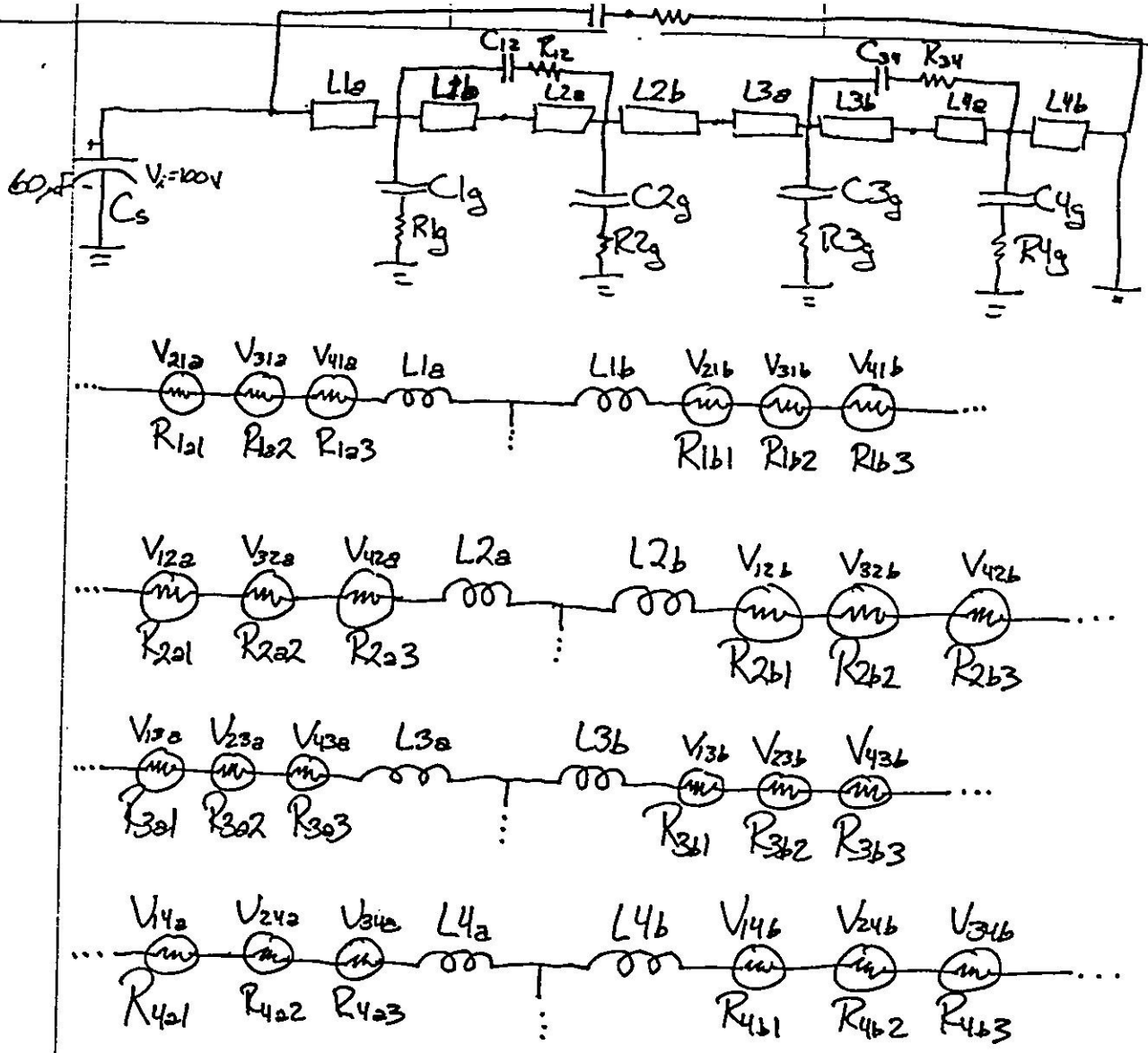
TECHNICAL NOTE

Date: 11/27/91
By: Eric Schmitz
Subject: Electrical Modelling of Magnets - Upper Inner Section
To: Wayne Koska

A 15m 50mm magnet (DC0310) was measured for values of inductance and mutual inductance between coils and then rung at 100V. Printouts of the ringing waveform were obtained. Using a circuit analysis program on the IBM PC, the magnet was electrically modelled, based on values obtained by direct measurement of the magnet. Several models were developed. A ring of each magnet model was then simulated, using the circuit analysis program, and compared to the actual result of ringing the magnet.

cc: R. Sims
L. Curry



Configuration: 1
Filenames: c50m1*.ckt

COIL MODEL (ECA filename: *.ckt)

COMPONENT	c50m1a	c50m1b	c50m1c	c50m1d	c50m1e	c50m1f	c50m1g	c50m1h	c50m1i	c50m1j	c50m1k	
V21a,b (=.5*V:21)	0.24	0	0.24	0.24	0.024	0.048	0.072	0.096	0.096	0.096	0.096	-
V31a,b (non-dim)	0.24	0	0	0.18	0.018	0.036	0.054	0.072	0.072	0.072	0.072	-
V41a,b	0.67	0	0	0.67	0.067	0.134	0.201	0.268	0.268	0.268	0.268	-
V12a,b	0.86	0	0.86	0.86	0.086	0.172	0.258	0.344	0.344	0.344	0.344	-
V32a,b	0.61	0	0	0.61	0.061	0.122	0.183	0.244	0.244	0.244	0.244	-
V42a,b	1.75	0	0	0.64	0.064	0.128	0.192	0.256	0.256	0.256	0.256	-
V13a,b	1	0	0	0.64	0.064	0.128	0.192	0.256	0.256	0.256	0.256	-
V23a,b	0.68	0	0	0.68	0.068	0.136	0.204	0.272	0.272	0.272	0.272	-
V43a,b	0.86	0	0.86	0.86	0.086	0.172	0.258	0.344	0.344	0.344	0.344	-
V14a,b	0.67	0	0	0.67	0.067	0.134	0.201	0.268	0.268	0.268	0.268	-
V24a,b	0.47	0	0	0.16	0.016	0.032	0.048	0.064	0.064	0.064	0.064	-
V34a,b	0.21	0	0.21	0.21	0.021	0.042	0.063	0.084	0.084	0.084	0.084	-
R1a,b;1,2,3 (ohms)	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	O
R2a,b;1,2,3	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	O
R3a,b;1,2,3	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	O
R4a,b;1,2,3	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	O
C1g, C4g (nF)	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	4.5	4.5	5.25	nF
C2g, C3g	25	25	25	25	25	25	25	25	9	9	10.5	nF
R1g, R2g (ohms)	100	100	100	100	100	100	100	100	100	85	75	O
R2g, R3g	100	100	100	100	100	100	100	100	100	85	75	O
C14 (nF)	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	13.5	13.5	15.25	nF
C12	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	13.5	13.5	15.25	nF
C34	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	13.5	13.5	15.25	nF
R14 (ohms)	100	100	100	100	100	100	100	100	100	85	75	O
R12	100	100	100	100	100	100	100	100	100	85	75	O
R34	100	100	100	100	100	100	100	100	100	85	75	O
L1a,b (=.5*L1) (uH)	499	499	499	499	499	499	499	499	499	499	499	uH
L2a,b	1801	1801	1801	1801	1801	1801	1801	1801	1801	1801	1801	uH
L3a,b	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	uH
L4a,b	499	499	499	499	499	499	499	499	499	499	499	uH
L1 (uH)	998	998	998	998	998	998	998	998	998	998	998	uH
L2	3601	3601	3601	3601	3601	3601	3601	3601	3601	3601	3601	uH
L3	4010	4010	4010	4010	4010	4010	4010	4010	4010	4010	4010	uH
L4	998	998	998	998	998	998	998	998	998	998	998	uH

PROGRESSIVE DERIVATION of VALUES for COIL MODEL: C50M1*.CKT

Eric Schmitz

11/21/91

C50M1A:

Mutual Inductance- Used values obtained by direct measurement of magnet.
Inductance- likewise.
Capacitance- Used values given for 40mm coil modeling, multiplied by 1.25.
Series Resistance of Inductors- Used values measured during sizing of coils.
Series Resistance of Capacitors- Assumed a value of 100 ohms.

C50M1B:

Set all mutual inductance to zero. All other values remained the same.

C50M1C:

Included only mutual inductance between two upper coils and between two lower coils. (No M between any upper coil and any lower coil.) All other values remained the same.

C50M1D:

Included M between two upper coils, between two lower coils, between two outer coils, and between two inner coils as measured. Other values seemed unreasonably high. Estimated values of M between upper inner and lower outer, and between upper outer and lower inner. Voltage gains were estimated as follows:

V42 should be less than V12 (V42 < V12), so try setting
V42 = .75 * V12. (V refers to voltage gain.)
likewise, V13 < V 43, so set V13 = .75 * V43,
V31 < V21, so set V31 = .75 * V21,
V24 < V34, so set V24 = .75 * V34.

All other values remained the same.

C50M1E:

Mutual inductance (voltage gain) values set to 1/10 those of C50M1D. All other values remained unchanged.

C50M1F:

Mutual inductance (voltage gain) values set to 2/10 those of C50M1D. All other values remained unchanged.

C50M1G:

Mutual inductance (voltage gain) values set to 3/10 those of C50M1D. All other values remained unchanged.

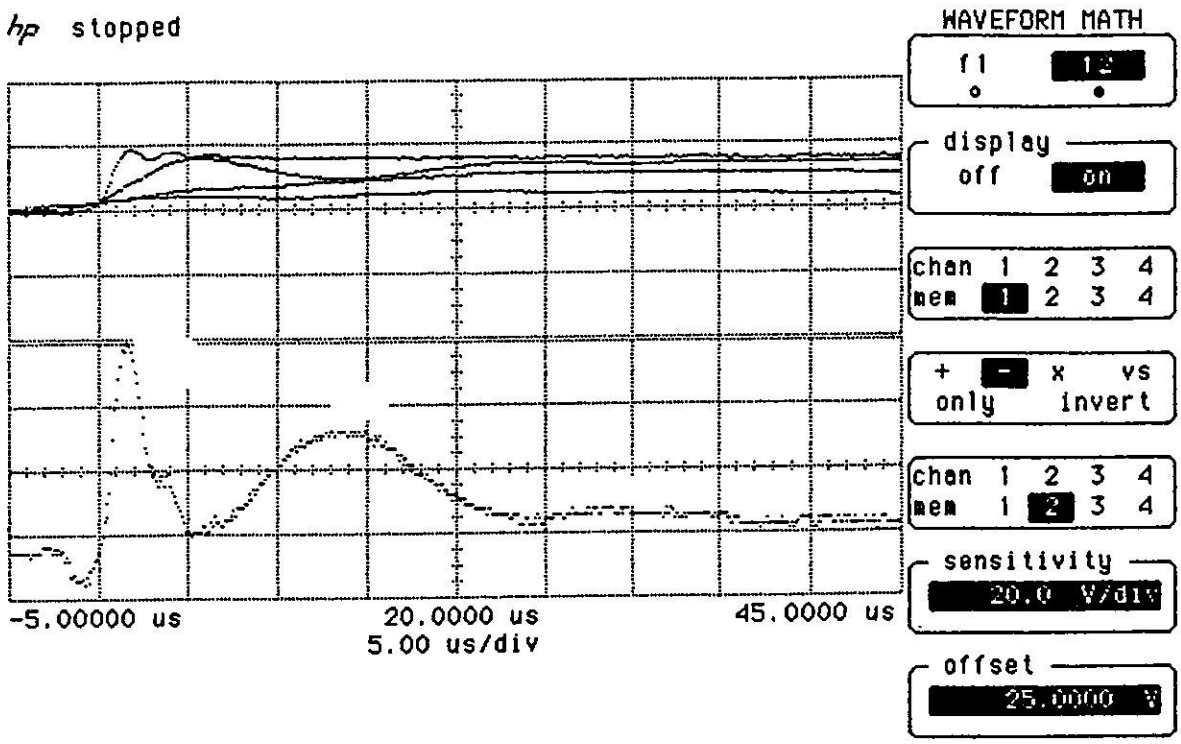
C50M1H:

Mutual inductance (voltage gain) values set to 4/10 those of C50M1D. All other values remained unchanged.

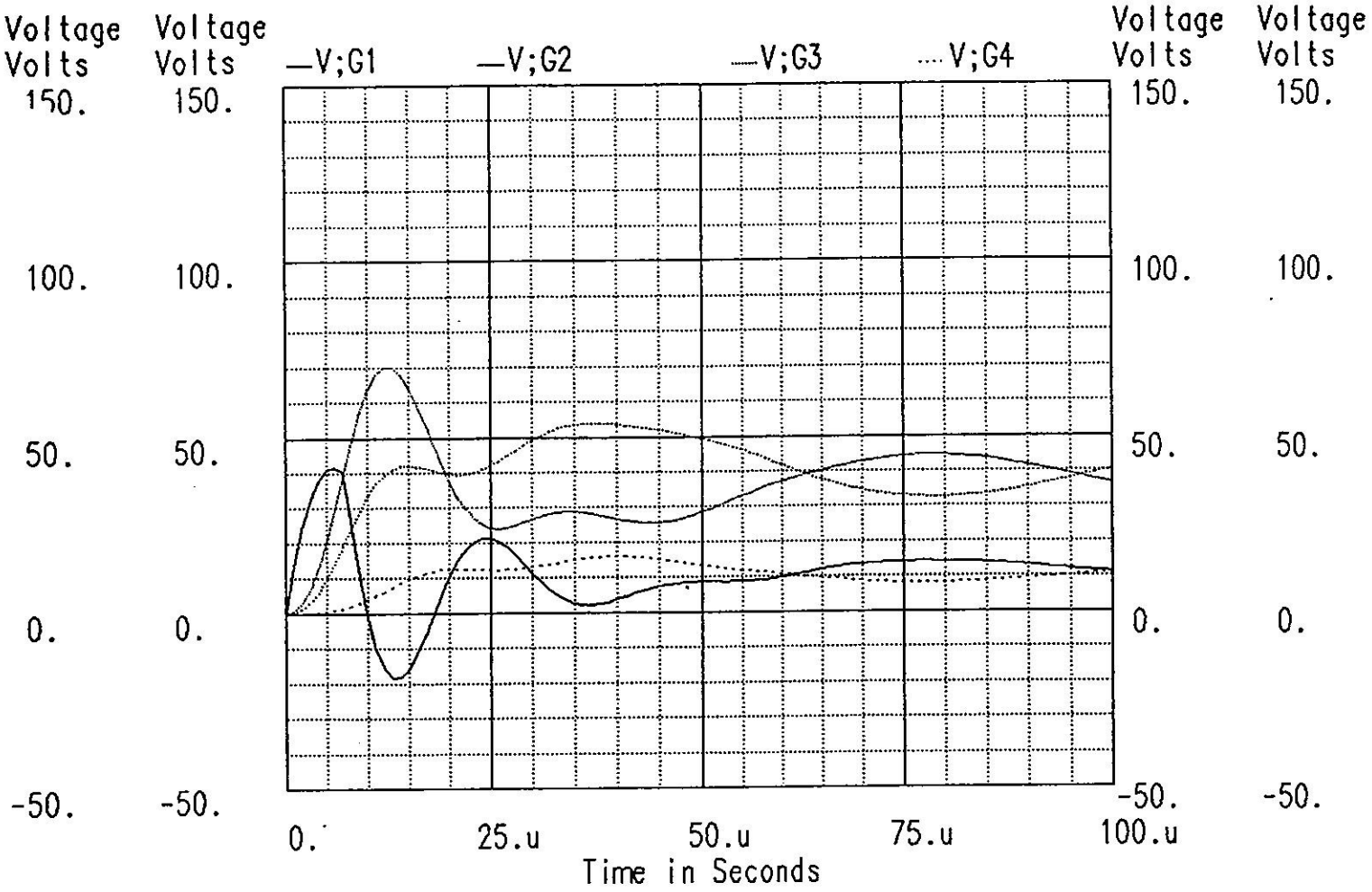
C50M1I:
Left mutual inductance alone this time. Used capacitance values of .3 times original.

C50M1J:
Changed series resistance of capacitors to 85 ohms.

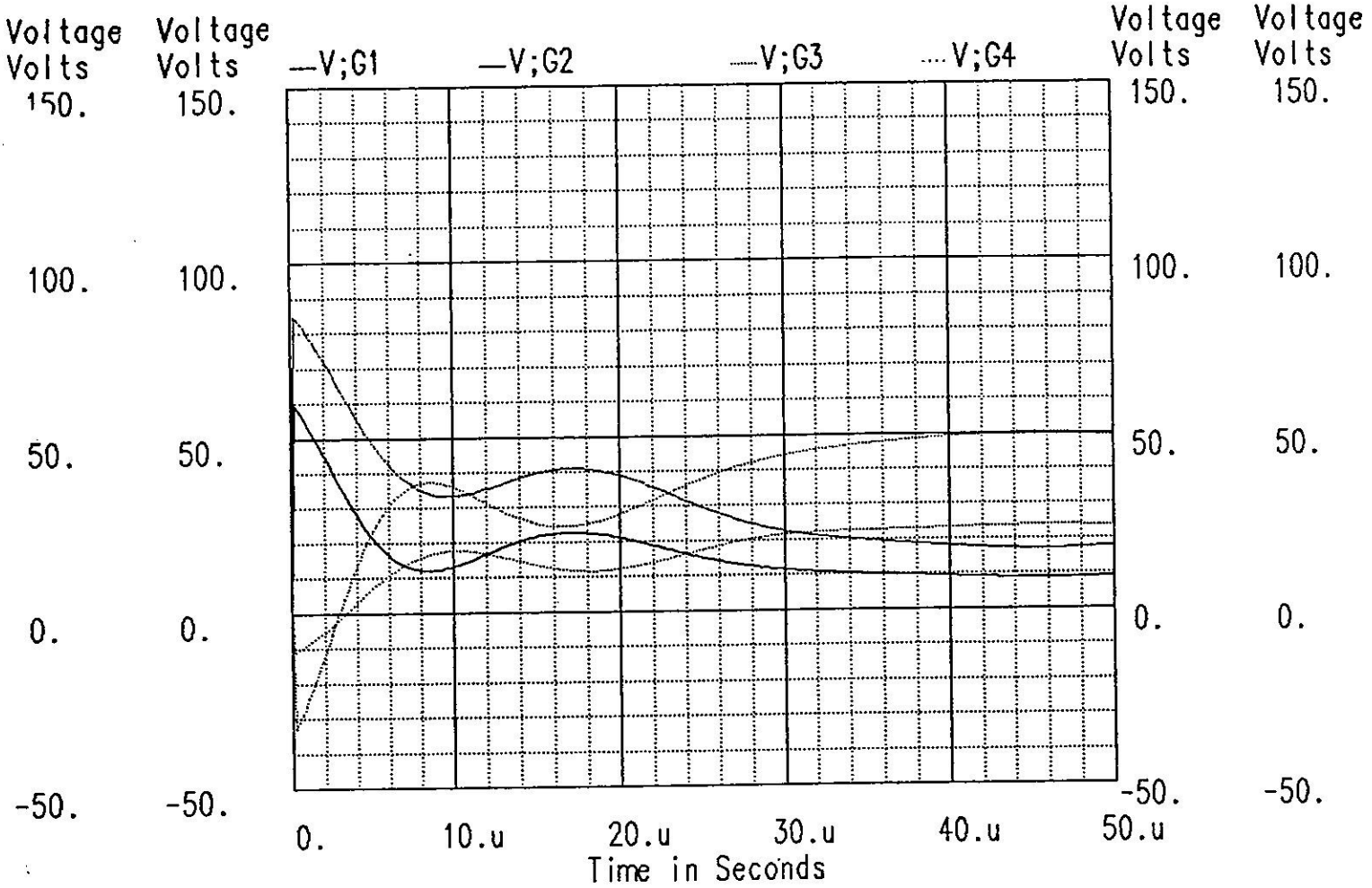
C50M1K:
Changed capacitance values to .35 times original, and dropped series resistance of capacitors to 75 ohms.


hp stopped
WAVEFORM MATH
f1 1+2
display
off on
chan 1 2 3 4
mem 1 2 3 4
+ - x vs
only invert
chan 1 2 3 4
mem 1 2 3 4
sensitivity
20.0 V/div
offset
25.0000 V
-5.00000 us
20.0000 us
5.00 us/div
45.0000 us

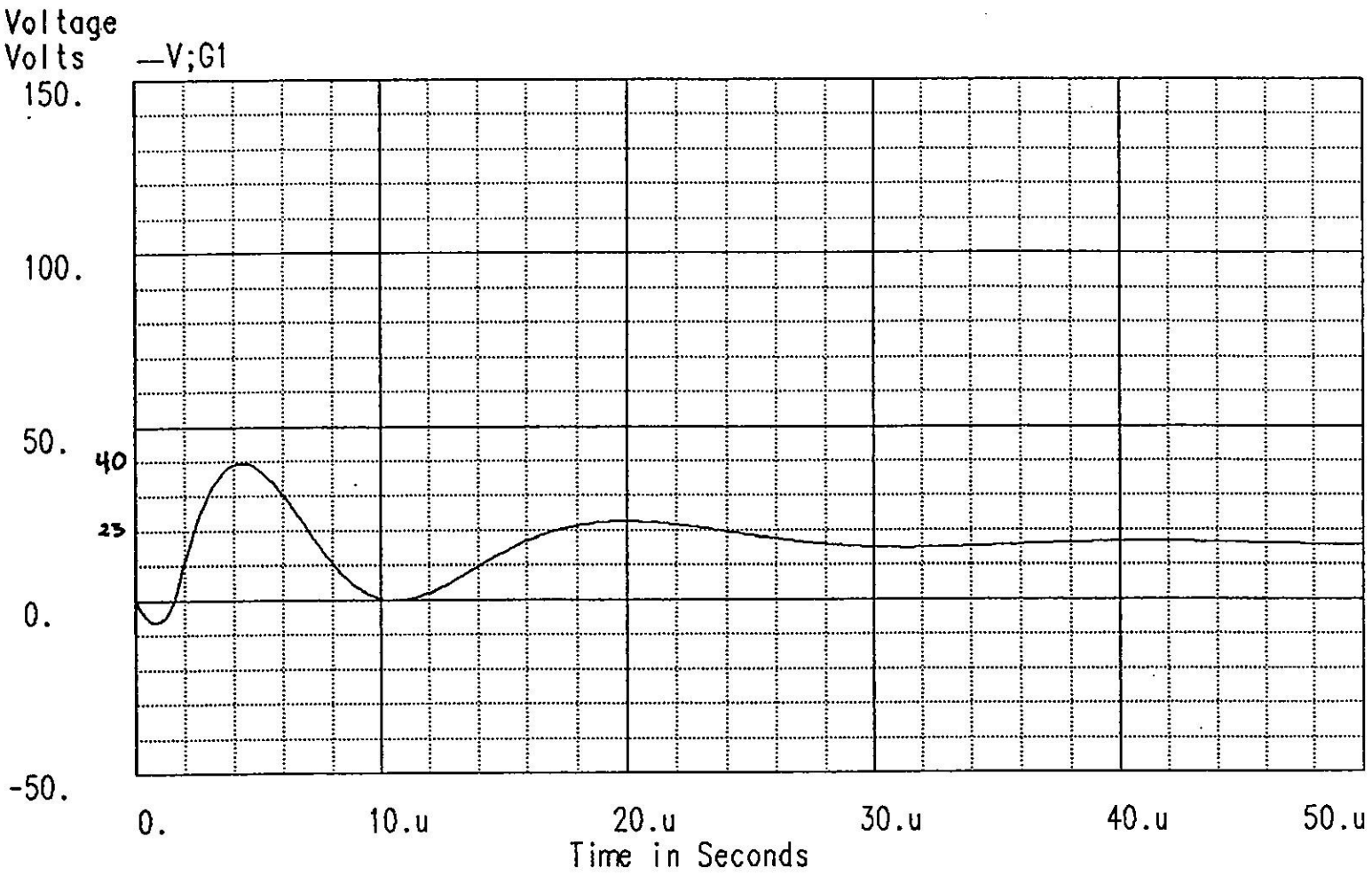
UI


Voltage Volts
Voltage Volts
—V;G1
—V;G2
—V;G3
....V;G4
Voltage Volts
Voltage Volts
150.
100.
50.
0.
-50.
0.
25.u
50.u
75.u
100.u
Time in Seconds

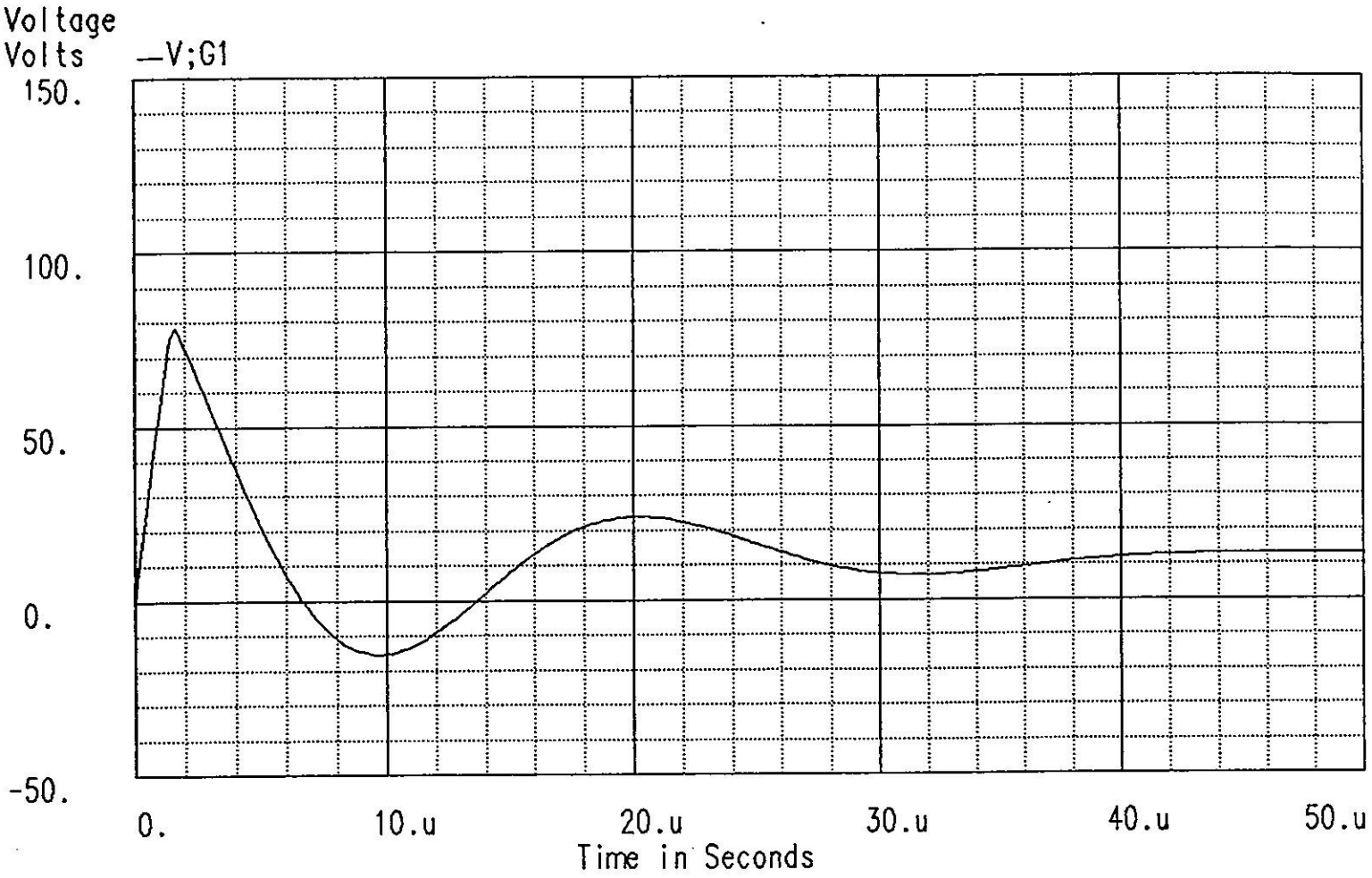
c50mlbmØ (M=Ø)


Voltage Volts
Voltage Volts
—V;G1
—V;G2
—V;G3
....V;G4
Voltage Volts
Voltage Volts
150.
100.
50.
0.
-50.
0.
10.u
20.u
30.u
40.u
50.u
Time in Seconds

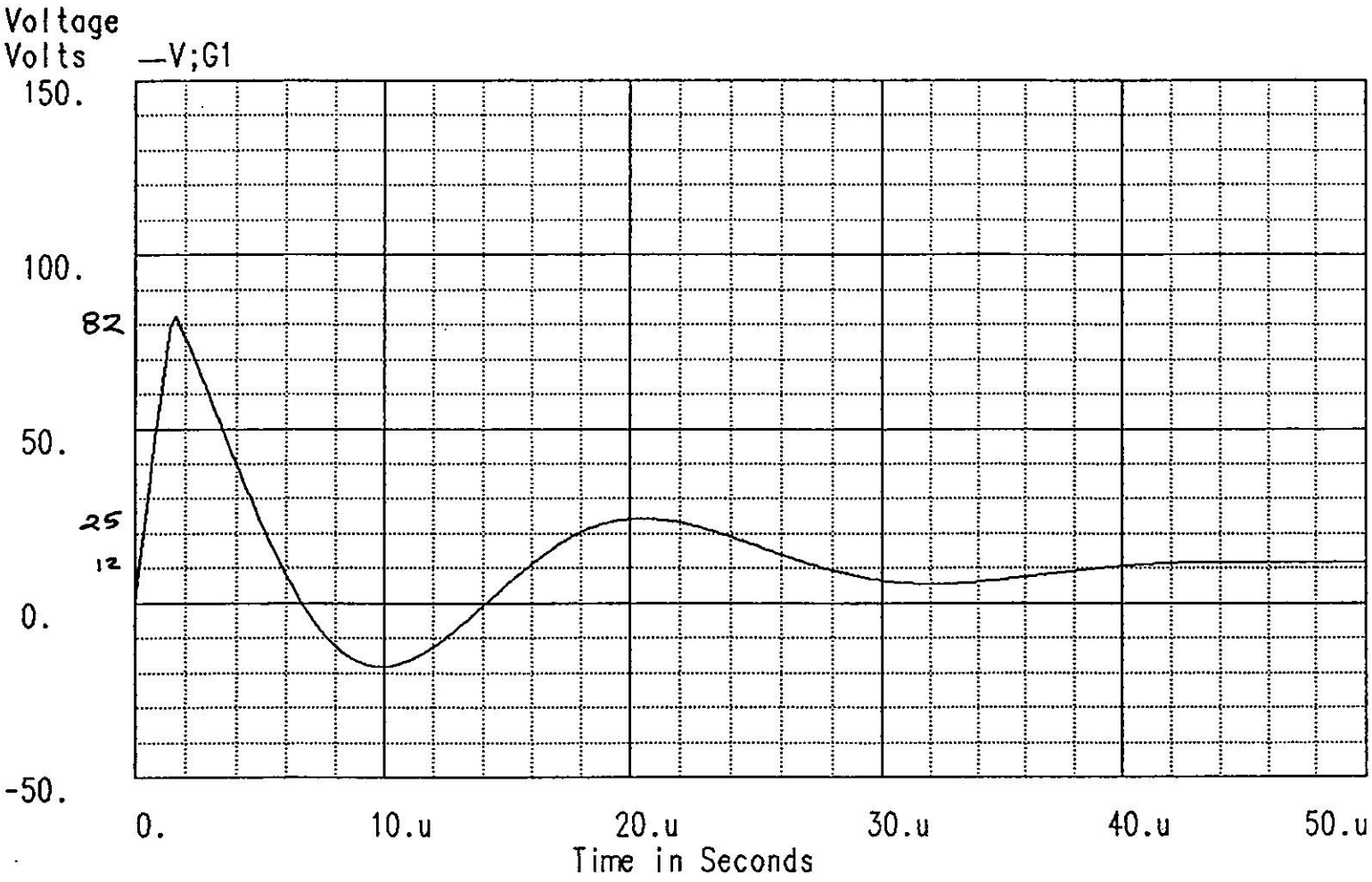
C50mlc



c50mld
UI
t_r = 1.5μs


Voltage
Volts
—V;G1
150.
100.
50.
0.
-50.
0.
10.u
20.u
30.u
40.u
50.u
Time in Seconds

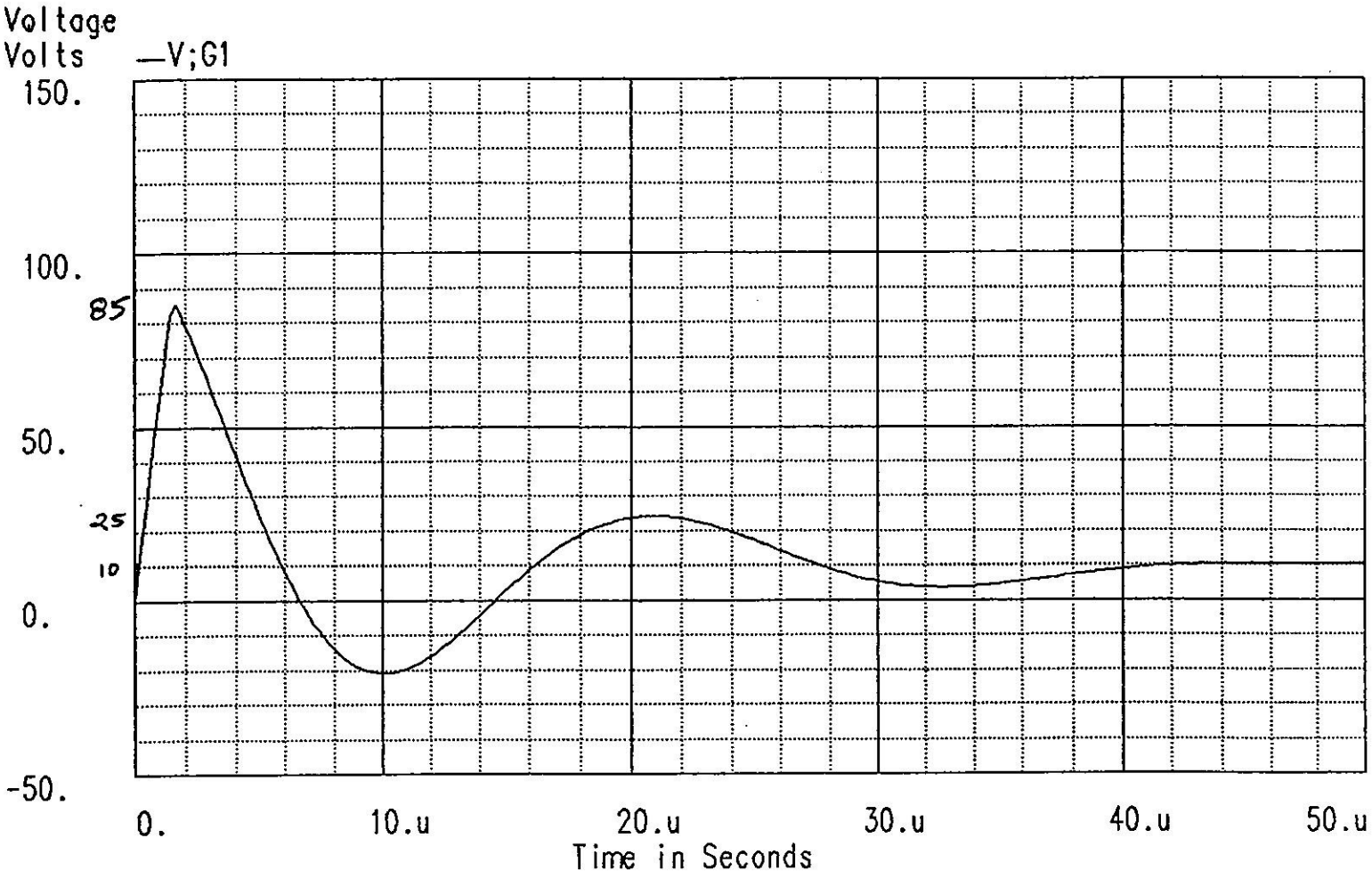
c50 mlg
UI



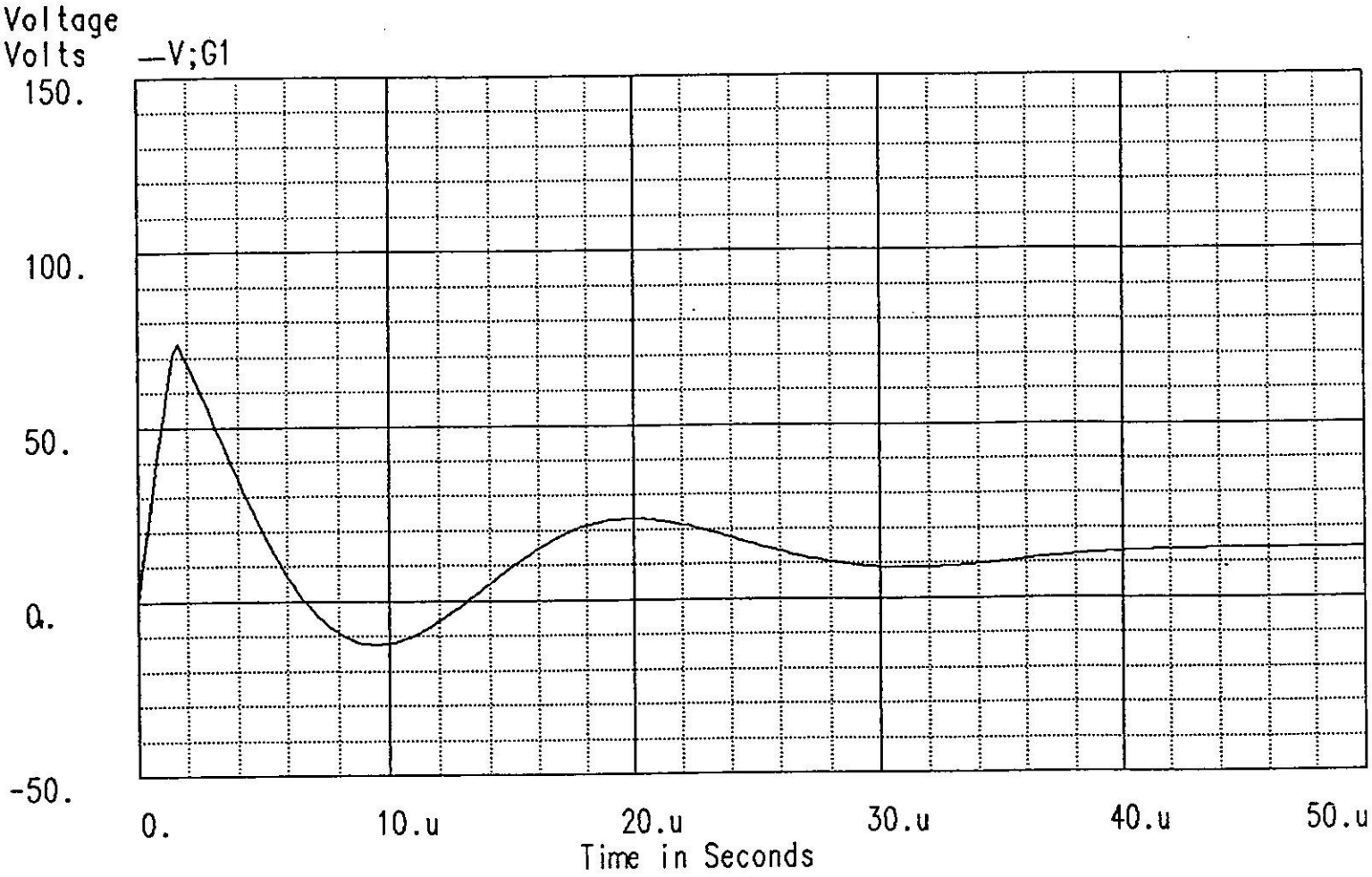
c50mlf

UI

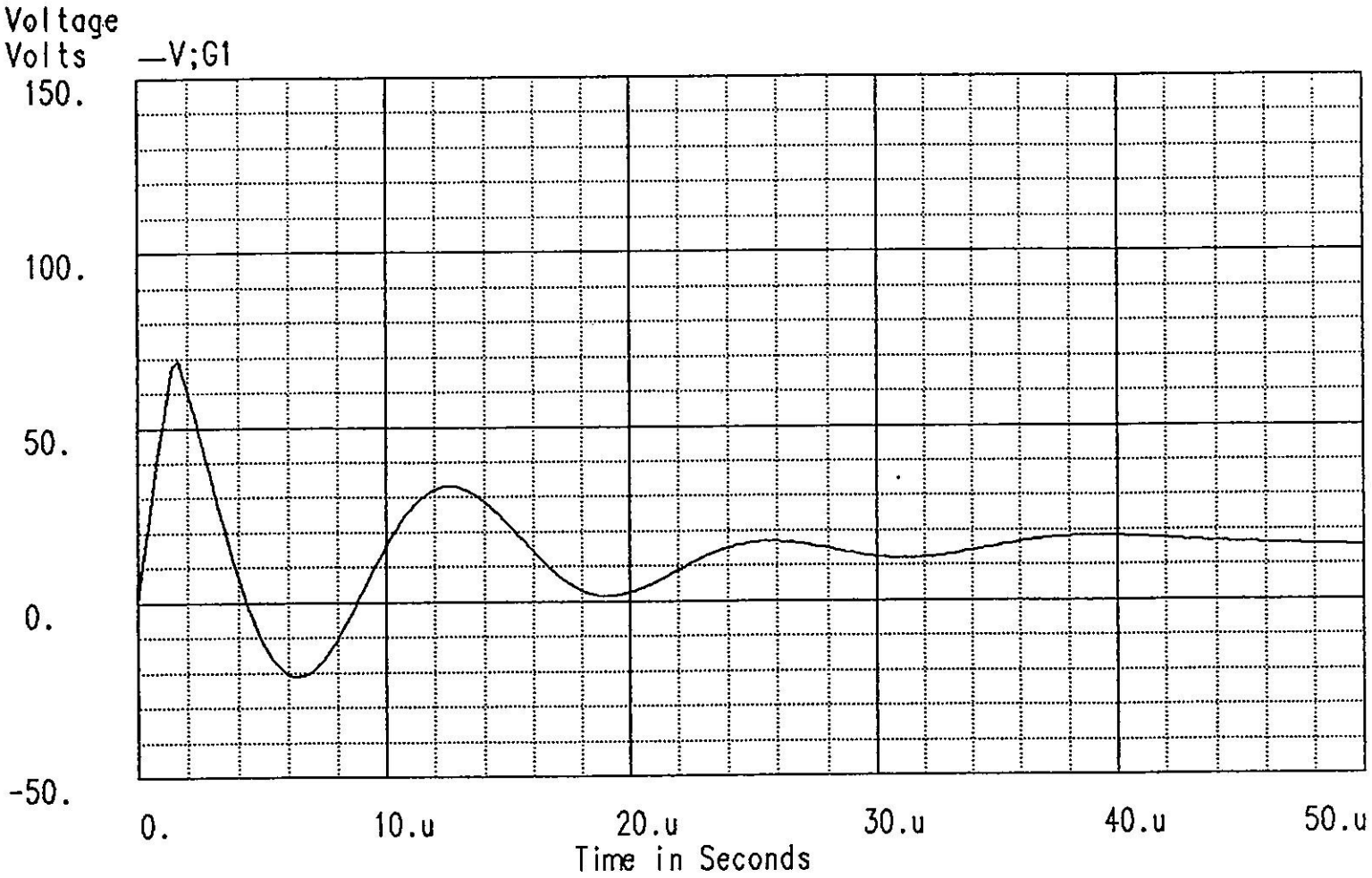
t_R=1.5ms



c50mle
Upper Inner
$t_r = 1.5\mu s$

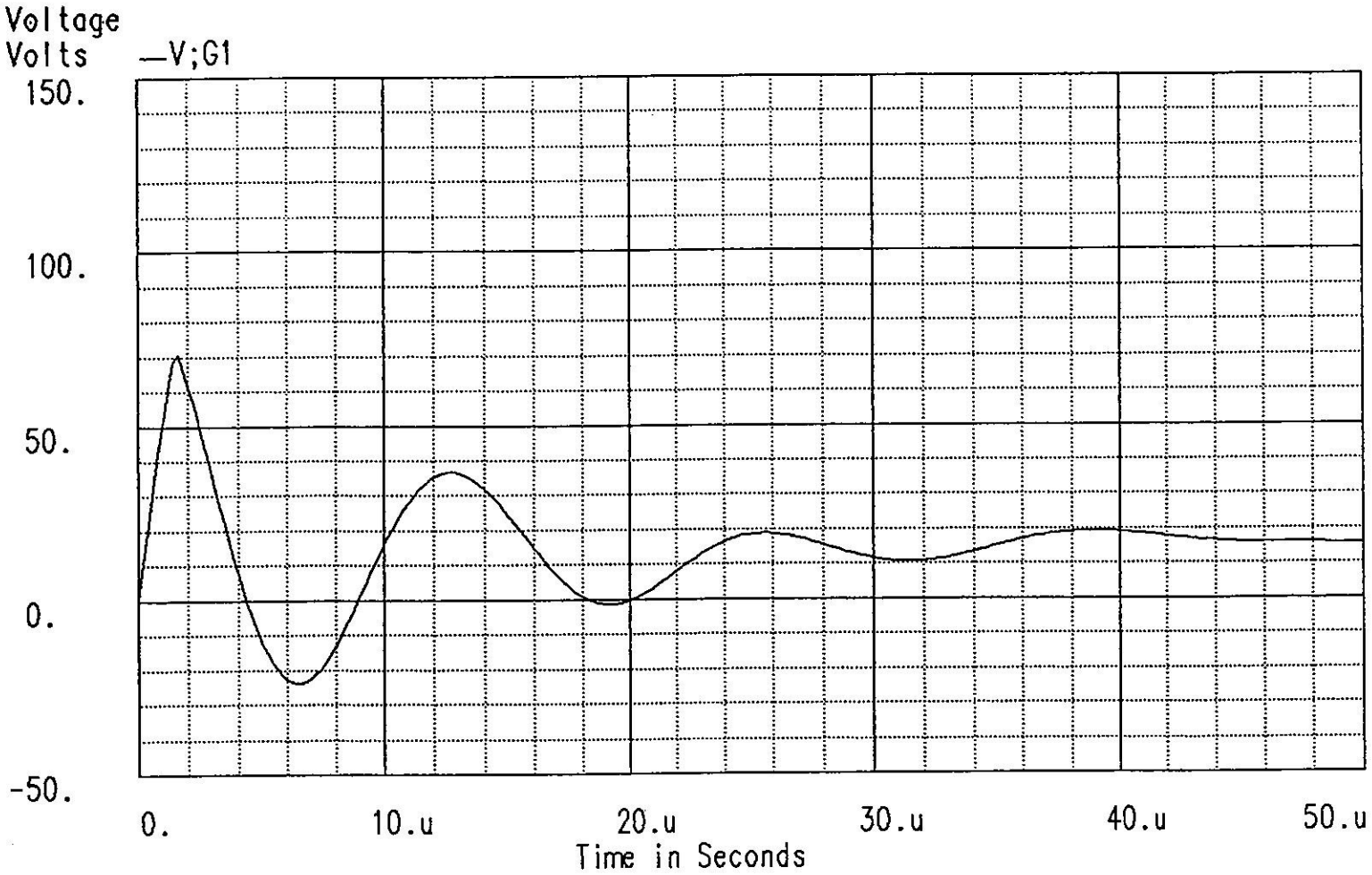

Voltage
Volts
—V;G1
150.
100.
50.
0.
-50.
0.
10.u
20.u
30.u
40.u
50.u
Time in Seconds

c50mlh
uI



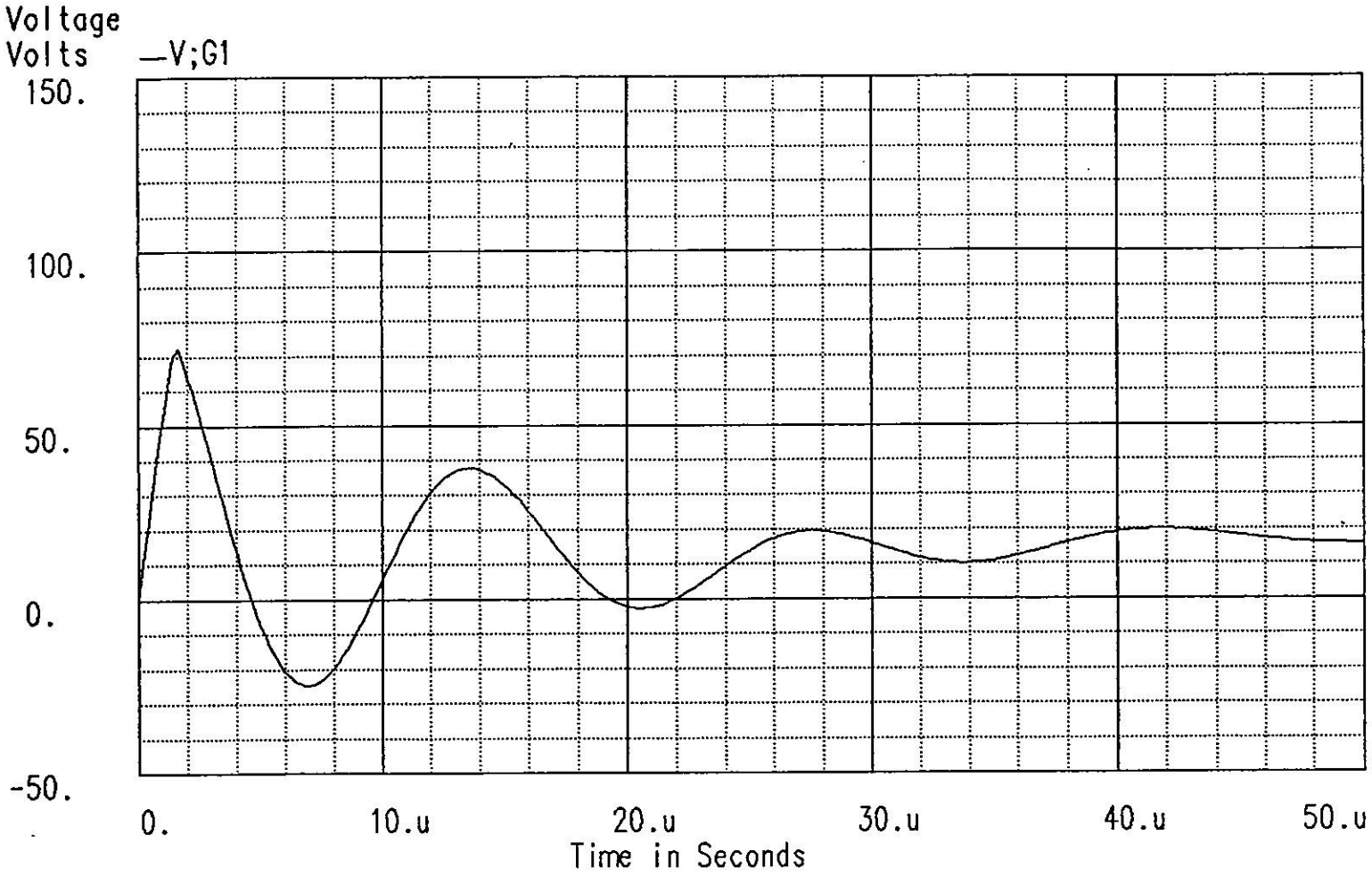
c 50mli

C = 3C c50mlh



c50mlj

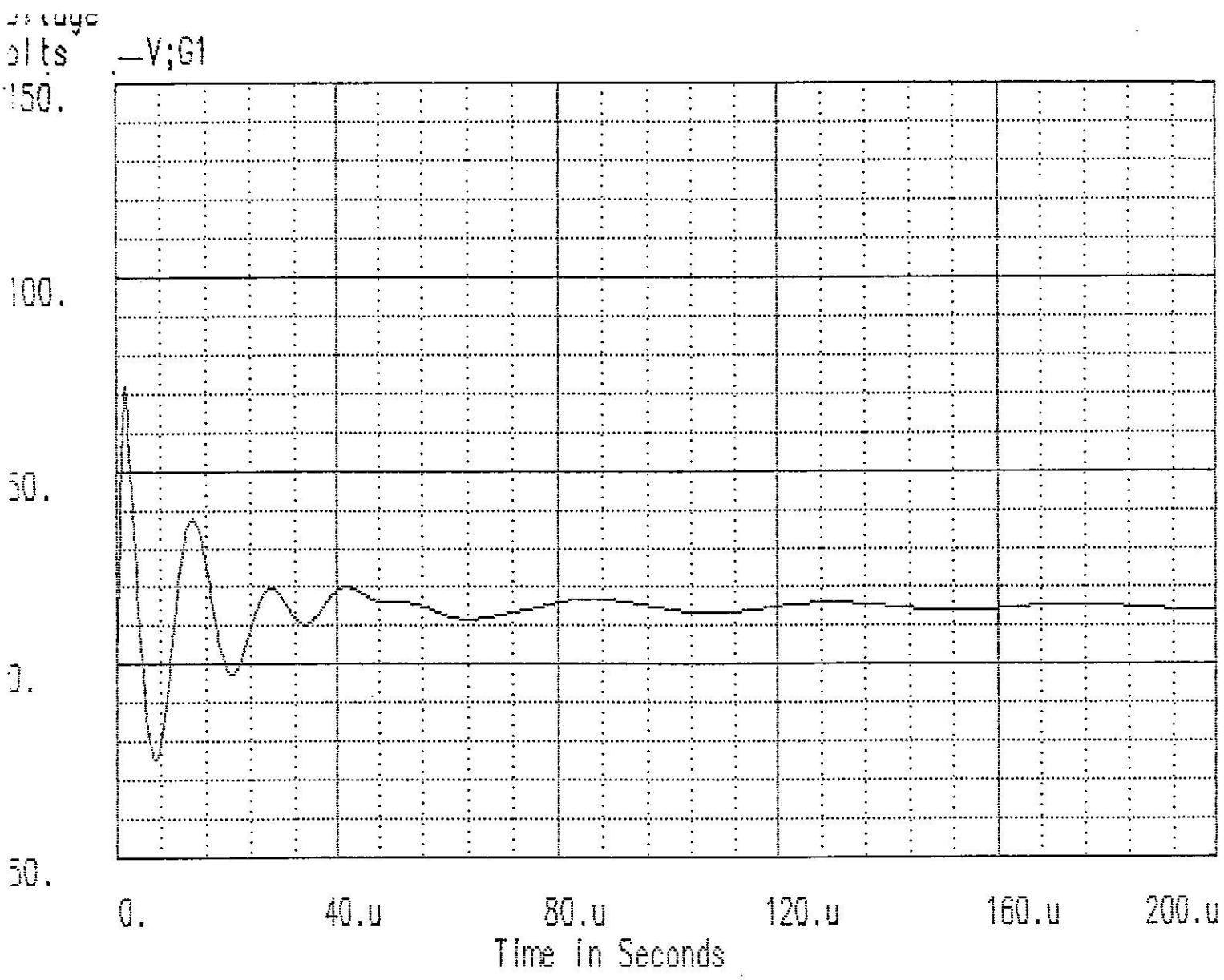
$R_c = 85\Omega$



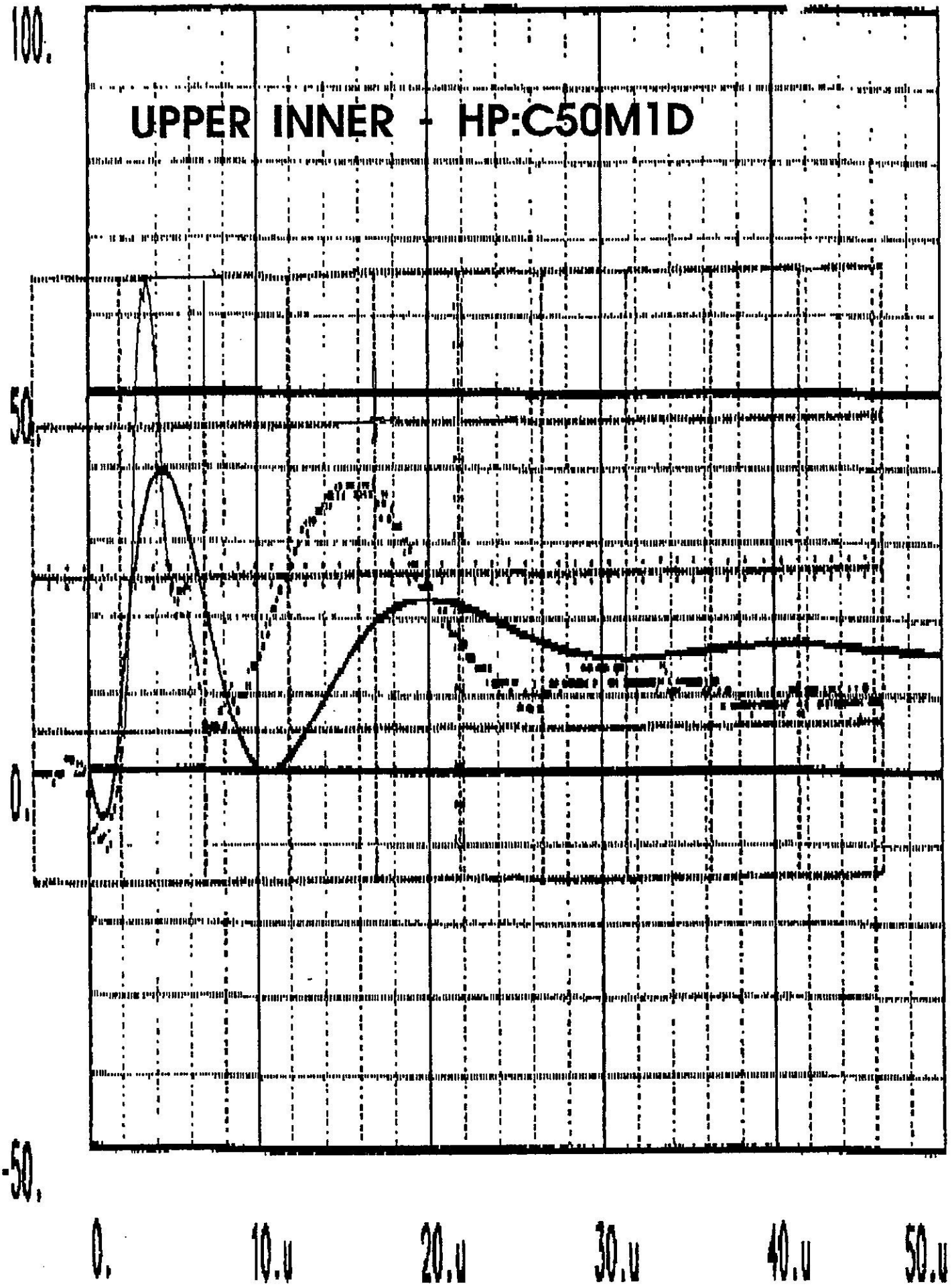
C50 m/k

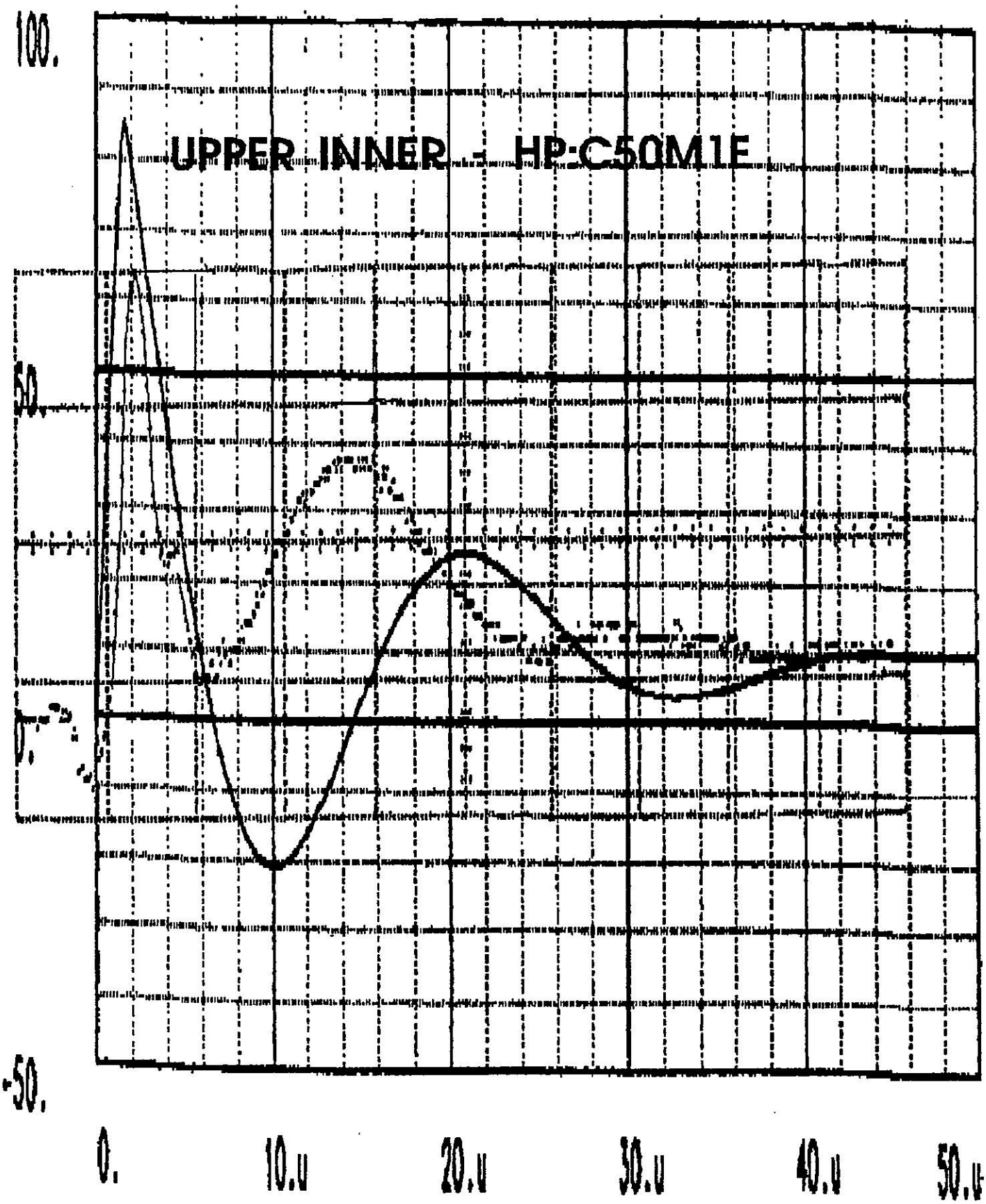
C = 35 Cn

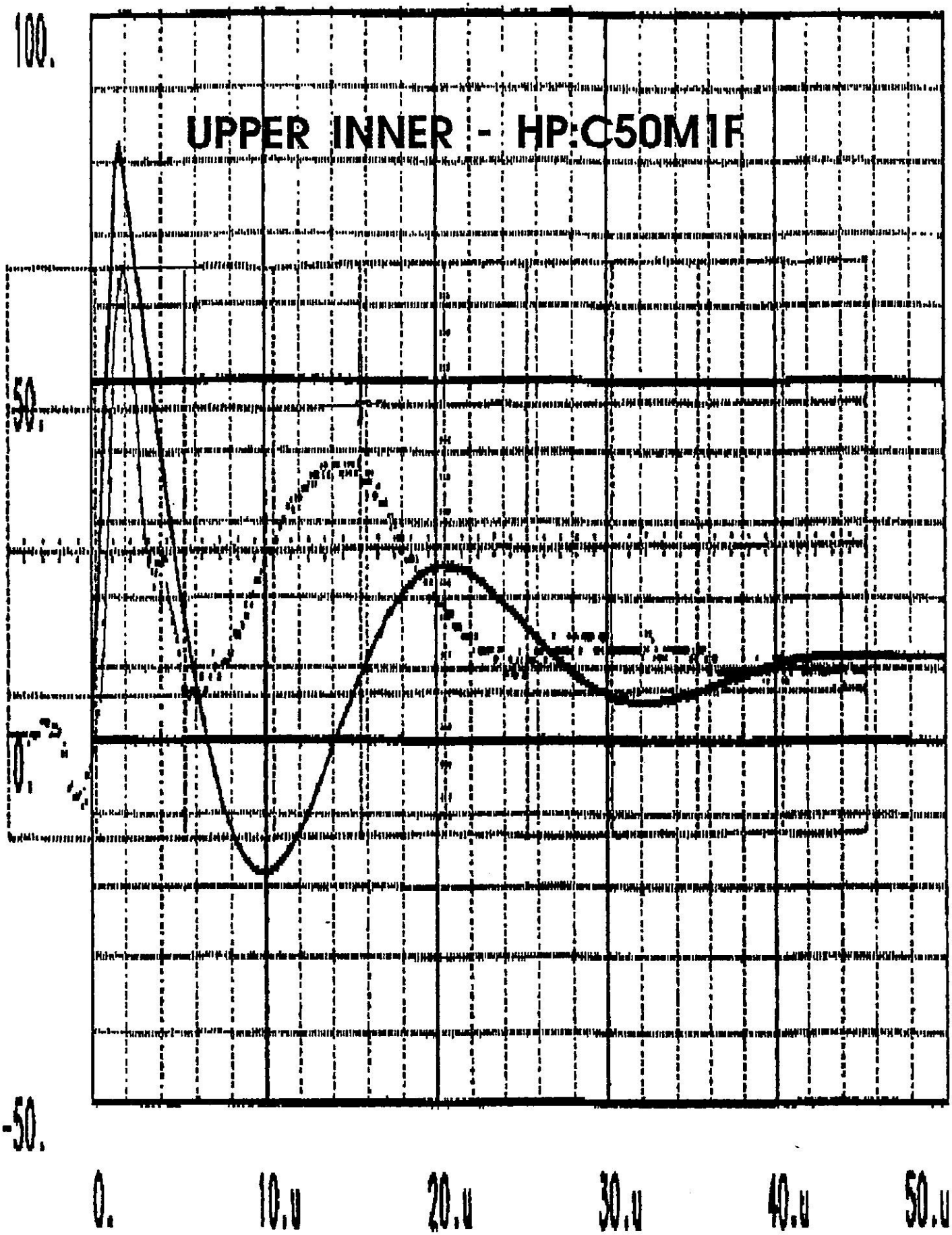
R = 75 Ω

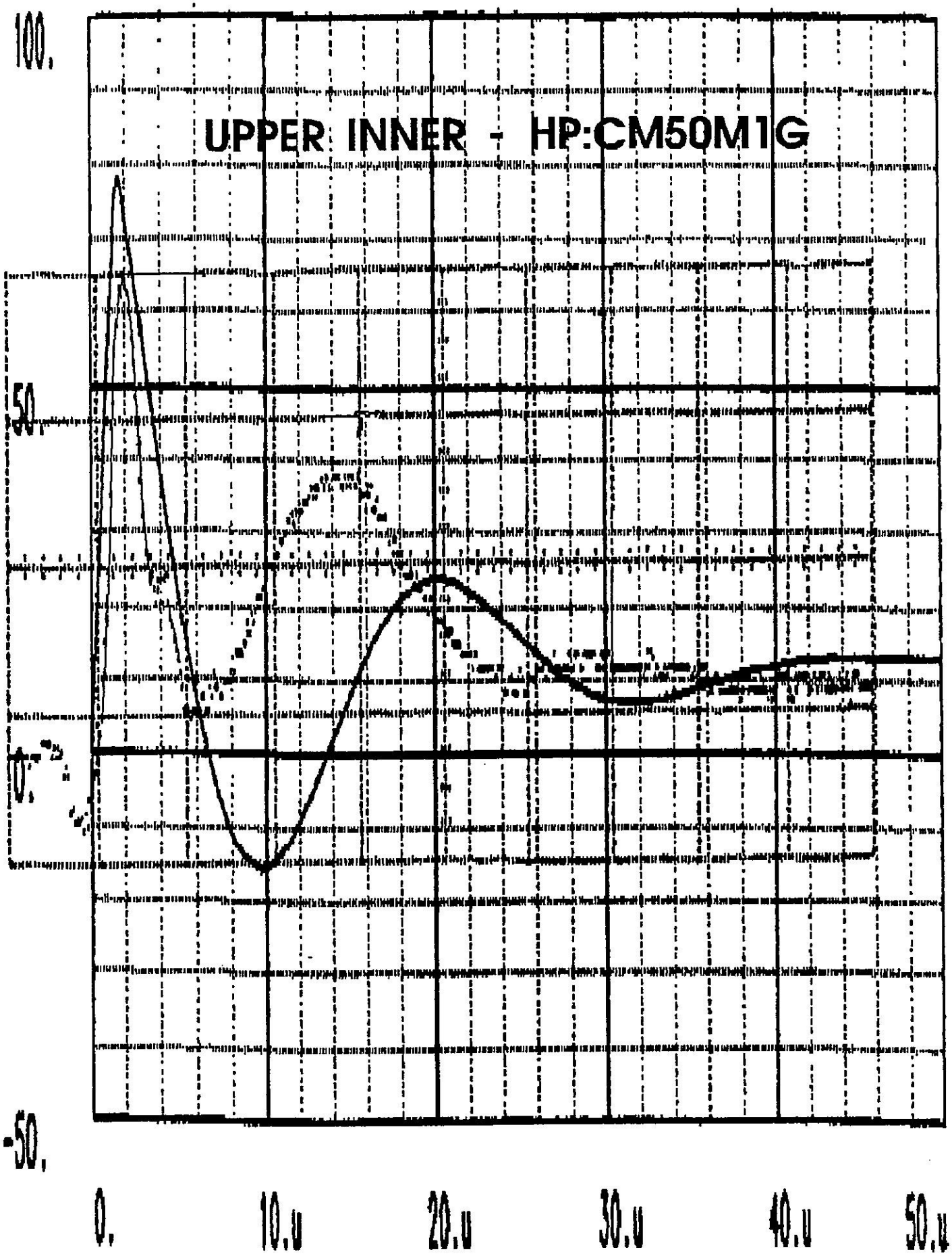

olts —V;G1
150.
100.
50.
0.
-50.
0.
40.u
80.u
120.u
160.u
200.u
Time in Seconds

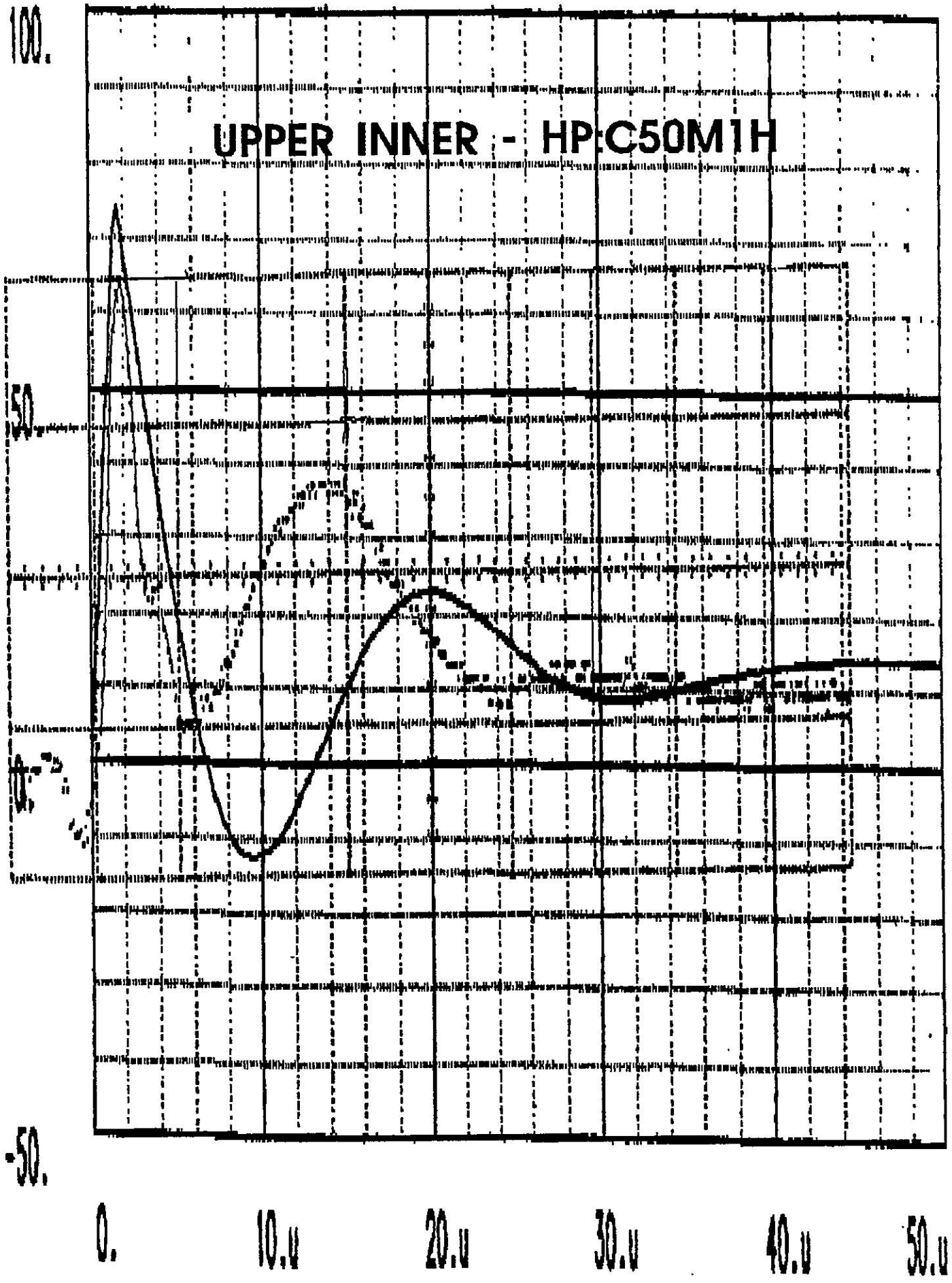
c50 mlk

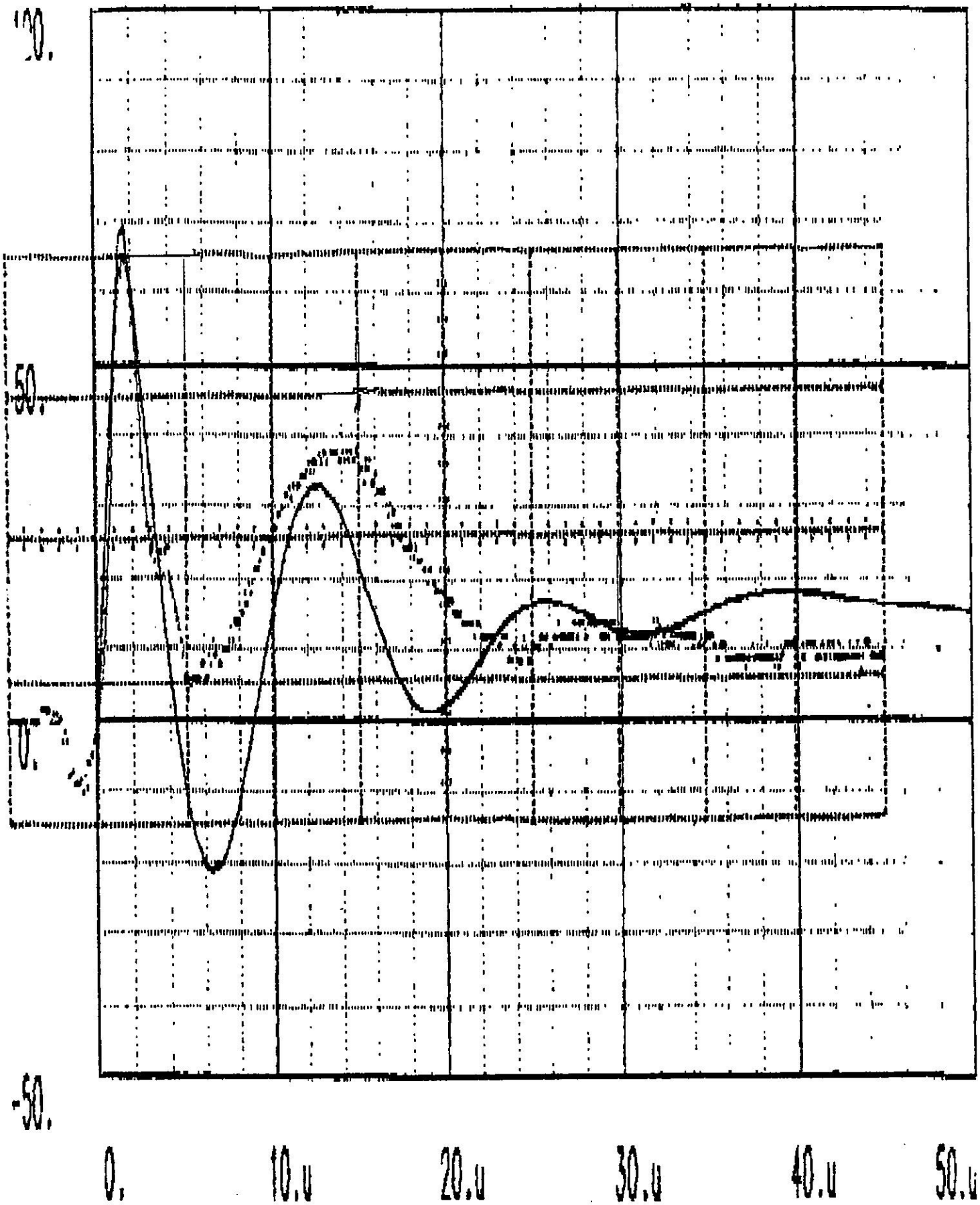

UPPER INNER - HP:C50M1D
100.
50.
0.
-50.
0.
10.u
20.u
30.u
40.u
50.u


UPPER INNER - HP-C50M1E
100.
50.
0.
-50.
0.
10.u
20.u
30.u
40.u
50.u

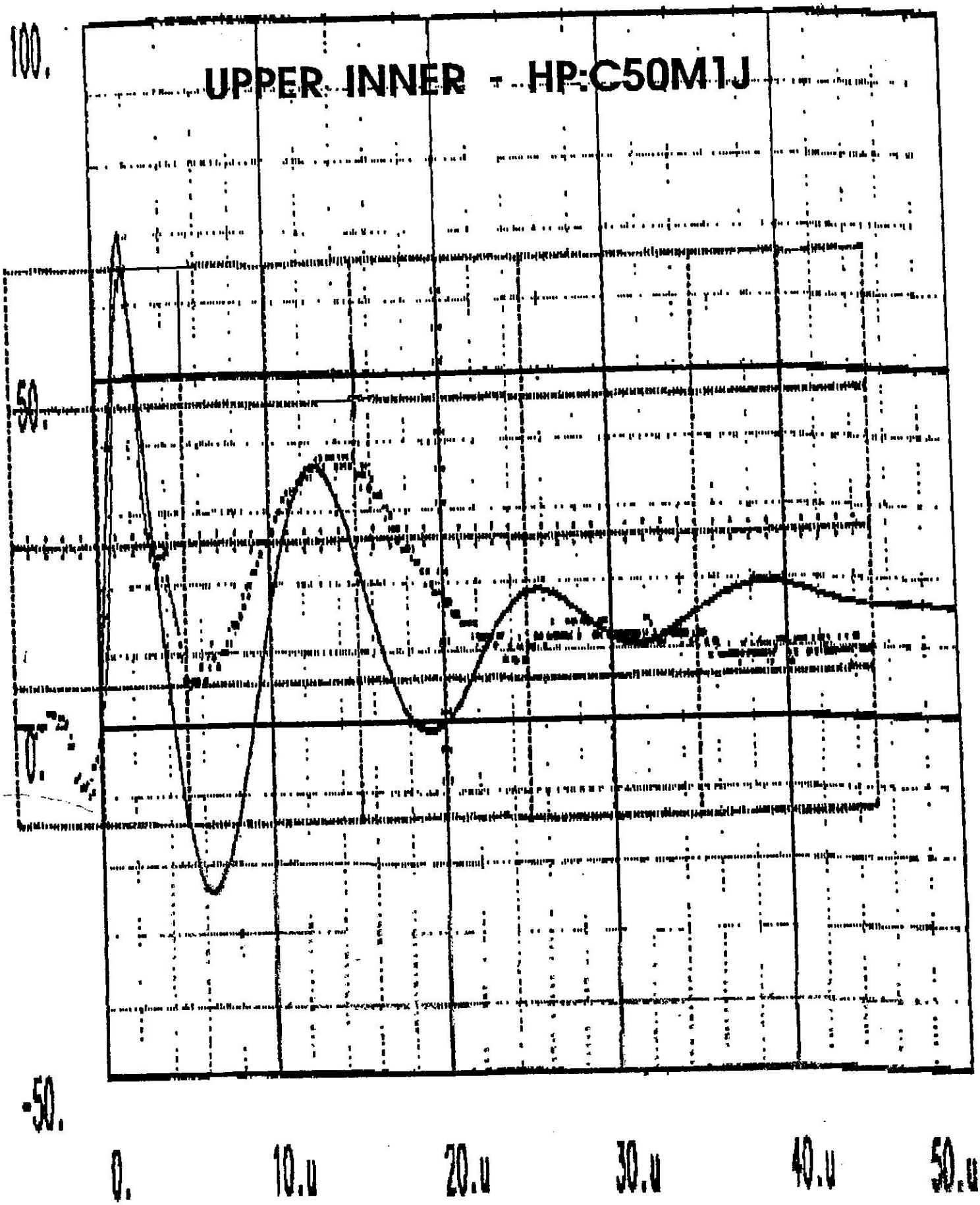

UPPER INNER - HP:C50M1F
100.
50.
0.
-50.
0.
10.u
20.u
30.u
40.u
50.u

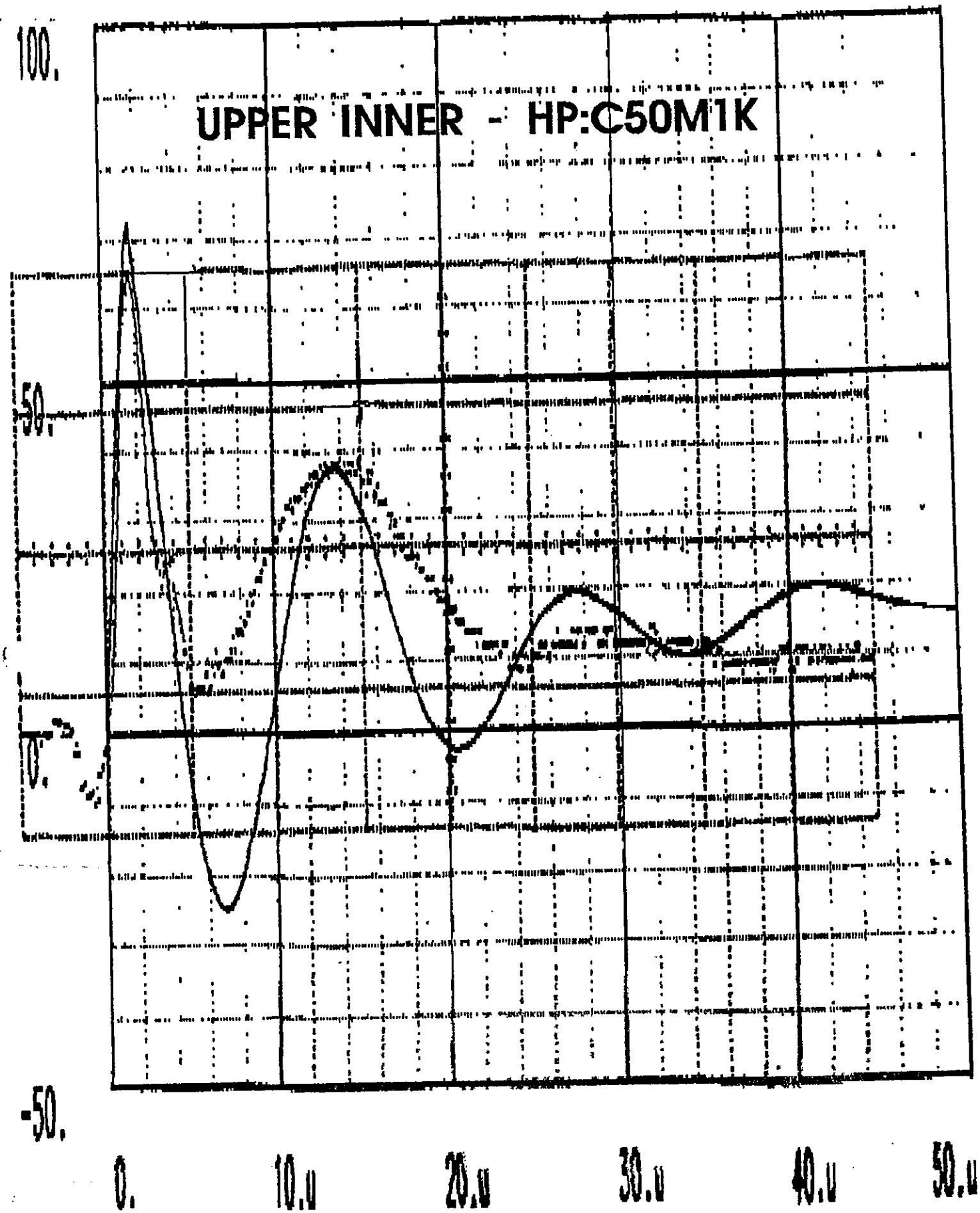

UPPER INNER - HP:CM50M1G
100.
50.
-50.
0.
10.u
20.u
30.u
40.u
50.u


UPPER INNER - HPtC50M1H
100.
50.
-50.
0.
10.u
20.u
30.u
40.u
50.u



UI c50mII


UPPER INNER - HP:C50M1J
100.
50.
0.
-50.
0.
10.u
20.u
30.u
40.u
50.u


UPPER INNER - HP:C50M1K
100.
50.
0.
-50.
0.
10.u
20.u
30.u
40.u
50.u