Fermilab

PBAR #432

COMMON MODE REJECTION OF STACK TAIL KICKER HYBRIDS

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The betatron heating of the core is commonly agreed to be due to a undesired difference mode in the kickers. This could be due to tolerances and mistakes in the kickers or in the hydrids which ideally drive the kickers in the sum mode. The purpose of this note is to estimate the effect of the latter. The hydrids, by the nature of their construction, have systematic errors. These errors appear to be larger than the errors which come from construction tolerances. The amount of betatron heating from a difference mode signal applied to the stack tail kickers is given by:

$$\frac{d\varepsilon}{dt} = \frac{n_k \beta_k}{(p/e)^2} \sum_n P(\omega) \frac{d(\omega)^2 Z_0}{n^2 h^2}$$

Where n_k is the number of kickers, β_k is the beta function at the kicker, p is the beam momentum, e is the proton charge. $P(\omega)$ is the sum of the power densities for the two sidebands at harmonic n. The kicker impedance is Z_0 and the sensitivity is $d(\omega)$. The sum over power densities is about 8 times the average power. The factor of 8 is a product of a factor of 4 because of the concentration of power at the stack tail and a factor of 2 because of the low frequency emphasis from the n^{-2} factor. Putting in numbers:

$$\frac{d\varepsilon}{dt} = \frac{150}{2\pi^2 (1\times10^9)} \; 8 \; \frac{1590(160)10}{(2385)^2} \left(\frac{1.5}{.03}\right)^2 \frac{100(3\times10^8)^2}{(8.8\times10^9)^2}$$

$$= 8\pi \text{ mm-mrad/sec or heating time} = .6 \text{ sec @} 5\pi \text{ mm-mrad}$$

where 2385 is the harmonic number at midband and 1590 is the total number of harmonics.

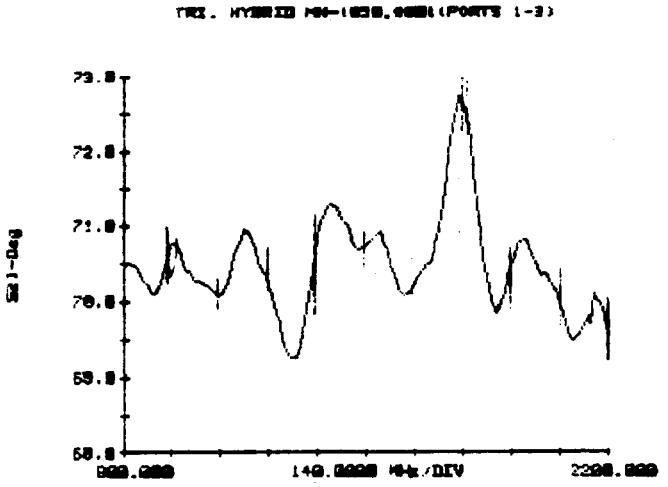
We next consider the amount of common-mode suppression in the stack tail hybrids. Figure 1 shows a network analyzer measurement of port 3 and figure 2 shows the same for port 4. The residual amount of (undesired) difference mode is given by the difference in the signal between the two ports (-3dB) and is shown in figure 3. The average rejection is about 25 dB.

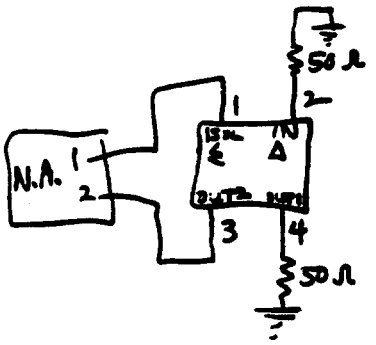
CONCLUSION: With 25 dB suppression of the common-mode signal one calculates a heating time of approximately 200 sec. This is comparable to the observed heating time of about 500 sec. We should therefore try to increase the common-mode suppression. Since there are 20 hybrids in the stack tail system reversing half of them should make at least a 25dB improvement. Because beta varies along the straight section the best way to symmetrize the hybrids is to flip ports on say the odd numbered hybrids on the first tank and the event numbered ports on the last tank. The middle tank should have its first and last hybrids flipped.

START= 800.00 STOP= 2200.00 NUMF= 141
TRI. HYBRID MH-1058.#001(PORTS 1-3)

AVERAGE DELAY IS 792.1 PICO-SECONDS 8 Aug 1984 07:22:36

MATERIAL	LENGTH IN CM	LENGTH IN IN	LENGTH IN FT
VACUUM	23.76	9.355	.7797
AIR	23.72	9.337	.7781
SEMI-RIGID (TEFLON)	16.52	6.502	.5419
COAX (FOAM)	20.91	8.233	.6861
STRIP FLEX (TEFLON)	16.49	6.493	.5411





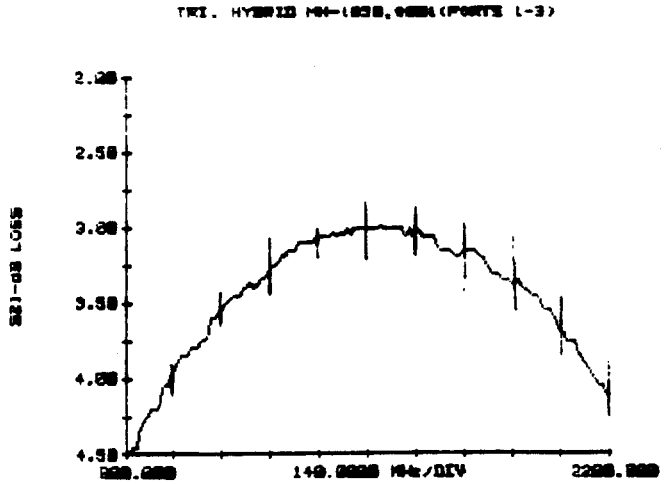
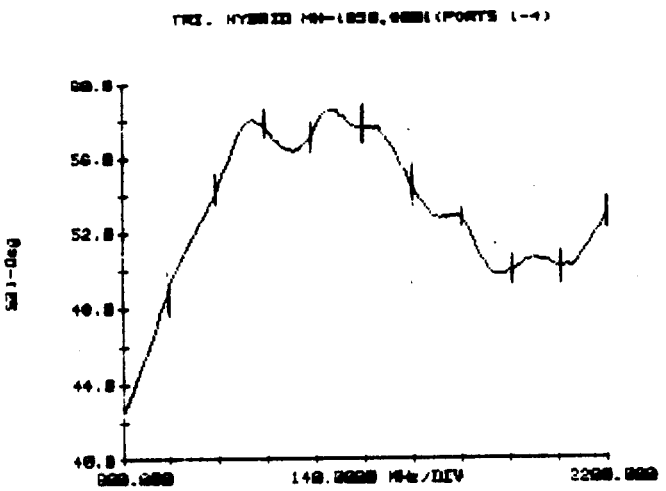


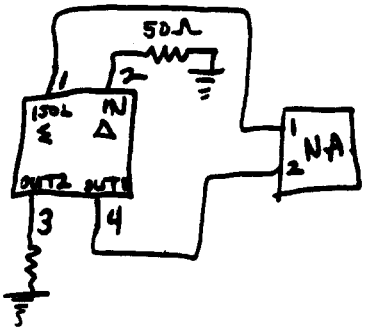
Figure 1

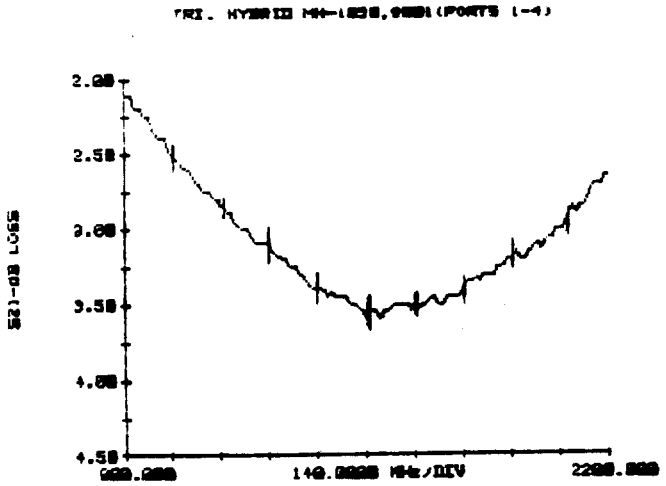
START= 800.00 STOP= 2200.00 NUMF= 141
TRI. HYBRID MH-1058.#001(PORTS 1-4)

AVERAGE DELAY IS 755.8 PICO-SECONDS 8 Aug 1984 07:30:10

MATERIAL	LENGTH IN CM	LENGTH IN IN	LENGTH IN FT
VACUUM	22.67	8.927	.7439
AIR	22.63	8.909	.7425
SEMI-RIGID (TEFLON)	15.76	6.204	.5170
COAX (FOAM)	19.95	7.856	.6547
STRIP FLEX (TEFLON)	15.74	6.195	.5163

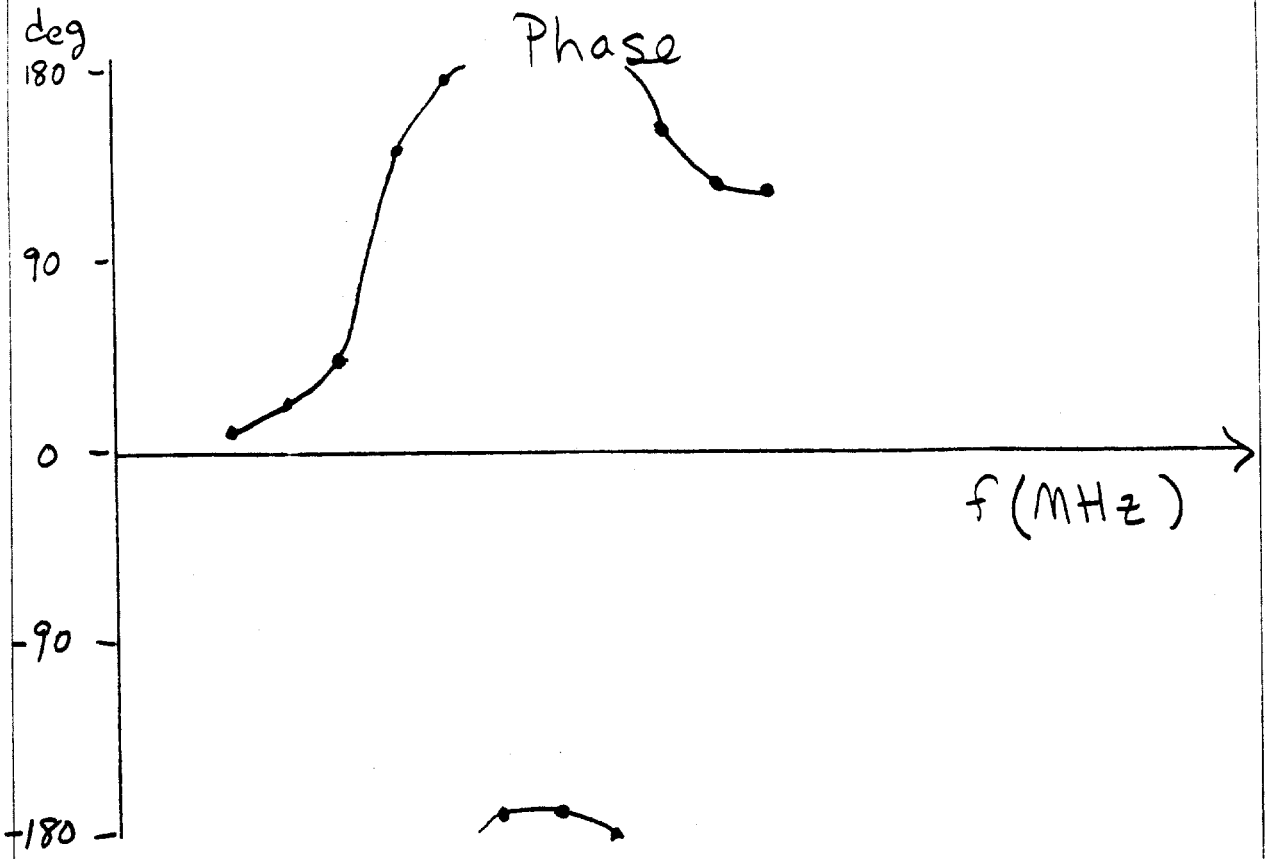






			Δ mod dB	
	43	[illegible]	-14.0	1
	[illegible]	61	-18.7	2
	[illegible]	[illegible]	-27.8	4
	[illegible]	[illegible]	-31.3	14
	[illegible]	[illegible]	-27.6	17
	[illegible]	[illegible]	-23.9	-16
	[illegible]	75	-27.1	-16
	[illegible]	[illegible]	-30.2	-18
	[illegible]	75	-27.1	14
	[illegible]	77	-22.4	12
	[illegible]	81	-18.0	12

Figure 2


deg
Phase
180
90
0
-90
-180
f (MHz)

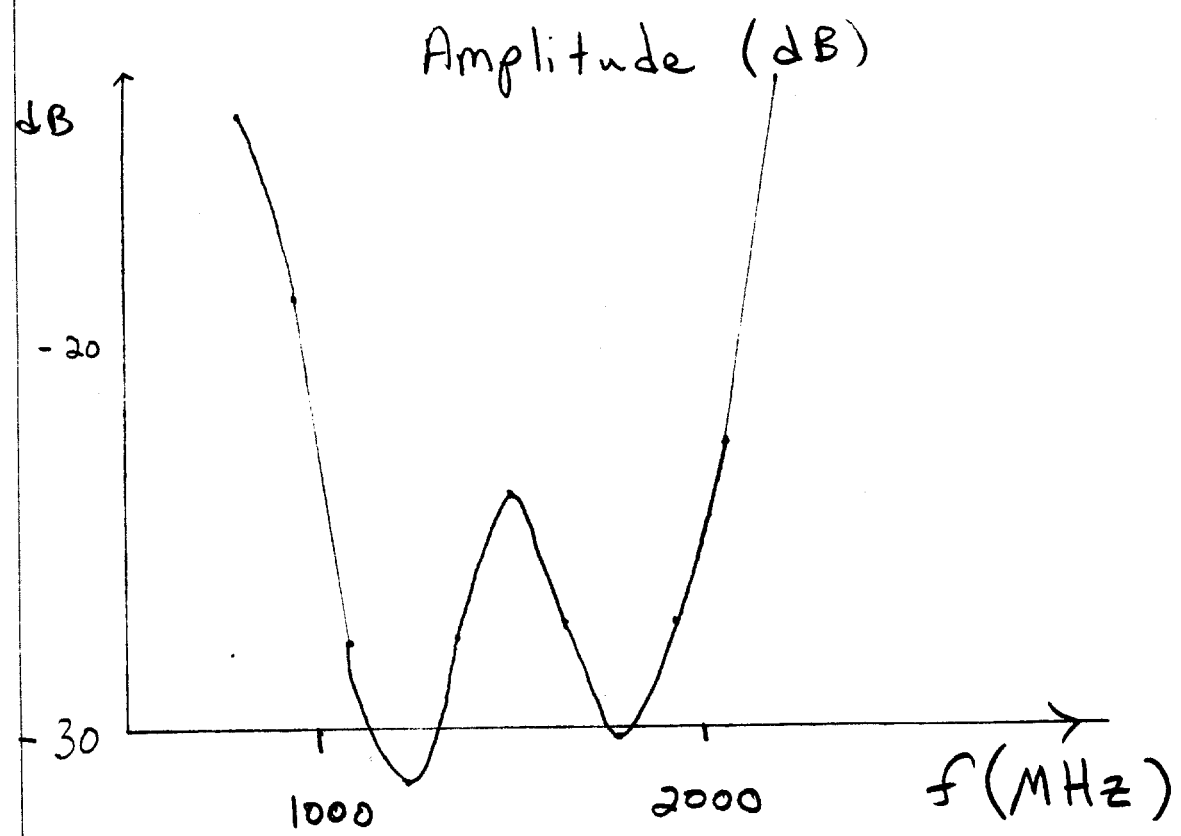

Amplitude (dB)
dB
-20
-30
1000
2000
f (MHz)

Figure 3