BNL-104631-2014-TECH

AGS/AD/Tech Note No. 204;BNL-104631-2014-IR

CALCULATION OF MOTOR SPEED OF THE SIEMENS M.G. SET DURING A PULSE

A. Feltman

July 1984

Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No.DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Accelerator Department
BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York 11973

AGS Division Technical Note
No. 204

CALCULATION OF MOTOR SPEED OF THE SIEMENS M.G. SET DURING A PULSE

A. Feltman

July 31, 1984

The motor generator system has been designed so that under normal circumstances the motor speed over the duration of an AGS magnet pulse varies by less than $\pm$ 2%. This is with a motor power input variation of less than $\pm$ 200 KW. Considering that the main magnet power supply output goes from +70 MW to -70 MW during the pulse, these power swings must be absorbed by the rotational energy of the MG set. This has been accomplished by designing the generator rotor with a large radius resulting in a large moment of inertia. At 1200 RPM, the stored energy is 310 MJ.

The motor speed at any time during a pulse can be determined by considering the electrical and mechanical relationships

$$1) \quad P_{in} = JW \frac{\partial W}{dt} + P_W + P_E$$

where

P_{in} = power into the motor
J = MG set moment of inertia $[40(10^3)$ kg $M^2]$
W = rotational speed in radians/sec
P_W = windage and bearing losses (850 KW)
P_E = electrical power

Three types of elements contribute to the electrical power term (P_E). They are resistance (P_R), inductance (P_L) and arc drop (P_A). Let us discuss these items a little further.

The arc drop term is attributed to the arc drop across the excitrons. For each excitron this is equivalent to a 16 volt battery in series 13 mΩ. For the whole power supply, this is equivalent to 128 volts in series with 50 mΩ. For convenience, this 50 mΩ and other power supply resistances are lumped in with the load resistance of 0.25 Ω to comprise a total resistance of 0.3 Ω. This 0.3 Ω will be used for the determination of the "P_R" term. This 128 volts will be used for the "P_A" term.

Now, the inductive term is something somewhat special. The main reason is that the prime source of the system inductance is that of the magnet whose inductance varies with the current. This variation is from 0.5 to 0.8 Henries. The main value used in this note will be 0.7 H. This includes also the reactive drop in the transformer connections, etc. It should also be pointed out that the "P_L" term can be either positive or negative depending upon whether the current is increasing or decreasing.

In light of these comments, we can then conclude that

$$2) \quad W \frac{\partial W}{\partial t} = \frac{(P_{in} - P_W)}{J} - \frac{(P_E + P_R + P_L)}{J}$$

Integrating both sides from 0 to t yields

$$3) \quad W^2 - W_o^2 = (\frac{P_{in} - P_W}{J/2})t - \frac{1}{J/2} \int_o^t (P_E + P_R + P_L)dt$$

$$4)\quad W^2 = W_o^2 + \left(\frac{P_{in} - P_W}{J/2}\right)t - \frac{1}{J/2}\int_o^t \left(E_E\, I + RI^2 + LI\,\frac{dI}{dt}\right)dt$$

If "I" has form

$$5)\quad I = I_o + \alpha\, t$$

then,

$$6)\quad \frac{dI}{dt} = \alpha$$

and then

$$7)\quad W^2 = W_o^2 + \left(\frac{P_{in} - P_W}{J/2}\right)t - \frac{1}{J/2}\int_o^t \left[\left(EI_o + \alpha LI_o + RI_o^2\right) + \right.$$

$$\left.\left(\alpha E_E + L\alpha^2 + 2\alpha RI_o\right)t + \alpha^2 Rt^2\right]dt$$

and

$$8)\quad W^2 = W_o^2 + \left(\frac{P_{in} - P_W}{J/2}\right)t - \left(\frac{E_E I_o + L\alpha I_o + RI_o^2}{J/2}\right)t$$

$$- \left(\frac{E_E\,\alpha + 2R\alpha I_o + \alpha^2 L}{2(J/2)}\right)t^2 - \frac{\alpha^2 Rt^3}{3(J/2)}$$

During a pulse, four current segements can be identified. They are: injection porch, rectify, flattop, and invert. The current characteristics during each of these intervals are as follows:

Injection Porch

$$9)\quad I_{IP} = 2956\ t \Big|_{o}^{t\ 0.11\ sec}$$

Rectify

$$10)\quad I_{R} = 325.16 + 10{,}500\ t \Big|_{o}^{t_R}$$

Flattop

$$11)\quad I_{F} = I_{F}\ (\text{constant})$$

Invert

$$12)\quad I_{I} = I_{F} - 11{,}250\ t \Big|_{o}^{t_I=0}$$

Therefore, during the injection porch,

$$13)\quad W^2 = W_o^2 + \left(\frac{P_{in} - 0.85(10^6)}{2(10^4)}\right)t - 162.4t^2 - 43.69t^3$$

Where W_o is approximately 1.5% above the synchronous (rotational) speed. The synchronous speed is 1200 RPM or 125.66 radians per second. 1.5% above this is about 128 radians per second. W_o^2 is then 16,384.

During rectify we get

$$14) \quad W_R^2 = W_{oR}^2 + \left(\frac{P_{in} - 0.85\ (10^6)}{2(10^4)}\right)t_R - 121t_R - 2014t_R^2 - 551t_R^3$$

Where t_R is reckoned from the end of the front porch (t - 0.11) and W_{oR} is the speed at the end of the front porch.

During flattop

$$15) \quad W_F^2 = W_{oF}^2 + \left(\frac{P_{in} - 0.85(10^6)}{2(10^4)}\right)t_F - \left(\frac{128\ I_{Fo} + 0.3I_{Fo}^2}{2(10^4)}\right)t_F$$

Where t_F is reckoned from the beginning of flattop and I_{Fo} is the current at the beginning of flattop.

For invert, the following relationship exists

$$16) \quad W_I^2 = W_{oI}^2 + \left(\frac{P_{in} - 0.85(10^6)}{2(10^4)}\right)t_1 + \left(\frac{7747\ I_{o1} - 0.3\ I_{o1}^2}{2(10^4)}\right)t_1$$

$$- (2179 - 0.1688\ I_{o1})t_1^2 - 632.8t_1^3$$

W_{o1} is the speed at beginning of invert at t_1 is reckoned from beginning of invert.

Assuming an M.G. set initial speed of 128 radians per second, the speed as a functin of time has been calculated over the duration of a typical 28 GeV/c AGS magnet current pulse. This corresponds to a current of 5050 amperes. This was done for a 1.0 second and a 2.0 second flattop. Two sets of calculations were made; one set for a motor net power input of four megawatts, the other for seven.

The results of these calculations are tabulated on the following pages. A plot is also included.

mvh

Distribution: Dept. S&P
Siemens Techs

INJECTION PORCH

$P_{IN} - P_W$ = 4MW 7MW

0.01	0.01	SEC
29.56	29.56	AMPS
128.0077487	128.0136075	RADS
0.02	0.02	SEC
59.12	59.12	AMPS
128.0153689	128.0270858	RADS
0.03	0.03	SEC
88.68	88.68	AMPS
128.0228599	128.0404337	RADS
0.04	0.04	SEC
118.24	118.24	AMPS
128.0302205	128.0536503	RADS
0.05	0.05	SEC
147.8	147.8	AMPS
128.0374498	128.0667347	RADS
0.06	0.06	SEC
177.36	177.36	AMPS
128.0445466	128.0796858	RADS
0.07	0.07	SEC
206.92	206.92	AMPS
128.0515102	128.0925027	RADS
0.08	0.08	SEC
236.48	236.48	AMPS
128.0583393	128.1051844	RADS
0.09	0.09	SEC
266.04	266.04	AMPS
128.0650331	128.1177299	RADS
0.1	0.1	SEC
295.6	295.6	AMPS
128.0715906	128.1301382	RADS
0.11	0.11	SEC
325.16	325.16	AMPS
128.0780106	128.1424083	RADS
0.12	0.12	SEC
354.72	354.72	AMPS
128.0842926	128.1545393	RADS

RECTIFY

PIN-PW 4MW 7MW 4MW 7MW

			0.13	0.13 SEC
			1690.16	1690.16 AMPS
			127.9867524	128.1331682 RADS
0.01	0.01	SEC	0.14	0.14 SEC
430.16	430.16	AMPS	1795.16	1795.16 AMPS
128.0865878	128.1626856	RADS	127.9674161	128.1197081 RADS
0.02	0.02	SEC	0.15	0.15 SEC
535.16	535.16	AMPS	1900.16	1900.16 AMPS
128.0872981	128.1692472	RADS	127.946322	128.1044937 RADS
0.03	0.03	SEC	0.16	0.16 SEC
640.16	640.16	AMPS	2005.16	2005.16 AMPS
128.0864101	128.1742114	RADS	127.9234562	128.0875117 RADS
0.04	0.04	SEC	0.17	0.17 SEC
745.16	745.16	AMPS	2110.16	2110.16 AMPS
128.0839111	128.1775654	RADS	127.8988048	128.0687483 RADS
0.05	0.05	SEC	0.18	0.18 SEC
850.16	850.16	AMPS	2215.16	2215.16 AMPS
128.0797879	128.1792966	RADS	127.8723539	128.0481898 RADS
0.06	0.06	SEC	0.19	0.19 SEC
955.16	955.16	AMPS	2320.16	2320.16 AMPS
128.0740275	128.179392	RADS	127.8440895	128.0258225 RADS
0.07	0.07	SEC	0.2	0.2 SEC
1060.16	1060.16	AMPS	2425.16	2425.16 AMPS
128.0666168	128.1778388	RADS	127.8139974	128.0016326 RADS
0.08	0.08	SEC	0.21	0.21 SEC
1165.16	1165.16	AMPS	2530.16	2530.16 AMPS
128.0575426	128.174624	RADS	127.7820634	127.975606 RADS
0.09	0.09	SEC	0.22	0.22 SEC
1270.16	1270.16	AMPS	2635.16	2635.16 AMPS
128.0467917	128.1697346	RADS	127.7482731	127.9477288 RADS
0.1	0.1	SEC	0.23	0.23 SEC
1375.16	1375.16	AMPS	2740.16	2740.16 AMPS
128.0343506	128.1631575	RADS	127.7126122	127.9179867 RADS
0.11	0.11	SEC	0.24	0.24 SEC
1480.16	1480.16	AMPS	2845.16	2845.16 AMPS
128.020206	128.1548796	RADS	127.6750661	127.8863657 RADS
0.12	0.12	SEC	0.25	0.25 SEC
1585.16	1585.16	AMPS	2950.16	2950.16 AMPS
128.0043445	128.1448876	RADS	127.6356203	127.8528512 RADS

RECTIFY CONTINUED

Pw-Pw	4MW	7MW		4MW	7MW	
	0.26	0.26	SEC	0.37	0.37	SEC
	3055.16	3055.16	AMPS	4210.16	4210.16	AMPS
	127.5942599	127.817429	RADS	127.0086199	127.2976415	RADS
	0.27	0.27	SEC	0.38	0.38	SEC
	3160.16	3160.16	AMPS	4315.16	4315.16	AMPS
	127.5509702	127.7800846	RADS	126.9430969	127.238162	RADS
	0.28	0.28	SEC	0.39	0.39	SEC
	3265.16	3265.16	AMPS	4420.16	4420.16	AMPS
	127.5057363	127.7408032	RADS	126.8754577	127.1765771	RADS
	0.29	0.29	SEC	0.4	0.4	SEC
	3370.16	3370.16	AMPS	4525.16	4525.16	AMPS
	127.458543	127.6995701	RADS	126.8056857	127.1128709	RADS
	0.3	0.3	SEC	0.41	0.41	SEC
	3475.16	3475.16	AMPS	4630.16	4630.16	AMPS
	127.4093754	127.6563706	RADS	126.7337645	127.047027	RADS
	0.31	0.31	SEC	0.42	0.42	SEC
	3580.16	3580.16	AMPS	4735.16	4735.16	AMPS
	127.358218	127.6111896	RADS	126.6596773	126.9790292	RADS
	0.32	0.32	SEC	0.43	0.43	SEC
	3685.16	3685.16	AMPS	4840.16	4840.16	AMPS
	127.3050555	127.5640121	RADS	126.5834072	126.9088609	RADS
	0.33	0.33	SEC	0.44	0.44	SEC
	3790.16	3790.16	AMPS	4945.16	4945.16	AMPS
	127.2498725	127.5148229	RADS	126.5049373	126.8365056	RADS
	0.34	0.34	SEC	0.45	0.45	SEC
	3895.16	3895.16	AMPS	5050.16	5050.16	AMPS
	127.1926532	127.4636067	RADS	126.4242503	126.7619465	RADS
	0.35	0.35	SEC	0.46	0.46	SEC
	4000.16	4000.16	AMPS	5155.16	5155.16	AMPS
	127.133382	127.4103482	RADS	126.3413289	126.6851665	RADS
	0.36	0.36	SEC			
	4105.16	4105.16	AMPS			
	127.0720429	127.3550317	RADS			

.41
.12
.67

FLAT TOP

4MW	7MW	PIN-PW	4MW	7MW
0.03 126.3987523	0.03 126.7542686	SEC RADS	1.23 125.3745798	1.23 126.4467686	SEC RADS
0.13 126.3137218	0.13 126.7286721	SEC RADS	1.33 125.2888542	1.33 126.4211098	SEC RADS
0.23 126.2286339	0.23 126.7030704	SEC RADS	1.43 125.2030699	1.43 126.3954458	SEC RADS
0.33 126.1434887	0.33 126.6774635	SEC RADS	1.53 125.1172268	1.53 126.3697767	SEC RADS
0.43 126.058286	0.43 126.6518515	SEC RADS	1.63 125.0313247	1.63 126.3441023	SEC RADS
0.53 125.9730257	0.53 126.6262343	SEC RADS	1.73 124.9453636	1.73 126.3184226	SEC RADS
0.63 125.8877076	0.63 126.6006119	SEC RADS	1.83 124.8593433	1.83 126.2927378	SEC RADS
0.73 125.8023316	0.73 126.5749843	SEC RADS	1.93 124.7732637	1.93 126.2670477	SEC RADS
0.83 125.7168977	0.83 126.5493516	SEC RADS	2.03 124.6871246	2.03 126.2413525	SEC RADS
0.93 125.6314057	0.93 126.5237136	SEC RADS			
1.03 125.5458554	1.03 126.4980705	SEC RADS			
1.13 125.4602469	1.13 126.4724221	SEC RADS			

INVERT AFTER 1SEC 1-LAT TOP

4MW	7MW	(P_{1H}-P_W)	4MW	7MW	
0.01	0.01	SEC	0.13	0.13	SEC
4937.66	4937.66	AMPS	3587.66	3587.66	AMPS
125.6159413	126.5735546	RADS	126.3666301	127.3892666	RADS
0.02	0.02	SEC	0.14	0.14	SEC
4825.16	4825.16	AMPS	3475.16	3475.16	AMPS
125.6849175	126.6479314	RADS	126.4212563	127.4493392	RADS
0.03	0.03	SEC	0.15	0.15	SEC
4712.66	4712.66	AMPS	3362.66	3362.66	AMPS
125.7527709	126.7211878	RADS	126.4746001	127.5081351	RADS
0.04	0.04	SEC	0.16	0.16	SEC
4600.16	4600.16	AMPS	3250.16	3250.16	AMPS
125.8194882	126.7933107	RADS	126.5266483	127.565641	RADS
0.05	0.05	SEC	0.17	0.17	SEC
4487.66	4487.66	AMPS	3137.66	3137.66	AMPS
125.8850562	126.8642873	RADS	126.5773874	127.6218439	RADS
0.06	0.06	SEC	0.18	0.18	SEC
4375.16	4375.16	AMPS	3025.16	3025.16	AMPS
125.9494615	126.9341045	RADS	126.6268041	127.6767306	RADS
0.07	0.07	SEC	0.19	0.19	SEC
4262.66	4262.66	AMPS	2912.66	2912.66	AMPS
126.0126909	127.0027492	RADS	126.6748848	127.730288	RADS
0.08	0.08	SEC	0.2	0.2	SEC
4150.16	4150.16	AMPS	2800.16	2800.16	AMPS
126.0747311	127.0702084	RADS	126.7216163	127.782503	RADS
0.09	0.09	SEC	0.21	0.21	SEC
4037.66	4037.66	AMPS	2687.66	2687.66	AMPS
126.135569	127.1364692	RADS	126.766985	127.8333623	RADS
0.1	0.1	SEC	0.22	0.22	SEC
3925.16	3925.16	AMPS	2575.16	2575.16	AMPS
126.1951911	127.20115184	RADS	126.8109774	127.8828527	RADS
0.11	0.11	SEC	0.23	0.23	SEC
3812.66	3812.66	AMPS	2462.66	2462.66	AMPS
126.2535842	127.2653431	RADS	126.85358	127.930961	RADS
0.12	0.12	SEC			
3700.16	3700.16	AMPS			
126.310735	127.3279302	RADS			

INVERT AFTER 1SEC FLAT-TOP CONTD

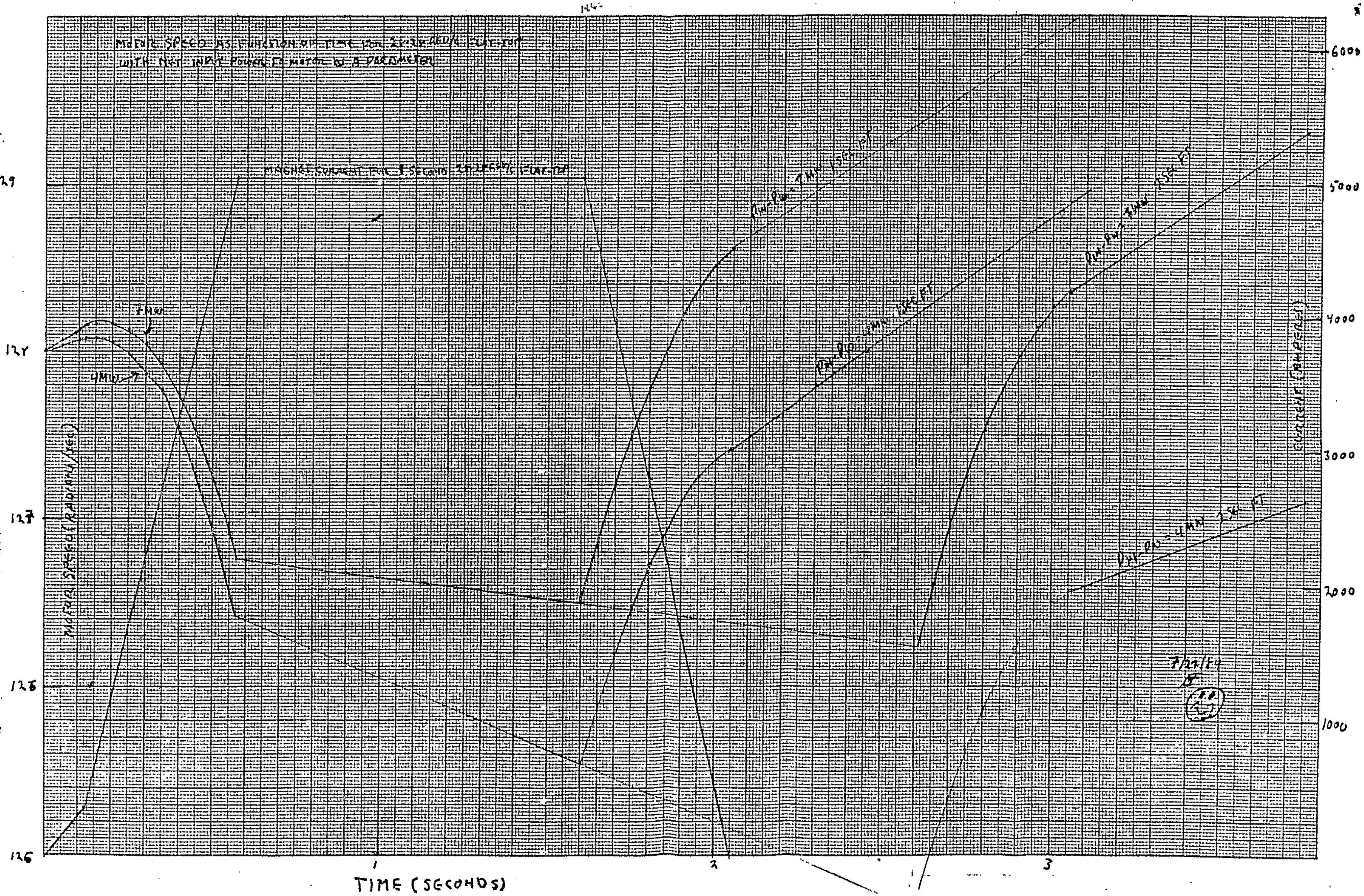
4MW	7MW	(P_{IN}-P_W)	4MW	7MW	
0.24	0.24	SEC	0.35	0.35	SEC
2350.16	2350.16	AMPS	1112.66	1112.66	AMPS
126.8947792	127.9776739	RADS	127.2514468	128.3956026	RADS
0.25	0.25	SEC	0.36	0.36	SEC
2237.66	2237.66	AMPS	1000.16	1000.16	AMPS
126.9345616	128.0229783	RADS	127.274738	128.4245263	RADS
0.26	0.26	SEC	0.37	0.37	SEC
2125.16	2125.16	AMPS	887.66	887.66	AMPS
126.9729135	128.0668606	RADS	127.2964466	128.4518795	RADS
0.27	0.27	SEC	0.38	0.38	SEC
2012.66	2012.66	AMPS	775.16	775.16	AMPS
127.0098212	128.1093077	RADS	127.3165585	128.4776483	RADS
0.28	0.28	SEC	0.39	0.39	SEC
1900.16	1900.16	AMPS	662.66	662.66	AMPS
127.0452712	128.1503061	RADS	127.3350598	128.501819	RADS
0.29	0.29	SEC	0.4	0.4	SEC
1787.66	1787.66	AMPS	550.16	550.16	AMPS
127.0792496	128.1898425	RADS	127.3519361	128.5243777	RADS
0.3	0.3	SEC	0.41	0.41	SEC
1675.16	1675.16	AMPS	437.66	437.66	AMPS
127.1117428	128.2279033	RADS	127.3671732	128.5453105	RADS
0.31	0.31	SEC	0.42	0.42	SEC
1562.66	1562.66	AMPS	325.16	325.16	AMPS
127.142737	128.2644752	RADS	127.3807569	128.5646034	RADS
0.32	0.32	SEC	0.43	0.43	SEC
1450.16	1450.16	AMPS	212.66	212.66	AMPS
127.1722184	128.2995447	RADS	127.3926727	128.5822425	RADS
0.33	0.33	SEC	0.44	0.44	SEC
1337.66	1337.66	AMPS	100.16	100.16	AMPS
127.2001731	128.3330981	RADS	127.4029063	128.5982137	RADS
0.34	0.34	SEC	0.45	0.45	SEC
1225.16	1225.16	AMPS	-12.34	-12.34	AMPS
127.2265872	128.3651219	RADS	127.4114432	128.6125029	RADS

INWRT AFTER 2SEC 28.28 GEV FLAT-TOP
C

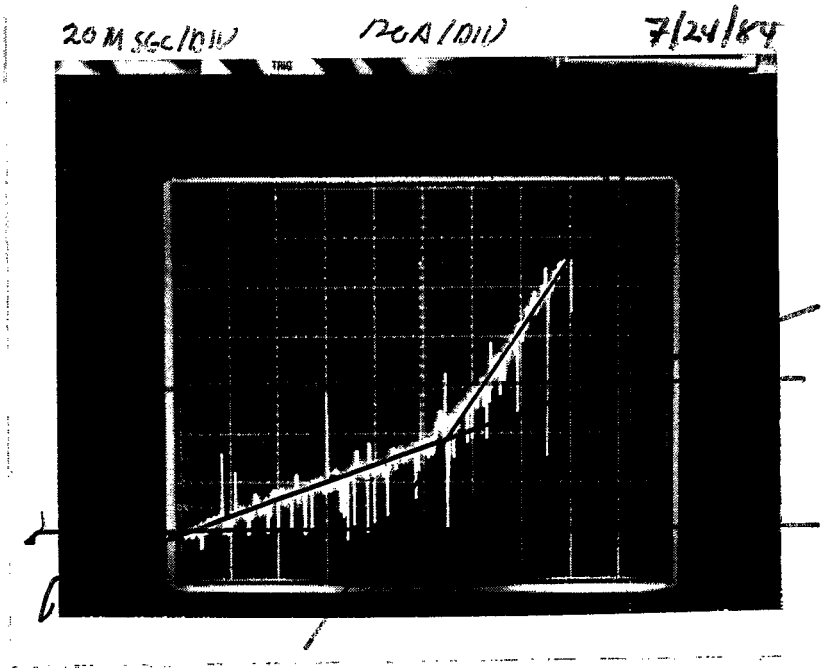
4MW		7MW		4MW		7MW	
0.01		0.01	SEC	0.12		0.12	SEC
4937.66		4937.66	AMPS	3700.16		3700.16	AMPS
124.7576929		126.31699	RADS	125.4572397		127.0728887	RADS
0.02		0.02	SEC	0.13		0.13	SEC
4825.16		4825.16	AMPS	3587.66		3587.66	AMPS
124.8271434		126.3915178	RADS	125.5135149		127.1343481	RADS
0.03		0.03	SEC	0.14		0.14	SEC
4712.66		4712.66	AMPS	3475.16		3475.16	AMPS
124.8954628		126.4649227	RADS	125.5685123		127.1945412	RADS
0.04		0.04	SEC	0.15		0.15	SEC
4600.16		4600.16	AMPS	3362.66		3362.66	AMPS
124.9626378		126.5371917	RADS	125.6222182		127.2534548	RADS
0.05		0.05	SEC	0.16		0.16	SEC
4487.66		4487.66	AMPS	3250.16		3250.16	AMPS
125.0286551		126.6083119	RADS	125.6746194		127.3110757	RADS
0.06		0.06	SEC	0.17		0.17	SEC
4375.16		4375.16	AMPS	3137.66		3137.66	AMPS
125.0935013		126.6782701	RADS	125.7257024		127.3673909	RADS
0.07		0.07	SEC	0.18		0.18	SEC
4262.66		4262.66	AMPS	3025.16		3025.16	AMPS
125.1571632		126.7470534	RADS	125.7754536		127.4223873	RADS
0.08		0.08	SEC	0.19		0.19	SEC
4150.16		4150.16	AMPS	2912.66		2912.66	AMPS
125.2196273		126.8146486	RADS	125.8238597		127.4760516	RADS
0.09		0.09	SEC	0.2		0.2	SEC
4037.66		4037.66	AMPS	2800.16		2800.16	AMPS
125.2808804		126.8810428	RADS	125.8709072		127.5283706	RADS
0.1		0.1	SEC	0.21		0.21	SEC
3925.16		3925.16	AMPS	2687.66		2687.66	AMPS
125.3409091		126.946223	RADS	125.9165823		127.5793312	RADS
0.11		0.11	SEC	0.22		0.22	SEC
3812.66		3812.66	AMPS	2575.16		2575.16	AMPS
125.3997		127.0101759	RADS	125.9608717		127.6289201	RADS

INVERT AFTER 2 SEC 28-28 GEOL PLAT-TOP COATED

4MW	7MW		4MW	7MW	
	0.23	SEC	0.35	0.35	SEC
0.23	2462.66	AMPS	1112.66	1112.66	AMPS
2462.66	127.6771241	RADS	126.4043036	128.1426861	RADS
126.0037618					
	0.24	SEC		0.36	SEC
0.24	2350.16	AMPS	0.36	1000.16	AMPS
2350.16	127.7239299	RADS	1000.16	128.1716669	RADS
126.0452388			126.4277507		
	0.25	SEC		0.37	SEC
0.25	2237.66	AMPS	0.37	887.66	AMPS
2237.66	127.7693242	RADS	887.66	128.199074	RADS
126.0852892			126.4496047		
	0.26	SEC		0.38	SEC
0.26	2125.16	AMPS	0.38	775.16	AMPS
2125.16	127.8132936	RADS	775.16	128.2248937	RADS
126.1238994			126.4698514		
	0.27	SEC		0.39	SEC
0.27	2012.66	AMPS	0.39	662.66	AMPS
2012.66	127.8558249	RADS	662.66	128.249112	RADS
126.1610555			126.~~4~~084765		
	0.28	SEC		0.4	SEC
0.28	1900.16	AMPS	0.4	550.16	AMPS
1900.16	127.8969046	RADS	550.16	128.2717151	RADS
126.1967438			126.5054657		
	0.29	SEC		0.41	SEC
0.29	1787.66	AMPS	0.41	437.66	AMPS
1787.66	127.9365192	RADS	437.66	128.2926891	RADS
126.2309507			126.5208048		
	0.3	SEC		0.42	SEC
0.3	1675.16	AMPS	0.42	325.16	AMPS
1675.16	127.9746554	RADS	325.16	128.3120201	RADS
126.2636622			126.5344793		
	0.31	SEC		0.43	SEC
0.31	1562.66	AMPS	0.43	212.66	AMPS
1562.66	128.0112997	RADS	212.66	128.3296939	RADS
126.2948645			126.5464748		
	0.32	SEC		0.44	SEC
0.32	1450.16	AMPS	0.44	100.16	AMPS
1450.16	128.0464385	RADS	100.16	128.3456965	RADS
126.3245438			126.5567769		
	0.33	SEC		0.45	SEC
0.33	1337.66	AMPS	0.45	-12.34	AMPS
1337.66	128.0800582	RADS	-12.34	128.3600138	RADS
126.352686			126.5653708		
	0.34	SEC			
0.34	1225.16	AMPS			
1225.16	128.1121453	RADS			


TIME (SECONDS)
1
2
3
126
128
129
6000
5000
4000
3000
2000
1000
7MW
4MW

Injection Porch

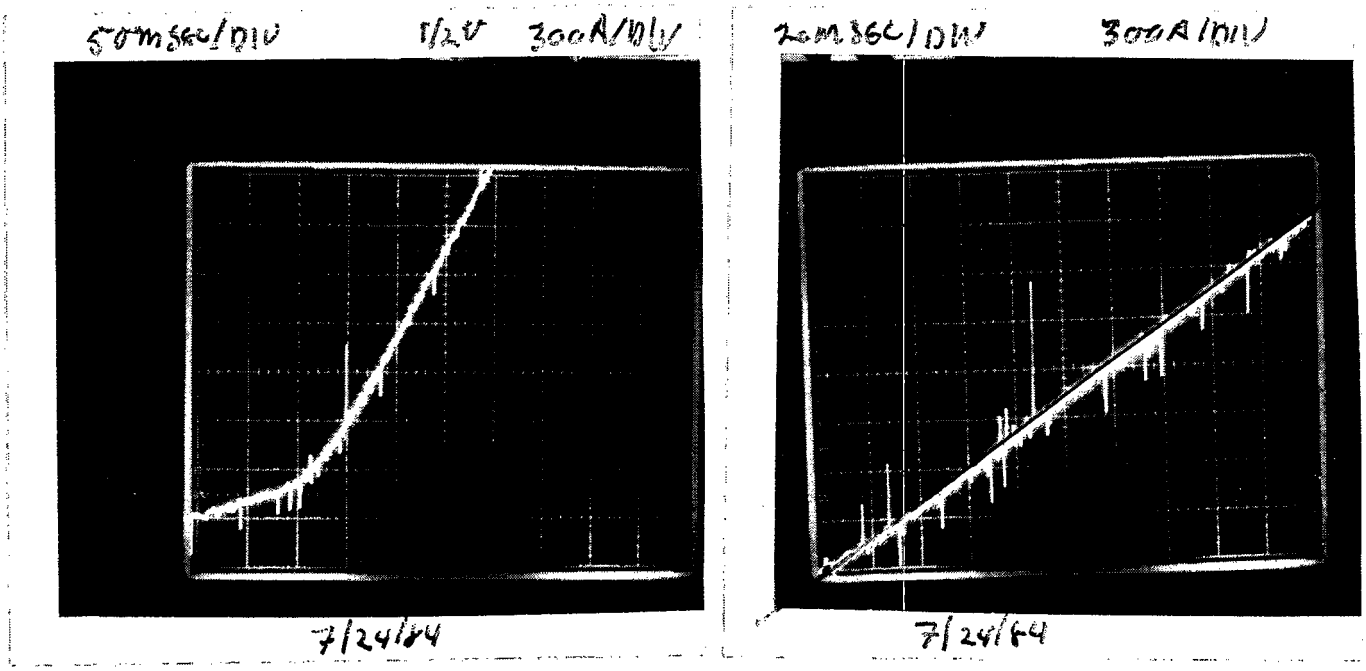


$$I = \frac{(120)(3)}{(0.02)(6.7)} = 2686.6t \cong 2687t \Big|_{0}^{0.11 \text{ sec}}$$

$$I_{0.11 \text{ sec}} = 295.6 \text{ Amps}$$

FIGURE 1

Rectify



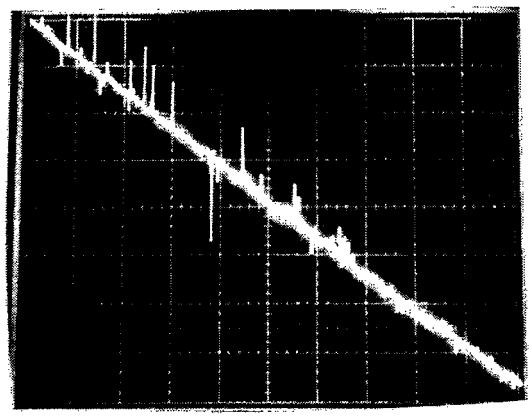
$$I = 295.6 + \frac{(300)(7)}{0.2} t^{-0.11} = 295.6 + 10{,}500\ (t - 0.11)$$

$$I = -860 + 10{,}500t \Big|_{0.11}^{t}$$

FIGURE 2

Invert

20 msec/Div 300 Amps/Div



$$I = I_F - \frac{(300)(7.5)}{0.2} = I_F - 11{,}250t$$

FIGURE 3