	No
Linac3	1	No



# **Experimental areas**

Machine:	Nb. Of PLCs	BIS connection
Hie-Isolde	2	No
Elena	1	No
Awake	1	Yes
East Area	1	No
HiRadMat	2	Yes
TT20	1	No



#### Ttr (Target Rotation Time) The target rotation time is the maximum length of time available for a token pass. During this time, all active nodes (DP-masters, etc.) are able to send once (token). The difference between the target rotation time and the actual hold time of a node determines the length of time remaining for the other active node (programming device, additional DP masters, etc.) masters to send data frames. Typical Ttr The typical data cycle time is the average response time on the bus when all the configured slaves are exchanging data with the DP master. None of the slaves reports any diagnostic messages and there is no additional message frame communication on the bus with programming devices or other active nodes, etc. This time is for informational purposes only and is not transferred to the nodes.

