Booster Main Power Supplies

Roberto Petrocelli

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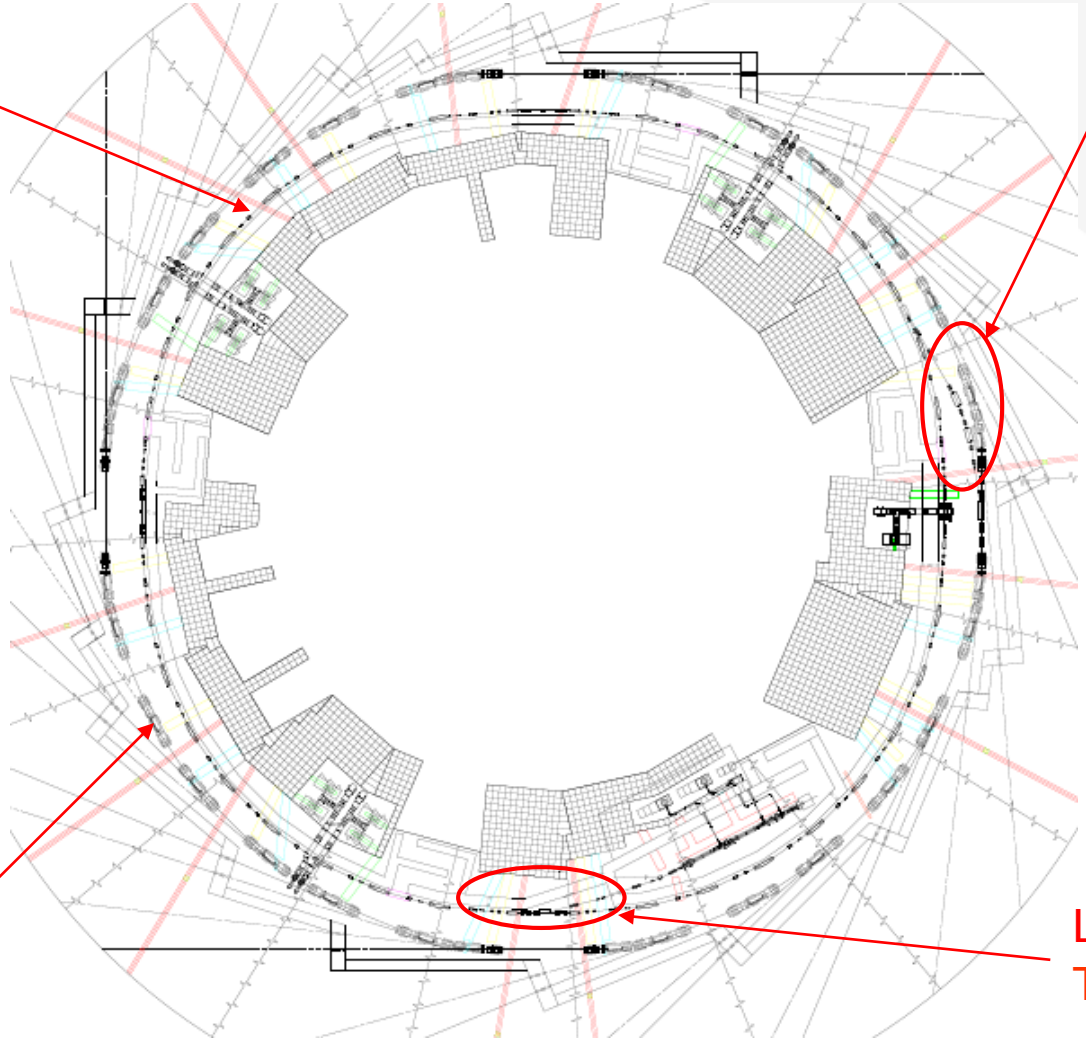
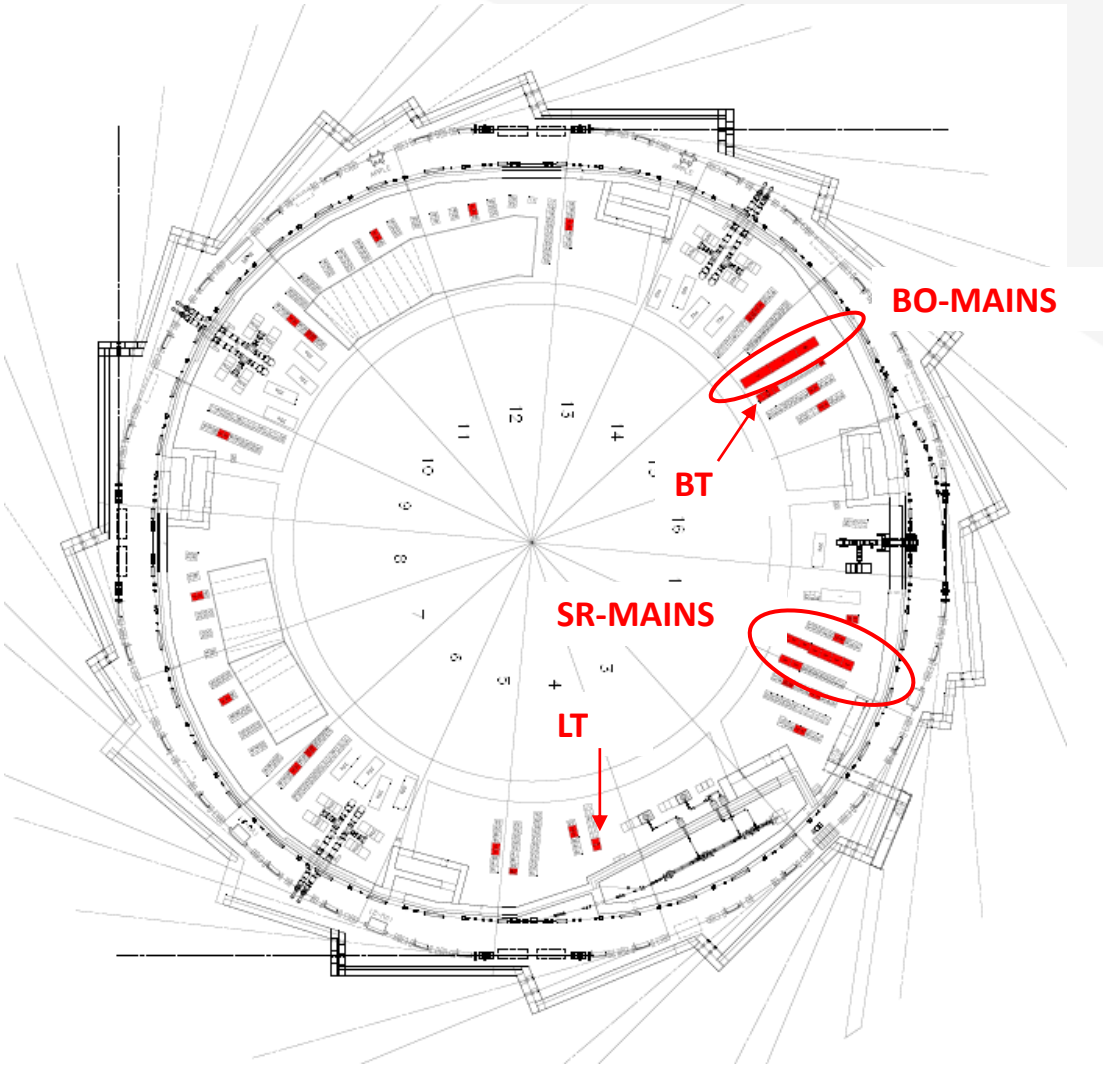
The ALBA Synchrotron

- ALBA is the Spanish synchrotron light source. It is a complex of electron accelerators to produce synchrotron light, which allows visualization and analysis of matter and its properties at atomic and molecular levels.
- ALBA is in operation since May 2012 and has seven beamlines which are able to perform experiments in different scientific fields: physics, chemistry, life sciences, materials science, cultural heritage, biology, nanotechnology,... Two new beamlines were initiated in 2014 to be devoted to infrared microspectroscopy and photoemission with angular resolution in 2017 and 2019, respectively. In 2016, a new microfocus beamline for macromolecular crystallography has been started with the aim of having the first users in 2020.
- This scientific infrastructure produces 5.700 hours of beamtime per year and is available for the academic and the industrial sector to give service to more than 1.000 researchers every year.

OVERVIEW OF ALBA SYNCHROTRON ACCELERATORS

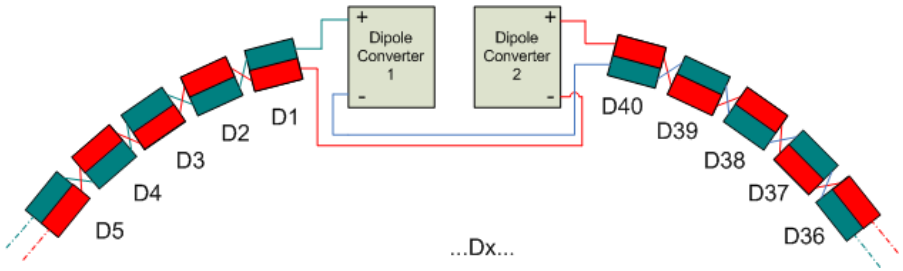


Distribution of Power Supplies in the Service Area

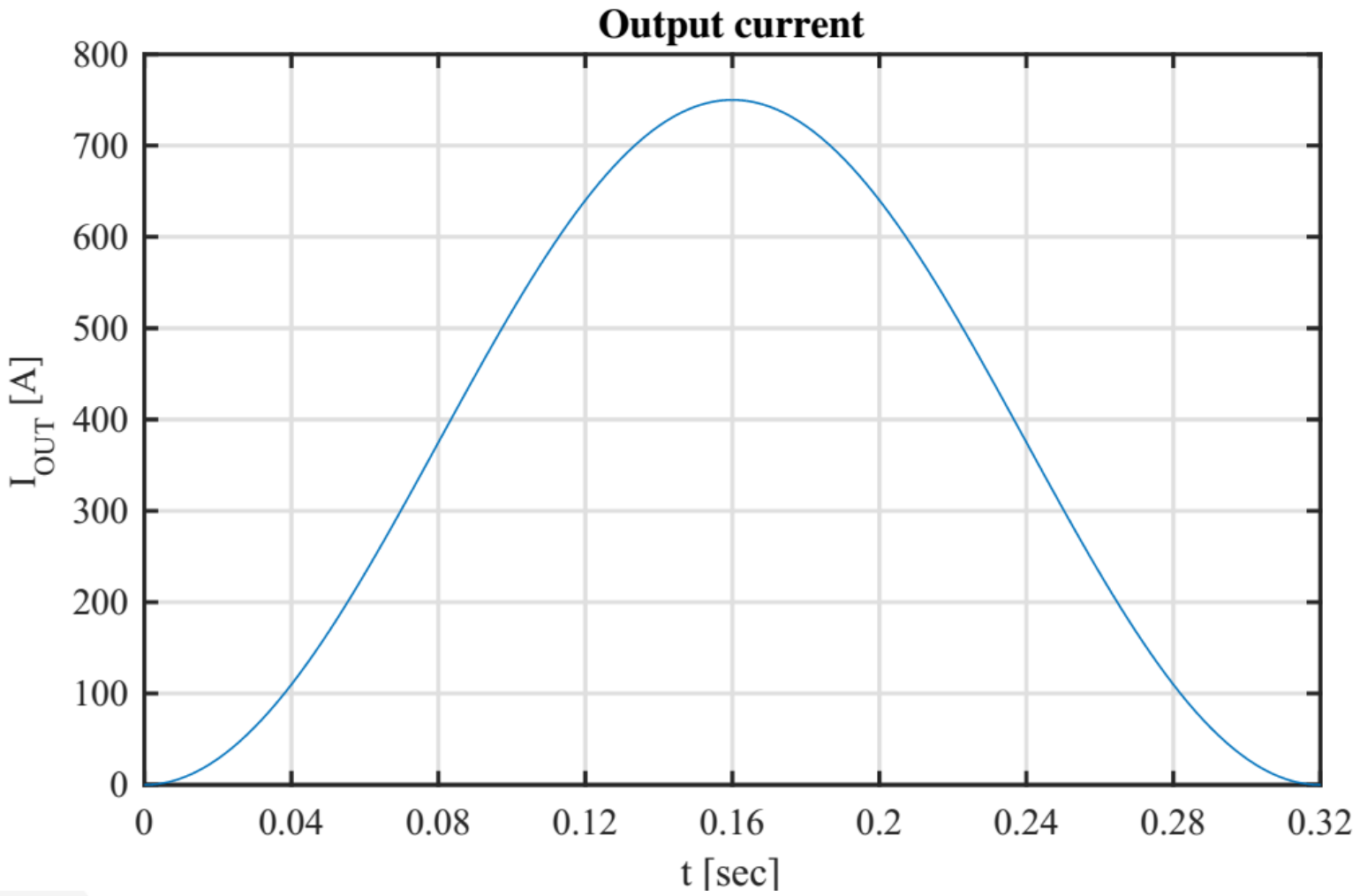


Magnet Families

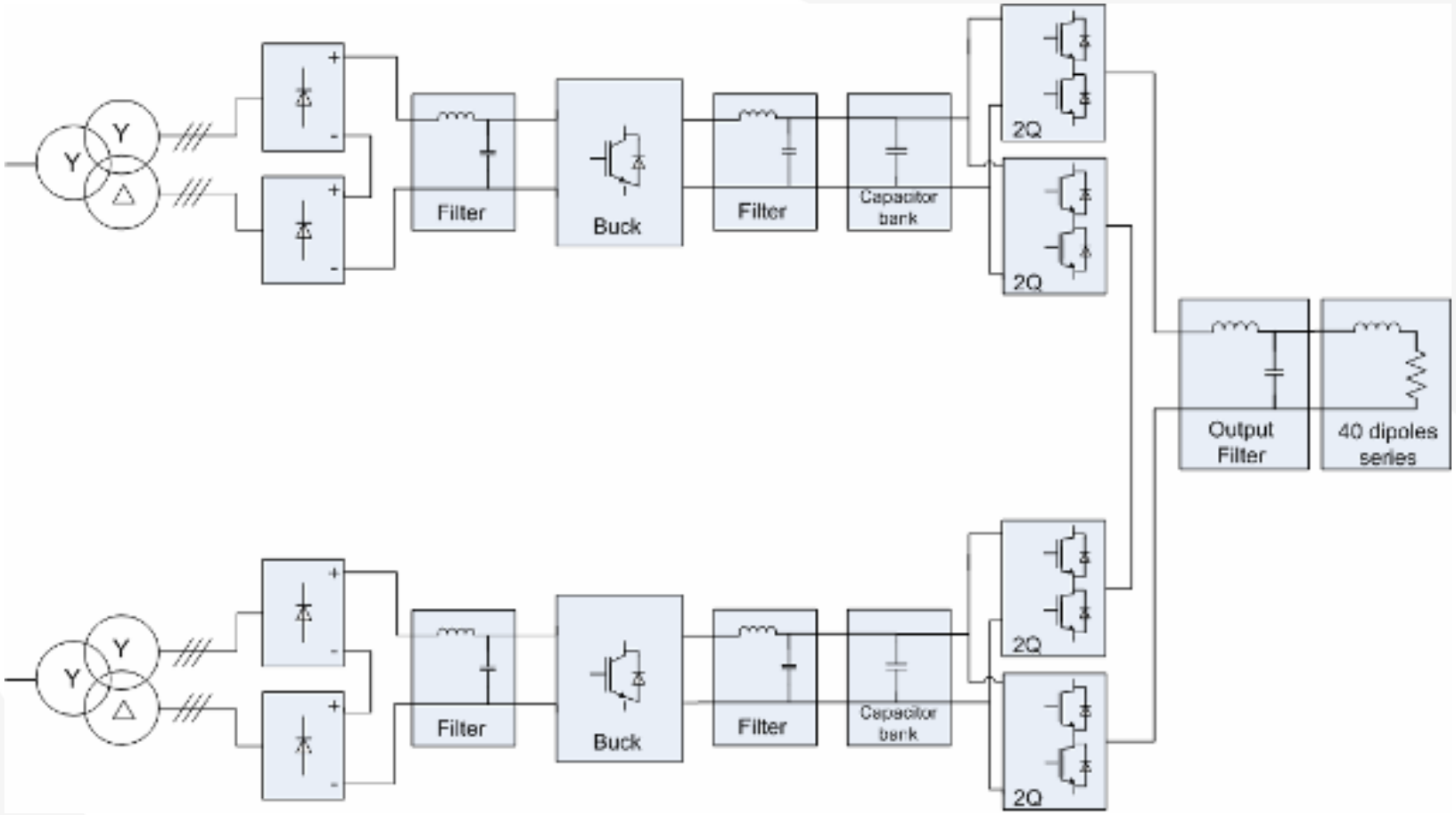
Type of PC	Bend	QS180	QS340	QC340
Nr of PCs	2	2	1	1
Load R [mOhm]	710	440	610	2360
Load L [mH]	200	27.2	48	216
Irated peak [A]	±750	±180	±180	±180
Vrated peak [V]	±1000	±120	±200	±750
Resolution [ppm]	5	5	5	5
Stability 100s 8h [ppm]	±15	±15	±15	±15
Reproducibility [ppm]	±50	±50	±50	±50

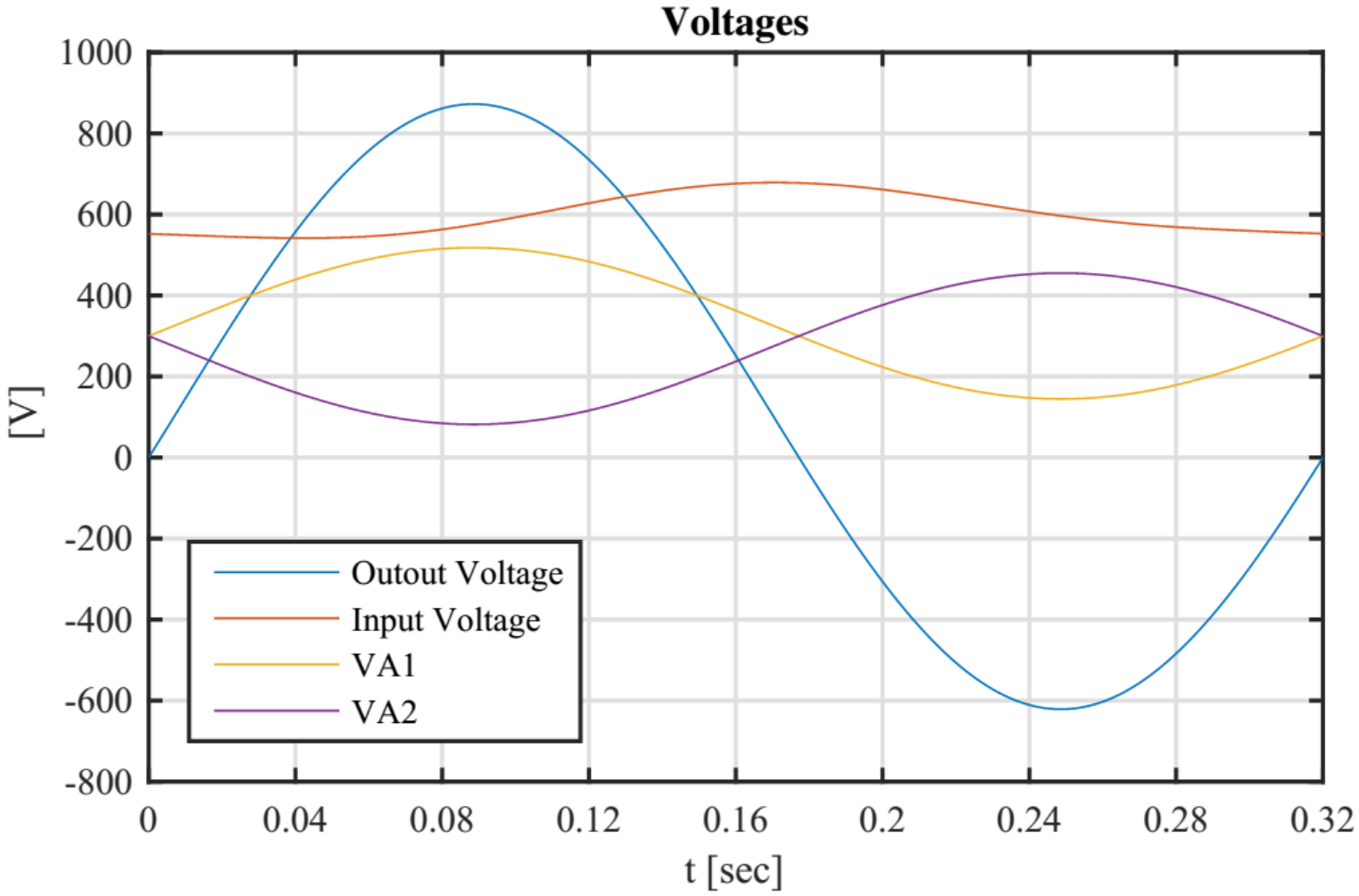


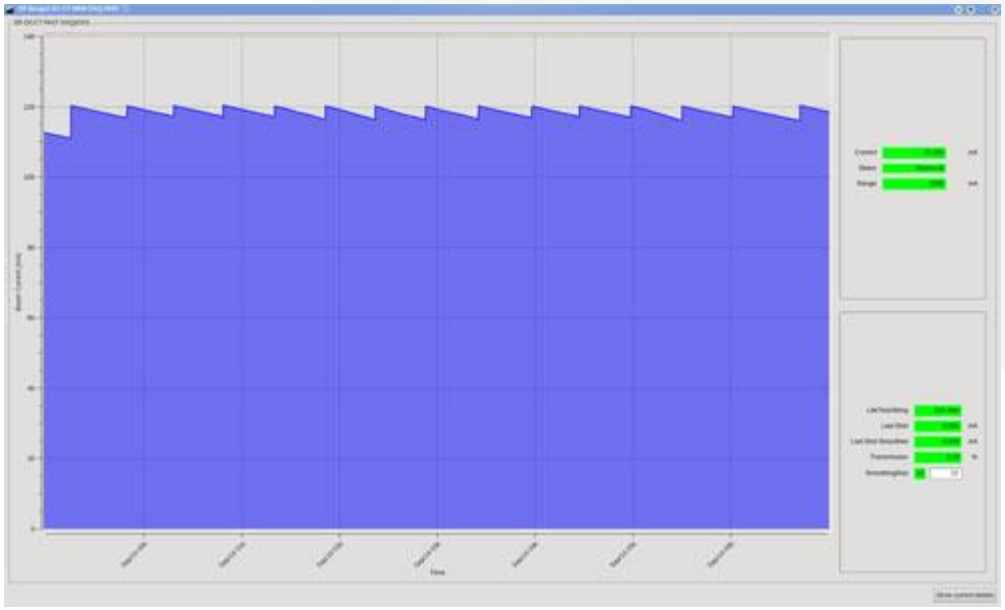
[Power Converters for ALBA Booster]


Output current
800
700
600
500
400
300
200
100
0
I_{OUT} [A]
0
0.04
0.08
0.12
0.16
0.2
0.24
0.28
0.32
t [sec]

Today's Booster Bending Power Supply




Voltages
1000
800
600
400
200
0
-200
-400
-600
-800
[V]
0
0.04
0.08
0.12
0.16
0.2
0.24
0.28
0.32
t [sec]
Outout Voltage
Input Voltage
VA1
VA2



Injection into Storage Ring every 20 minutes

https://www.albasynchrotron.es/en/accelerators/operations

TOP-UP OPERATION AT ALBA SYNCHROTRON LIGHT SOURCE

Idle	ramping	Idle	ramping	Idle
1170sec	30 sec	1170sec	30 sec	1170sec

- A timing system produce trigger signals for the different components of the acelerators
  - ALBA TIMING SYSTEM - A KNOWN ARCHITECTURE WITH FAST INTERLOCK SYSTEM UPGRADE

- Trigger signal could a TTL electric signal or fiber optic.
- This signal triggers the output current waveform
- Setpoints for the output current waveform are pre loaded into the power supply control.

- Two Main Problems
  - Very low lifetime of 2Q modules under the stress of top-up operation.

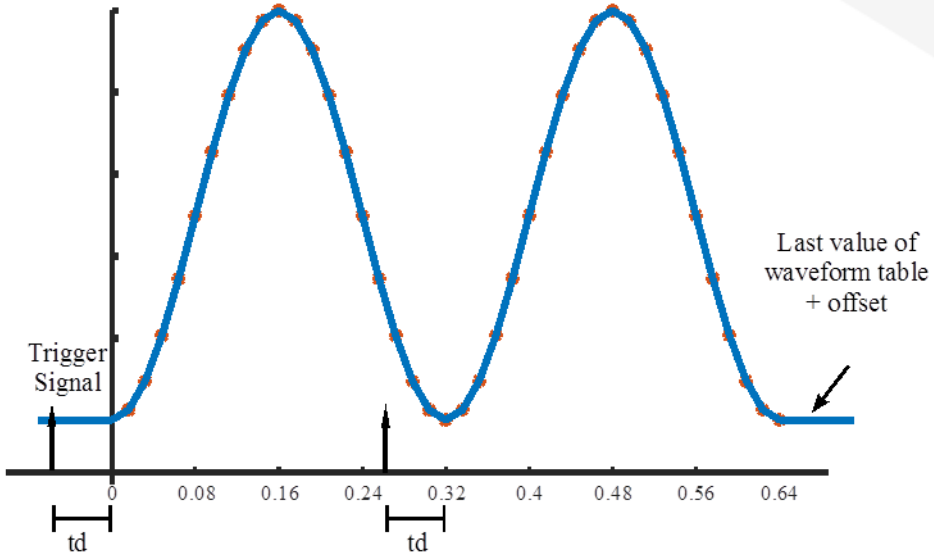
    Power and thermal cycling.

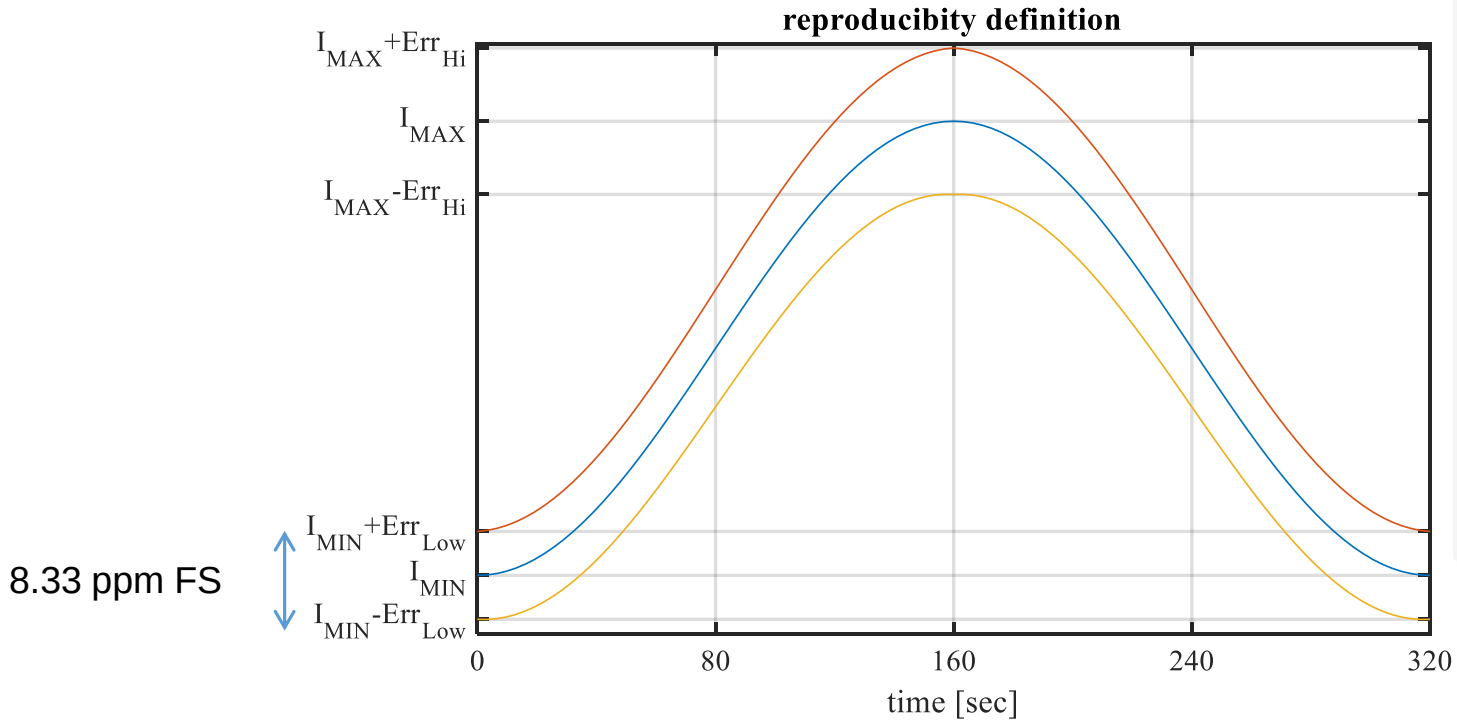
  - Large difficulties to make failure diagnostics when the control/regulation boards are involve.

- Booster Power supplies has been identified as the highest risk for the long term operation of the facility

	Dipole	QS180	QS340	QC340
Units	2	2	1	1
Load				
R [Ω]	0.335	0.36	0.57	2.28
ΔR[Ω] (1)	2%			
L [mH]	100(2)	27.2	48	216
I_{PEAK} [A] max	700		180	
I_{RMS} [A] max	434		112	
V_{PEAK} [V]	+/-800	+/- 120	+/- 200	+/- 750
Input Power [kW]	75	5	8	32
resolution	10ppm			
Typical output waveform				
I_{MIN} [A]	22		4	
I_{MAX} [A]	660		160	

Operation conditions	
Mains	
Line voltage [V]	400 +/- 10%
Frequency [Hz]	50
Short circuit capacity	< 40MVA
Cooling water	
Water conductivity uS/cm	0.2
Inlet temperature [ºC]	23 +/- 1
Max temperature variation [ºC]	17
Inlet pressure [bar]	10
Outlet pressure [bar]	4


Last value of
waveform table
+ offset
Trigger
Signal
0
0.08
0.16
0.24
0.32
0.4
0.48
0.56
0.64
td
td



8.33 ppm FS

Relative error E_{REL} [ppm]	125	
$I_{ERR(Low)}$ (3)	I_{MIN} E_{REL} or 2.75 mA	I_{MIN} E_{REL} or 0.5 mA
$I_{ERR(Hi)}$ (3)	I_{MAX} E_{REL} or 2.75 mA	I_{MAX} E_{REL} or 0.5 mA

Tracking Error:

Tracking error E_{TCK} [ppm]	1000

The tracking error is defined as follow:

$$\left| \frac{I_{OUTPUT}(t) - I_{REF}(t - t_d)}{I_{REF}(t - t_d)} \right| \leq E_{TCK}$$

•

Where:

$I_{OUTPUT}(t)$ = output current of a power supply

$I_{REF}(t)$ = input reference values downloaded into the power supply

t_d = delay time

ALBA Operations Calendar, January 2019-December 2019

BL operation	BL	BL users (external, friendly, in-house & commissioning)
bl operation	bl	BL/FE/ID Commissioning & Accelerator Optimization for BLs
Start-up	M	Start up of accelerators with beam & Accelerator's Studies
Warm-up	W	Warm: Linac & RF & magnets & sub-systems maintenace and optimisation
Shutdown	Off	Civil Engineering, Accelerators and BL maintenance with no beam, installations and upgrades
Public & CELLS holiday		

Weekday	JANUARY Week Day	Shift M	A	N	FEBRUARY Week Day	Shift M	A	N	MARCH Week	Shift M	A	N	APRIL Week Day	Shift M	A	N	MAY Week	Shift M	A	N	JUNE Week Day	Shift M	A	N	JULY Week Day	Shift M	A	N	AUGUST Week Day	Shift M	A	N	SETEMBER Week Day	Shift M	A	N	OCTOBER Week Day	Shift M	A	N	NOVEMBER Week Day	Shift M	A	N	DECEMBER Week Day	Shift M	A	N
Mo	1												1	M	M	M									1	M	M	M																				
Tu	1	W	W	W									2	BL	BL	BL									2	BL	BL	BL									1	BL	BL	BL								
We	2	W	W	W									3	BL	BL	BL	1	BL	BL	BL					3	BL	BL	BL									2	BL	BL	BL								
Th	3	W	W	W									4	BL	BL	BL	2	BL	BL	BL					4	BL	BL	BL									3	BL	BL	BL								
Fr	4	W	W	W	1	BL	BL	BL	1	BL	BL	BL	5	BL	BL	BL	3	BL	BL	BL					5	BL	BL	BL	1	Off	Off	Off					4	BL	BL	BL	1	BL	BL	BL				
Sa	5	W	W	W	2	BL	BL	BL	2	BL	BL	BL	6	BL	BL	BL	4	BL	BL	BL	1	BL	BL	BL	6	BL	BL	BL	2	Off	Off	Off					5	BL	BL	BL	2	BL	BL	BL				
Su	6	W	W	W	3	BL	BL	BL	3	M	M	M	7	M	M	M	5	BL	BL	BL	2	BL	BL	BL	7	BL	BL	BL	3	Off	Off	Off	1	W	W	W	6	M	M	M	3	BL	BL	BL	1	BL	BL	BL
Mo	2 7	W	W	W	4	M	M	M	4	SPK	W	W	8	BL	BL	BL	6	M	M	M	3	M	M	M	8	M	M	M	4	Off	Off	Off	2	SPK	SPK	W	7	PSS	W	W	4	M	M	M	2	M	M	M
Tu	8	W	W	W	5	BL	BL	BL	5	W	W	W	9	BL	BL	BL	7	BL	BL	BL	4	BL	BL	BL	9	BL	BL	BL	5	Off	Off	Off	3	SPK	SPK	W	8	PSS	W	W	5	BL	BL	BL	3	BL	BL	BL
We	9	W	W	W	6	BL	BL	BL	6	W	W	W	10	BL	BL	BL	8	BL	BL	BL	5	BL	BL	BL	10	BL	BL	BL	6	Off	Off	Off	4	W	W	W	9	W	W	W	6	BL	BL	BL	4	BL	BL	BL
Th	10	W	W	W	7	BL	BL	BL	7	W	W	W	11	BL	BL	BL	9	BL	BL	BL	6	BL	BL	BL	11	BL	BL	BL	7	Off	Off	Off	5	M	M	W	10	W	W	W	7	BL	BL	BL	5	BL	BL	BL
Fr	11	W	W	W	8	BL	BL	BL	8	W	W	W	12	BL	BL	BL	10	BL	BL	BL	7	BL	BL	BL	12	BL	BL	BL	8	Off	Off	Off	6	M	M	W	11	W	W	W	8	BL	BL	BL	6	BL	BL	BL
Sa	12	W	W	W	9	BL	BL	BL	9	W	W	W	13	W	W	W	11	BL	BL	BL	8	BL	BL	BL	13	BL	BL	BL	9	Off	Off	Off	7	M	M	M	12	W	W	W	9	BL	BL	BL	7	BL	BL	BL
Su	13	W	W	W	10	BL	BL	BL	10	W	W	W	14	W	W	W	12	BL	BL	BL	9	BL	BL	BL	14	BL	BL	BL	10	Off	Off	Off	8	M	M	M	13	W	W	W	10	M	M	M	8	BL	BL	BL
Mo	3 14	W	W	W	11	M	M	M	11	M	M	M	15	W	W	W	13	M	M	M	10	M	M	M	15	M	M	M	12	Off	Off	Off	9	M	M	M	14	M	M	M	11	PSS	W	W	9	M	M	M
Tu	15	W	W	W	12	BL	BL	BL	12	BL	BL	BL	16	W	W	W	14	BL	BL	BL	11	BL	BL	BL	16	BL	BL	BL	13	Off	Off	Off	10	BL	BL	BL	15	BL	BL	BL	12	PSS	W	W	10	BL	BL	BL
We	16	W	W	W	13	BL	BL	BL	13	BL	BL	BL	17	W	W	W	15	BL	BL	BL	12	BL	BL	BL	17	BL	BL	BL	14	Off	Off	Off	11	BL	BL	BL	16	BL	BL	BL	13	W	W	W	11	BL	BL	BL
Th	17	W	W	W	14	BL	BL	BL	14	BL	BL	BL	18	W	W	W	16	BL	BL	BL	13	BL	BL	BL	18	BL	BL	BL	15	Off	Off	Off	12	BL	BL	BL	17	BL	BL	BL	14	W	W	W	12	BL	BL	BL
Fr	18	W	W	W	15	BL	BL	BL	15	BL	BL	BL	19	W	W	W	17	BL	BL	BL	14	BL	BL	BL	19	BL	BL	BL	16	Off	Off	Off	13	BL	BL	BL	18	BL	BL	BL	15	W	W	W	13	BL	BL	BL
Sa	19	W	W	W	16	BL	BL	BL	16	BL	BL	BL	20	W	W	W	18	BL	BL	BL	15	BL	BL	BL	20	BL	BL	BL	17	Off	Off	Off	14	BL	BL	BL	19	BL	BL	BL	16	W	W	W	14	BL	BL	BL
Su	20	W	W	W	17	M	M	M	17	BL	BL	BL	21	W	W	W	19	M	M	M	16	BL	BL	BL	21	BL	BL	BL	18	Off	Off	Off	15	BL	BL	BL	20	BL	BL	BL	17	W	W	W	15	M	M	M
Mo	4 21	W	W	W	18	M	M	M	18	M	M	M	22	W	W	W	20	W	W	W	17	M	M	M	22	M	M	M	19	Off	Off	Off	16	M	M	M	21	M	M	M	18	M	M	M	16	BL	BL	BL
Tu	22	W	W	W	19	BL	BL	BL	19	BL	BL	BL	23	W	W	W	21	W	W	W	18	BL	BL	BL	23	BL	BL	BL	20	Off	Off	Off	17	BL	BL	BL	22	BL	BL	BL	19	BL	BL	BL	17	BL	BL	BL
We	23	M	M	W	20	BL	BL	BL	20	BL	BL	BL	24	M	M	M	22	W	W	W	19	BL	BL	BL	24	BL	BL	BL	21	Off	Off	Off	18	BL	BL	BL	23	BL	BL	BL	20	BL	BL	BL	18	BL	BL	BL
Th	24	M	M	W	21	BL	BL	BL	21	BL	BL	BL	25	M	M	M	23	W	W	W	20	BL	BL	BL	25	BL	BL	BL	22	PSS	W	W	19	BL	BL	BL	24	BL	BL	BL	21	BL	BL	BL	19	BL	BL	BL
Fr	25	M	M	M	22	BL	BL	BL	22	BL	BL	BL	26	BL	BL	BL	24	W	W	W	21	BL	BL	BL	26	BL	BL	BL	23	PSS	W	W	20	BL	BL	BL	25	BL	BL	BL	22	BL	BL	BL	20	W	W	W
Sa	26	M	M	M	23	BL	BL	BL	23	BL	BL	BL	27	BL	BL	BL	25	W	W	W	22	BL	BL	BL	27	BL	BL	BL	24	PSS	W	W	21	BL	BL	BL	26	BL	BL	BL	23	BL	BL	BL	21	W	W	W
Su	27	M	M	M	24	BL	BL	BL	24	BL	BL	BL	28	BL	BL	BL	26	W	W	W	23	W	W	W	28	M	M	M	25	PSS	W	W	22	BL	BL	BL	27	BL	BL	BL	24	BL	BL	BL	22	W	W	W
Mo	5 28	M	M	M	25	M	M	M	25	M	M	M	29	M	M	M	27	M	M	M	24	W	W	W	29	Off	Off	Off	26	PSS	W	W	23	M	M	M	28	M	M	M	25	M	M	M	23	W	W	W
Tu	29	BL	BL	BL	26	BL	BL	BL	26	BL	BL	BL	30	BL	BL	BL	28	BL	BL	BL	25	W	W	W	30	Off	Off	Off	27	PSS	W	W	24	BL	BL	BL	29	BL	BL	BL	26	BL	BL	BL	24	W	W	W
We	30	BL	BL	BL	27	BL	BL	BL	27	BL	BL	BL					29	BL	BL	BL	26	W	W	W	31	Off	Off	Off	28	PSS	W	W	25	BL	BL	BL	30	BL	BL	BL	27	BL	BL	BL	25	W	W	W
Th	31	BL	BL	BL	28	BL	BL	BL	28	BL	BL	BL					30	BL	BL	BL	27	W	W	W					29	SPK	W	W	26	BL	BL	BL	31	BL	BL	BL	28	BL	BL	BL	26	W	W	W
Fr									29	BL	BL	BL					31	BL	BL	BL	28	W	W	W					30	SPK	W	W	27	BL	BL	BL					29	BL	BL	BL	27	W	W	W
Sa									30	BL	BL	BL									29	W	W	W					31	W	W	W	28	BL	BL	BL					30	BL	BL	BL	28	W	W	W
Su									31	BL	BL	BL									30	W	W	W									29	BL	BL	BL									29	W	W	W
Mo																																	30	M	M	M									30	W	W	W
Tu																																													31	W	W	W

2019 versio 3.0