

BETATRON TUNES and the CURRENT in the QUADRUPOLE TRIM COIL

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BETATRON TUNES and the CURRENT
in the QUADRUPOLE TRIM COIL

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Abstract

The current requirement in the quadrupole trim coil depends on both the current in the main power supply and the betatron tunes. A SYNCH program resides in the RHIC data base (BNLDAG::[RHIC.BOOSTER]BSTUNE.DAT) can be used to calculate the required trim current in the quadrupoles.

1. The Program and Discussion

Since a single power supply is used initially for the dipole and quadrupoles, the betatron tune of the machine can be adjusted by a power supply current in the quadrupole trim coil. A program is needed to calculate the trim current for a given betatron tune. This report shows an example of using the SYNCH to calculate the trim current requirement.

In the Appendix, the boxed region of the SYNCH input file can be viewed as a black-box. On the other hand, the first few lines should be changed according to the realistic data, where:

BOI	:	Transfer function in (Tesla/Amp)
IDIP	:	Current in the main dipole power supply in [Amp]
GLOI	:	Integrated transfer function of the short quadrupole in T/A
LDIP	:	Dipole effective length in [m] for QD
LQL	:	Long quadrupole length in [m] for QF
LQ£	:	Short quadrupole length in [m] for QF
QX	:	Horizontal betatron tune
QY	:	Vertical betatron tune

When you put in the number obtained from the magnet measurement data and the preferred betatron tunes, the SYNCH input file can be executed to obtain the current needed in the trim coil, called ITF and ITD in Amperes.

In the example (shown in the Appendix) we use 1000 Amp.

The SYNCH input file resides at:

BNLDAG::DUA3:[RHIC.BOOSTER]BSTUNE.DAT

To execute the program, you can COPY BSTUNE.DAT to your directory and work in the following procedure:

```
$ASSIGN    BSTUNE.DAT    FOR002
$ASSIGN    BSTUNE.OUT    FOR003
$RUN       DUA3:[RHIC.AP.SYNCH]SYNCH
```

The result of ITF and ITD currents are obtained in the BSTUNE.OUT file. If ITF and ITD are positive, they increase the quadrupole strength (shorter focal length).

Similar procedure can be worked out in the MAD input file. From the operational point of view, the trim coil should be calculated and parametrized as a function of the current in the main power supply. The trim power supply function generation can be used to track the acceleration cycle.

Calculation based on the present Booster magnet measurement gives the trim current in the focusing and defocusing quads as:

$$I_{TF} = [0.807 (Q_x - Q_x^o) + 0.256 (Q_y - Q_y^o)] I \quad (1)$$

$$I_{TD} = [0.250 (Q_x - Q_x^o) + 0.779 (Q_y - Q_y^o)] I \quad (2)$$

where I is the main power supply current, Q_x^o and Q_y^o are the betatron tunes without trim power supply, i.e., $Q_x^o \approx 4.6$, $Q_y^o \approx 4.55$ obtained from the present magnet measurement. If the magnet measurement data are different, only Q_x^o and Q_y^o will be changed.

Note also that the accuracy of Eqs. (1) and (2) are about 1 ~ 2%. This is due to the fact that the relation between the tunes and the quadrupole strength is not linear. However, Eqs. (1) and (2) should be valid for obtaining the correct tune to about 1 ~ 2%.

Equations (1) and (2) also give the sensitivity of trim current in changing the tune. At $I = 1000A$, the tune of the machine will be changed by 0.01 if I_T is changed by 10A.

When I_T reaches the peak trim current of the trim power supply, the tunes of the machine will drift toward Q_x^o and Q_y^o as I in the main dipole supply is increased. The time dependence of Q_x and Q_y can also be obtained from Eq. (1) and (2), i.e.

$$Q_x = Q_x^o + 1.38 I_{TF}/I - 0.443 I_{TD}/I$$

$$Q_y = Q_y^o - 0.453 I_{TF}/I + 1.43 I_{TD}/I$$

Appendix

BNLDAG :: DUA3 : [RHIC BOOSTER] BSTUNE.DAT

\$ TYPE BSTUNE.DAT

BSTT	RUN	AGS BOOSTER TUNE CALCULATION	
BOI	=	.000243564	Transfer function in [T/A]
GLOI	=	.0009123 *	[G _{dc} /I] of F Quad in [T/A]
IDIP	=	1000.	current in dipole in [A]
LDIP	=	2.42	Length of dipole in [m]
LQL	=	0.5064	" " D Quad in [m]
LQS	=	0.4937	" " F Quad in [m]
QX	=	3.755	Horizontal tune
QY	=	4.775	Vertical tune

NCPY

C=====

C THE FOLLOWING PART CAN BE VIEWED AS A BLACK BOX FOR THE TUNE CALCULATION

B#OI	=	GLOI	/	.4937	
BI	=	BOI	*	IDIP	
B#B	=	B#OI	/	BOI	
BR	=	17.6			
BZ	=	1.27990812			
.BST	BML	QD	S30	BEND	S100 QF S30 BEND S100 QD S370 QF
		S30	BEND	S100 QD S30	BEND S100 QF S370
		QD	S30	BEND	S100 QF S30 BEND S100
GF	=	9.83525219			
GD	=	-10.116755			
S30	DRF	.3			
S370	DRF	3.70			
S100	DRF	1.0			
BEND	MAG	2.4		BR	BZ
MUX	=	QX	/	6.	
MUY	=	QY	/	6.	
TUNE	SUB				
QF	MAG	.50375	GF	BR	
QD	MAG	.50375	GD	BR	
MP	MMM	.BST			
	END				
CBST	CYC	6	.BST		
FQ	FITQ	TUNE	MP	GF	GD 1 1MUX MUY
LDR	=	2.4			
LQR	=	0.50375			
B#OI	CALC	RCL	B#B	RCL	BOI *
B#Q	CALC	RCL	B#B	RCL	BI *
B#F	CALC	RCL	GF	RCL	LQR * RCL LQS /
		RCL	BI	*	RCL BZ / RCL LDIP * RCL LDR /
B#TF	CALC	RCL	B#Q	-	
ITF	CALC	RCL	B#OI	/	5. *
B#D	CALC	RCL	GD	CHS	RCL LQR * RCL LQL /
		RCL	BI	*	RCL BZ / RCL LDIP * RCL LDR /
B#TD	CALC	RCL	B#Q	-	
ITD	CALC	RCL	B#OI	/	5. *
C	THE TRIM COIL CURRENT IS				
	PRNT	ITF	ITD		
C	BST	CYC	6	.BST	
	FIN				
	STOP				