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 time 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.

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

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

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

BSTT RUN		AGS BOOSTER TUNE CALCULATION		
BOI	=	.000243564	_____	Transfer function in [T/A]
GLOI	=	.0009123 *	0.994 _____	[G ₀ L/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				

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