

SPS energy saving system for greater avaibility and reliability



Abstract

The Super Proton Synchrotron is the main injector for the Large Hadron Collider (LHC). The 7 km SPS accelerates particles from 14 to 450 GeV. The deployment of the new Function Generator Controller allowed the development of an energy saving system optimising the magnetic cycle by pulsing only when needed. The FGC framework in the SPS will simplify operation and add more flexibility, reliability and availability. This system will be the new standard across the accelerator complex.



SPS Dynamic	Economy
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Triggered automatically by the level of the beam intensity.

- Main Dipole Power Supplies stay at injection energy.
- All ring circuits stay at minimum current.
- All transfer line circuits except injection line (TT10) stay at minimum current because the next beam injection on the same cycle passes through TT10 to go to the injection dump.
- The scraper will not execute its cycle.
- We can force the pulse manually for verification purposes.

	5000 -			
	4000 -			
	1000	After injection we need a fast trigger from BCT to know if we are playing normal or economy cycle.		
	3000 -		LSA Pai	rameter (ms)
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Т	Hiradmat (High Radiation to Materials)	26 GeV	440 Gev	Fast extraction
0	MD pulsed (Machine Development)	14 to 26 GeV	80 to 450GeV	No extraction
Ν	MD coastable	26 GeV	26 to 270 GeV	No extraction
	Noth Area (Fixed Target)	17.07 GeV	27 to 450 GeV	Slow extraction
	LHC (Pilot, 200ns)	17.07 Gev	450 GeV	Fast extraction
	MD Pulsed (Machine Development)	17.07 GeV	80 to 450 GeV	No extraction
IN	MD coastable	17.07 GeV	17.07 to 270 GeV	No extraction

Fast Beam Detection

- a) BCT3, BCT4 (Beam current transformer) will:
 - -Publish intensity in the ring at 20 ms after injection.
- b) BCTECO (Economy server) will:
 - Subscribe and compare the value with a threshold set for each cycle.
 - If Value < threshold.
 - Open the loop of the Beam Interlock Controller (firing emergency dump).
 - Triggers the LOCAL TIMING which in one turn triggers the economy event generation in the cable.
 - Closed the loop of the Beam Interlock Controller at the end of the cycle.
- c) On this timing event
 - The emergency dump is fired a second time for redundancy.

event on MT

- All FGC crates switch to partial economy.

All of this must be executed in ~40 ms.





SPS Full Economy

Triggered by manual switch of external condition or a missing signal from electricity network supplier.

- Timing system will publish an event Full Eco in telegram.
- Main Dipole Power Supplies stay at 13.5 GeV for all cycles.
- All ring circuits stay at Imin.
- All transfer line circuits including TT10 stay at minimum current.
- 660 circuits switch on full economy.
- We can force the pulse manually for verification purposes.

	Publication Full Eco Start Full Economy Energy 13.5 GeV Full Economy	ſ

Full Economy Control





Hardware Conditio	ons	Hard/So	ft Conditions		Software Condi	tions	
Name	Status	Name	Priority	Status	Name	Status	
I_SPS	ОК	LS.LHCSYNC	SOFT	ок	R_S.LHC25NS	ACTIVE	•
I_S.PROT	OK	S.EDF	SOFT	ОК	R_S.MD3	OFF	
I_S.ION	ОК				R_S.COAST	OFF	
I_S.MD	OK				R_S.SFTION4	ACTIVE	
I_S.DUMP	OK				R_S.LHCMD4	ACTIVE	
I_S.FTARGET	OK				R_S.MD4	OFF	
I_S.CNGS	OK				I_S.SIS_TT60	ACTIVE	
I_S.TI2	OK				I_S.SIS_TT66	ACTIVE	
I_S.TI8	OK				I_S.SIS_TT40	ACTIVE	
I_S.HIRADMAT	OK				I_S.SIS_TI2_INJ	ACTIVE	
R_S.LSEQ_ID0	BAD				I_S.SIS_RING	ACTIVE	
R_S.LSEQ_ID1	BAD				I_S.SIS_TT41	ACTIVE	
R_S.LSEQ_ID2	OK				I_S.SIS_TI2_DUMP	ACTIVE	
I_S.PROT_FT	BAD				I_S.SIS_TI8_DUMP	ACTIVE	

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Transfer Line Dynamic Destination Economy

a) Transfer LHC B2.

- East extraction bumpers, TT40 and TI8 will pulse only on dynamic destination TI8_DUMP, LHC_B2.

Dynamic Destination Economy Triggered

b) Transfer LHC B1.

- West extraction bumpers, TT60 and TI2 will pulse only on dynamic destination TI2_DUMP, LHC_B1.

c) Transfer Hiradmat.

- West extraction bumpers, TT60 and TT66 will pulse only on dynamic destination Hiradmat. d) Overriding will be possible to test the lines.

Displayed Function: APPOS.SR2.REL22134/IREF		Displayed Function: MPLH6167/IREF
Main bending TI8	\frown	Extraction bumper Est extraction
		120
4909 -		
3300 -		80-
		60
2000 -		
1490		
		-20
0	15000 3000	
	2000	o 3000 10000 20000



With these three modes of economy not only do we gain an electrical energy saving but also we solicit the transformers, the power converters, the magnets and the vacuum chambers inside the dipoles only when beam is present in the machine. We therefore increase the life span of each element of the machine and in turn the reliability and availability of the SPS complex as a whole.