Energy Ramping in BEPCII

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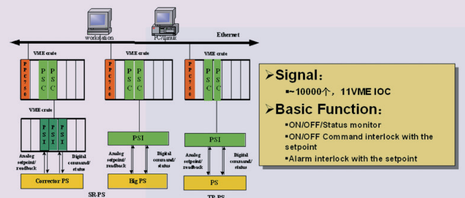
The Upgrade Project of Beijing Electron Positron Collider (BEPCII)

PS Control System



➢Signal：
- ←10000个，11VME IOC

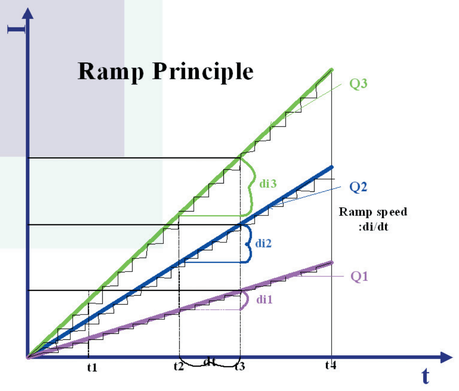
➢Basic Function：
- ON/OFF/Status monitor
- ON/OFF Command interlock with the setpoint
- Alarm interlock with the setpoint

Table 1. PS families for BEPCII rings

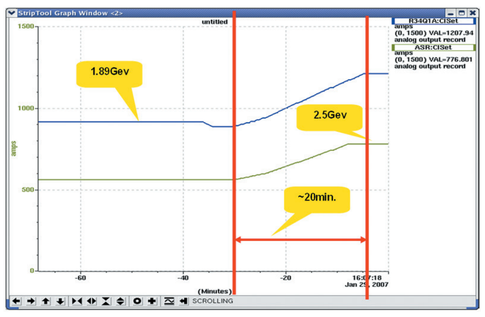
Name	Dipolar	Quadrupole	Sextupole	skQ	Other Q	SC magnet	Kicker	Correctors
Number	4	116	36	9	19	16	4	140
Stability $\Delta I/I$, [p.p.m]	50	100	100	100	100	100	100	100

Linear Ramping Principle

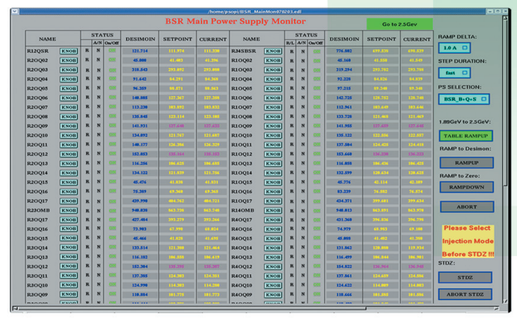
- The maximum steps of the power supplies can be calculated according to the given maximum delta per step and given initial and final current.
- The number of steps is determined by the formula: (desimon-setpoint)/delta.
- The program sends out different setpoints step by step so that the power supplies can be set to their own desired value.



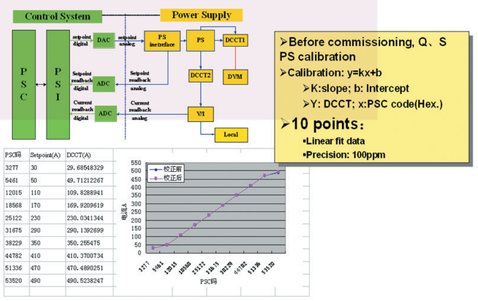
Testing Results



BSR Monitor and Ramping OPI



PS Control Calibration

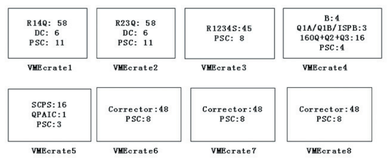


➢Before commissioning, Q、S PS calibration
➢Calibration: y=kx+b
- ➢K:slope; b: Intercept
- ➢Y: DCCT; x:PSC code(Hex.)

➢10 points：
- •Linear fit data
- •Precision: 100ppm

PSC码	Setpoint(A)	DCCT(A)
3277	30	29. 68563829
5461	50	49. 71212267
12015	110	109. 8288941
18568	170	169. 9209619
25122	230	230. 0361364
31675	290	290. 1392699
38229	350	350. 256475
44782	410	410. 3700734
51336	470	470. 4890251
53520	490	490. 5238247

B、Q、S PS Control Distribution



- PS distribution is different, B PS independent, Q/S PS+ DC PS
- 1 DC power to 10 choppers，for example :5 OQ and 5 IQ
- Different PSC number in each VME crate:
  - PVs Num. Different ,Different CPU load
- EPICS default clock : 60Hz PVs processing slow
- Ramping Program in each IOC: not synchronously

Stage 3(Jan. 07)

- Change EPICS clock from 60Hz to 600Hz
- Testing with beam(2 times)(On Jan. 30)
  - Current=46mA, slow speed,delta=0.5A,
    - Ramping from 1.89GeV to 2.5GeV:5 min. no beam loss
  - Current=47.89GeV, fast speed, delta=1.0A
    - Ramping from 1.89GeV to 2.5GeV:1.5 min. a little bit beam loss
- Testing with beam(on Feb. 4)
  - Current=250mA,fast speed, delta=1.0A
    - Ramping from 1.89GeV to 2.5GeV(with 3 stops): ~1.5min. No beam loss
    - Continuing the ramping, a beam loss was encountered when the energy reached

PS OPI

- There are 3 logical rings called BSR、BER、BPR.
- 4 panels per ring (BSR/BER/BPR)：
  - B、Q、S Monitor
  - B、Q、S ON/OFF
  - Corrector Monitor
  - Corrector ON/OFF

Testing results

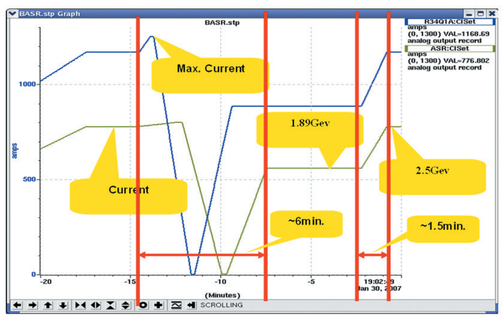
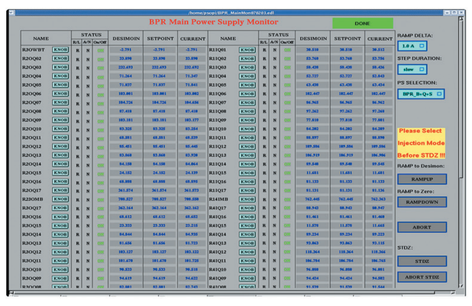


Table Ramping

- In order to ensure continuous ramping without the beam loss, we used two broken straight line instead of one straight line to fit the magnet measurement curve.
- The advantage of this way is that the current setpoints are closer to the magnet measurement data.
- One broken straight line is for 1.89GeV to 2.3GeV, another is for 2.3GeV to 2.5GeV.
- The energy and designed current values are saved into the database running on a soft IOC.
- The ramping program can get the designed current value by setting the energy.

BPR PS Monitor

- Left: region 2、3，Right: region 1、4
- 8row info，Magnet/Knob/Status/Arlam/DESIMON/Setpoint/Current
- Ramping/STDZ/Execution Status Monitor



Three Stage Testing

- Stage 1(first half of Dec. 2006)
  - A ramping program in every IOC
  - EPICS IOC clock 60Hz
- Stage 2(second half of Dec. 2006)
  - A ramping program in a independent IOC
  - EPICS IOC clock 60Hz
- Stage3(Jan. 2007)
  - A ramping program in a independent IOC
  - Change EPICS IOC clock from 60Hz to 600Hz

Testing results

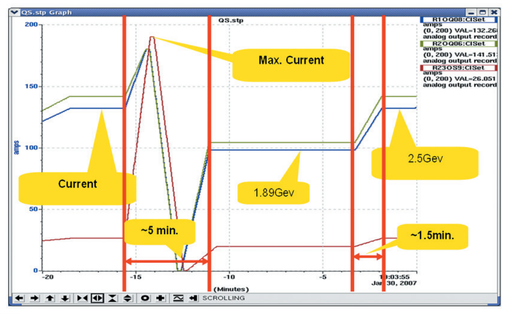
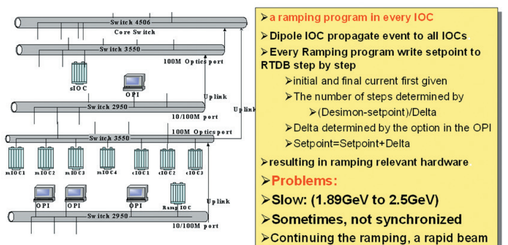


Table Ramping

- For eg. The ramping program set 2.3GeV energy to the energy PV, then get the designed current values at 2.3GeV, calculate delta from the current setpoint values to the designed current values, linear ramping to 2.3GeV, then get get the designed current values at 2.5GeV, go same way, up to 2.5GeV.
- The whole procedure is done by one button “ Table Ramp”. By testing with the beam, there was no beam loss happened. It took about 2 min.
- The ramping program was put into the second synchrotron running.(May-July, 2007)
- It was going very well.

PS Control Commissioning

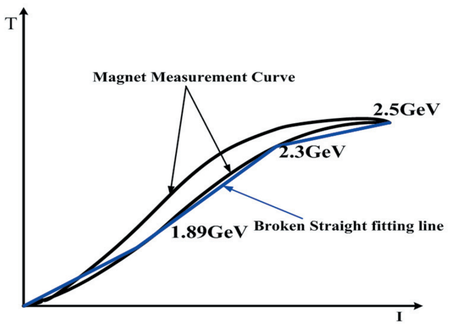
- Device commissioning started region by region
- On one hand magnets were installed, on the other hand magnet PS remote controls were tested
- Short time for All PS control testing with the magnets
- PS ramping region by region put into operation at the beginning of the beam commissioning
- After the commissioning, start to develop the ramping program of the entire ring BSR
- Short testing time for ramping program



VME crates in the network

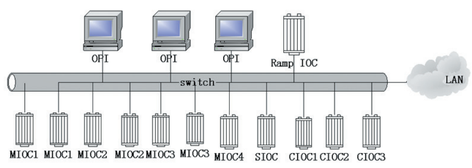
➢a ramping program in every IOC
➢Dipole IOC propagate event to all IOCs
➢Every Ramping program write setpoint to RTDB step by step
- ➢initial and final current first given
- ➢The number of steps determined by
  - ➢(Desimon-setpoint)/Delta
- ➢Delta determined by the option in the OPI
- ➢Setpoint=Setpoint+Delta

➢resulting in ramping relevant hardware
➢Problems:
➢Slow: (1.89GeV to 2.5GeV)
➢Sometimes, not synchronized
➢Continuing the ramping, a rapid beam loss was encountered when the energy reached



Stage 1(2006.11-2006.12)

Stage 2 (06.12)

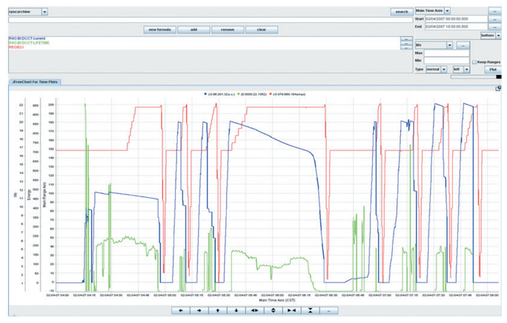


- Re-arrange VME IOC distribution in the network
- All IOCs are connected to a way to minimize the unrelated network traffic.
- EPICS clock 60Hz
- A ramping program in a independent IOC, no synchronization problem
- Ramping Slow: 20 min. (1.89GeV to 2.5GeV)
- Reason:
  - EPICS clock 60Hz resulting PVs processing slow
  - Time interval between two steps must be long enough

PS Ramping

- SR First Running: 2006.12.25 –2007.2.2
- Important Issue: Energy Ramping in BSR
- Requirements:
  - All PS in BSR are ramped to the desired value synchronously (from 1.89GeV to 2.5GeV)
- Implementation:
  - PS Control distributed(11 VME IOC)
  - Ramping program in every IOC
    - EPICS event to trigger every ramping program
    - Real-time DB processing slow(60Hz clock) , different CPU load, synchronization problem
  - Ramping program in a independent VME IOC
    - Change EPICS clock from 60Hz to 600Hz
      - Real-time database processing fast
    - write setpoint to setpoint DB of the all IOCs step by step
    - Ramping procedure is getting fast

Energy(B current)/Lifetime/ Current Ramping no beam loss



Summary

- Ramping program has a enough fast speed now
- Improvement on Ramping Quality with beam
- Different magnets, different PS, different magnetic field response
- Energy ramping in BSR has been running very well.
- It play an important role in BEPCII synchrotron radiation running.