File 2 places

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AGS Department

(1) To RSC chair
(2) to chipmunk

MEMORANDUM

Date: January 27, 1999

To: Dana Beavis, Chairman, Radiation Safety Committee

From: Joe Geller

Subject: Time to Chipmunk Interlock for Large Radiation Faults

The minimum chipmunk time to interlock is **not less than .52 seconds**, for a chipmunk radiation monitor exposed to >10 rad dose for an interval ranging from several μs to 5 ms. A **minimum time to trip of .75 seconds** is recommended for radiation safety planning purposes as explained below.

The minimum time to chipmunk interlock is determined by the internal chipmunk circuitry briefly described here. Chipmunk operation is governed by the response of the ionization chamber, the input integrator, the electrometer, a charge pump circuit, and finally the rate meter integrator. The attached simulations and graph show how the chipmunk interlock responds for various other exposures. Originally developed by Fermi National Accelerator Laboratory, the circuitry was optimized for reliability, noise rejection, and analog meter operation.

Ion chamber response to a fast very high radiation dose is reduced to approximately 5% of the chamber's DC response to low radiation fields. Regardless of how fast the ionization of its propane gas takes place, the ion collection process takes on the order of 5 ms. This 5 ms time scale is considered instantaneous for the purposes of chipmunk discussion. Any event which deposits greater than ≈100 nanoCoulombs of charge on the input .02 μF capacitor will cause the electrometer current to frequency converter to instantly saturate at 5 kHz. The current to frequency converter output is divided by 2 for a Quality Factor of 2.5. This output is connected to a 1 ms time constant charge pump, essentially a diode envelope detector, and adds a few ms delay. It is followed by a conventional integrator, charging $\tau \approx 3$ s, which then dominates the minimum response time.

Below a 10 μrad instantaneous dose, chipmunk interlock simulation becomes a slightly different problem since the input capacitor is discharging

during the period of interest and the current to frequency converter output frequency is changing. For the cases discussed here, where the trip occurs in much less than 20 s, the input time constant, the electrometer output frequency is essentially constant during the period of interest.

The actual minimum response time of a specific installed unit will be determined by the actual calibration of that chipmunk conservatively taken be ± 20% absolute, including the current state of its chamber gas pressure. Additionally, various cascaded relays in the security system might add 50 to 100 ms to satisfaction of accelerator system response to a chipmunk interlock. A minimum time to trip of **.75 seconds is** advised to account for possible variations and additional security system relay delay times for radiation safety planning purposes.

This memo is based on Fermi Tech Note TM-1512 (chipmunk chamber response for fast dose), study of the existing design by myself, including ICAP and SPICE simulations, and informal communications with F. Krueger and J. Larson, the original designers.

cc:

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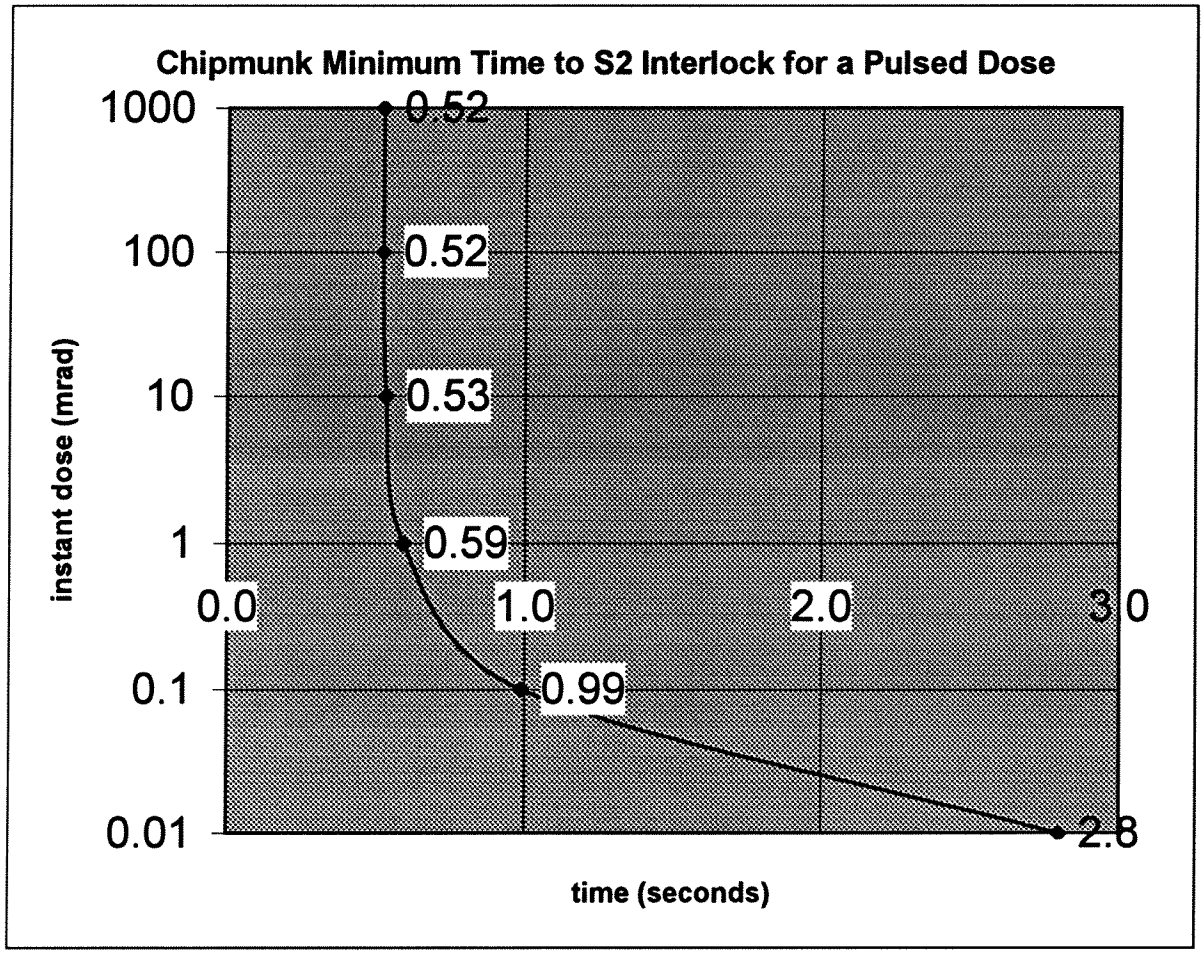
Response of a Chipmunk to Instantaneous Irradiation

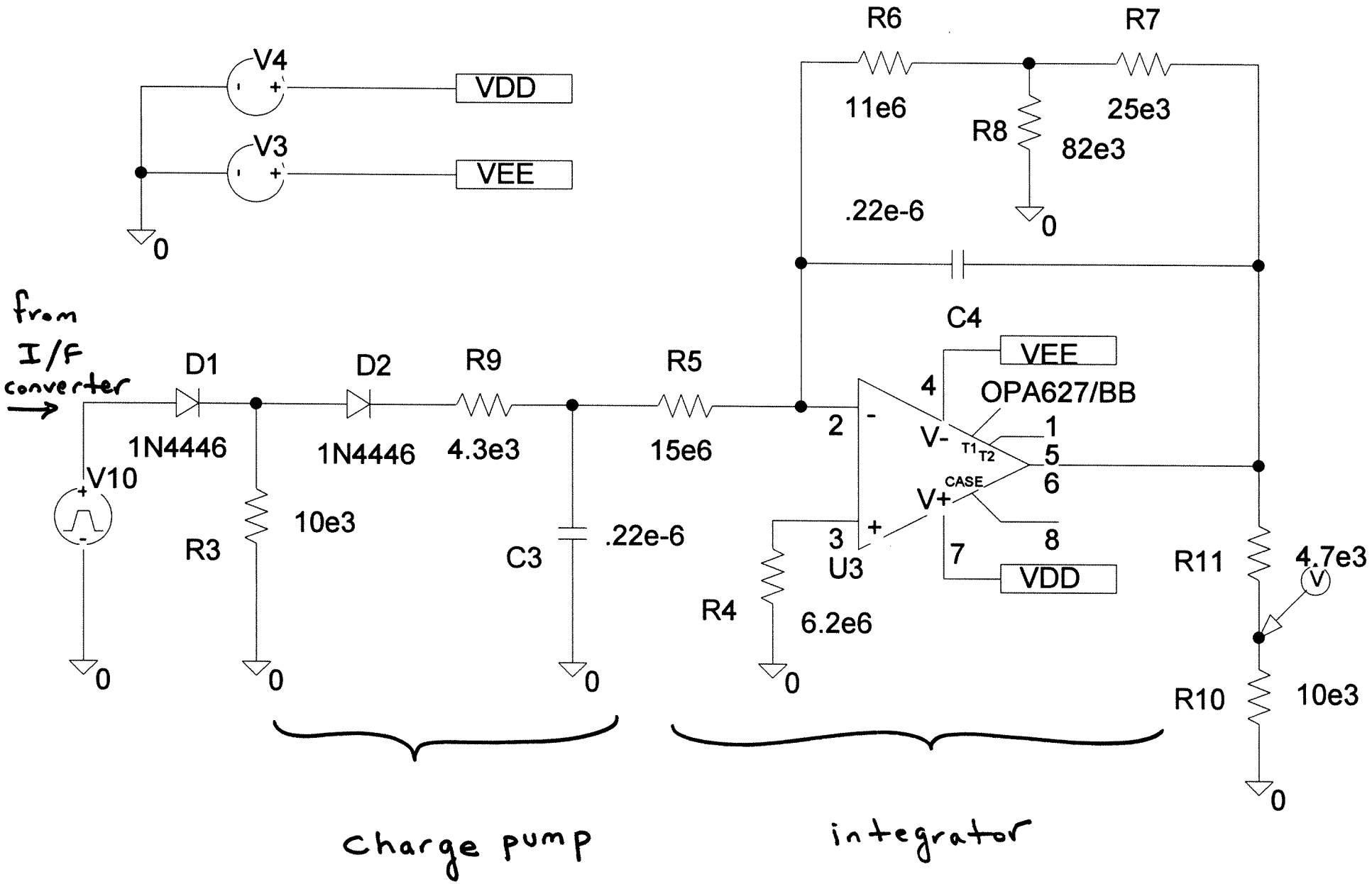
(Full Dose in less than 5 ms)

Dose mrad	x	Chamber Response @ 100%	x	~Chamber Efficiency	=	Charge Coulombs	=>	~Voltage .02 mF	=>	I/F Hz/2 QF 2.5	=>	Minimum Time to Trip seconds
0.01		2.30E-09		1.00		2.30E-11		1.2E-03		0.58		2.8
0.1		2.30E-09		1.00		2.30E-10		1.2E-02		5.75		0.99
1		2.30E-09		0.97		2.23E-09		0.1		55.8		0.59
10		2.30E-09		0.76		1.75E-08		0.9		437		0.53
100		2.30E-09		0.30		6.90E-08		3.5		1725		0.52
1000		2.30E-09		0.06		1.38E-07		6.9	*	2500		0.52

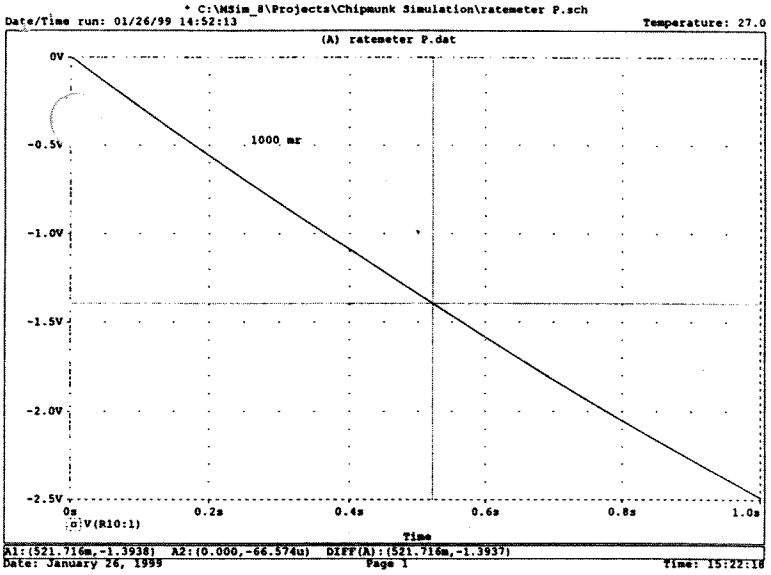
Response is the time from instantaneous dose to "S2" interlock.

* saturation, 2500 is max frequency @ QF = 2.5





chipmunk rate meter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0V
-0.5V
-1.0V
-1.5V
-2.0V
-2.5V
0s
0.2s
0.4s
0.6s
0.8s
1.0s
V(R10:1)
Time
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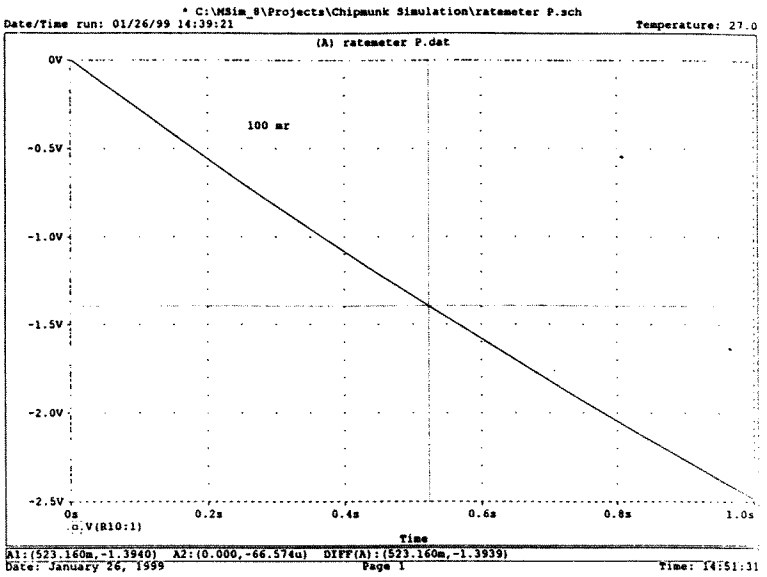
Date: January 26, 1999
Page 1
Time: 15:22:18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(A) ratemeter P.dat
100 mr
0V
-0.5V
-1.0V
-1.5V
-2.0V
-2.5V
0s
0.2s
0.4s
0.6s
0.8s
1.0s
V(R10:1)
Time
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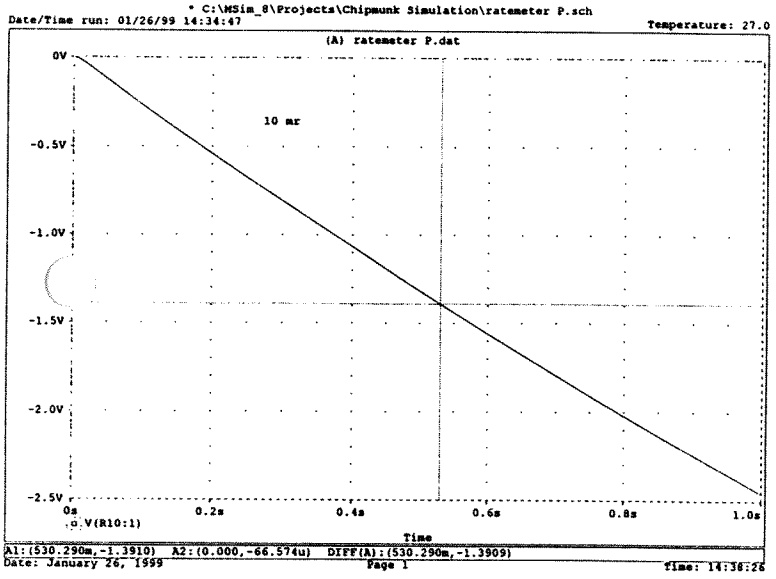
Date: January 26, 1999
Page 1
Time: 14:51:31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(A) ratemeter P.dat
10 mr
0V
-0.5V
-1.0V
-1.5V
-2.0V
-2.5V
0s
0.2s
0.4s
0.6s
0.8s
1.0s
V(R10:1)
Time
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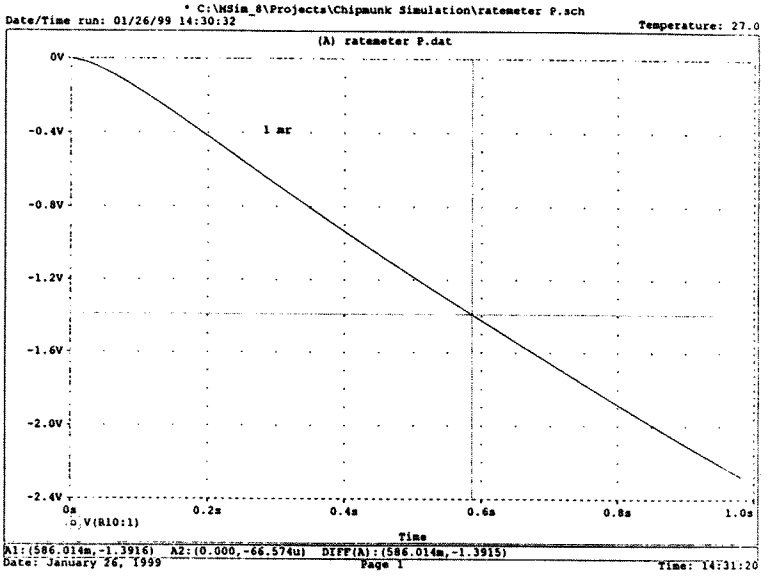
Date: January 26, 1999
Page 1
Time: 14:38:28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(A) ratemeter P.dat
1 mr
0V
-0.4V
-0.8V
-1.2V
-1.6V
-2.0V
-2.4V
0s
0.2s
0.4s
0.6s
0.8s
1.0s
V(R10:1)
Time
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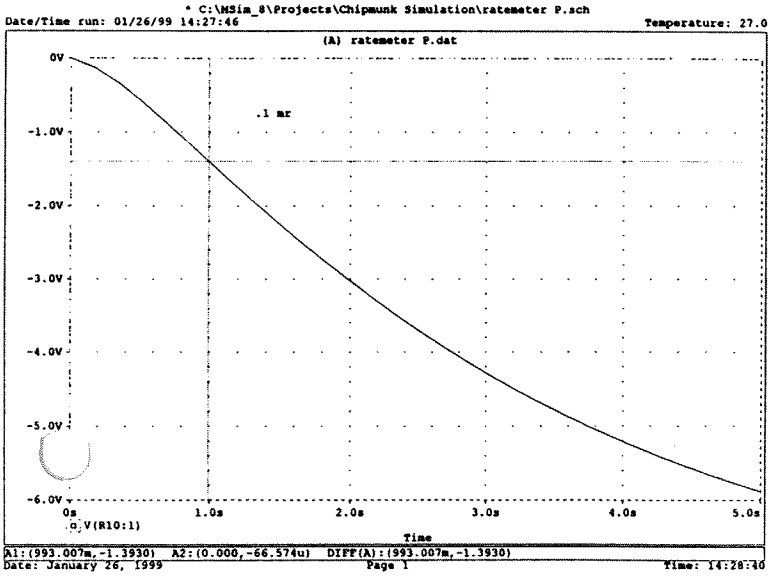
Date: January 26, 1999
Page 1
Time: 14:31:20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(A) ratemeter P.dat
.1 mr
0V
-1.0V
-2.0V
-3.0V
-4.0V
-5.0V
-6.0V
0s
1.0s
2.0s
3.0s
4.0s
5.0s
V(R10:1)
Time
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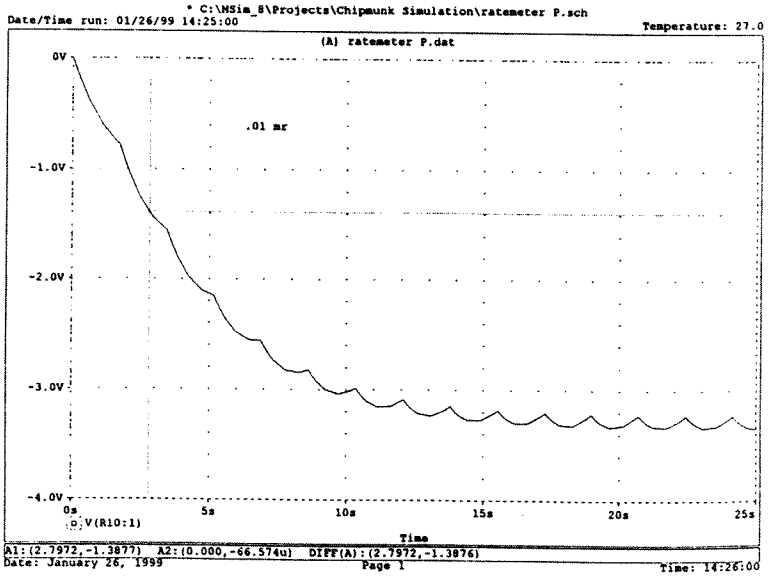
Date: January 26, 1999
Page 1
Time: 14:20:40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(A) ratemeter P.dat
.01 mr
0V
-1.0V
-2.0V
-3.0V
-4.0V
0s
5s
10s
15s
20s
25s
V(R10:1)
Time
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Date: January 26, 1999
Page 1
Time: 14:26:00