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*TS-SSC 91-248

TECHNICAL NOTE

Date: 12/12/91
By: Eric Schmitz
Subject: Analysis of Probe Effect in Magnet Ringing Waveform
To: Wayne Koska

Since using different oscilloscope probe setups in the magnet ringing experiments produced some very different resulting waveforms, an analysis was done in order to determine thr reason for the discrepancies. Using the ECA-2 circuit analysis program on the PC, two models of the ringer setup were developed which illustrated the two differing experimental results. The difference in the models seems to indicate the most probable source of the discrepancy.

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Analysis of Probe Effect in Magnet Ringing Waveform

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12/12/91

During the course of magnet ringing experiments, it was noticed that using different oscilloscope probe setups produced slightly different waveform traces on the scope. The most noticeable difference was seen in the first millisecond of the ring. Ideally, the waveform should have a very sharp rise, then break into the ringing curve, as in figure 1. Using "HP probe #1" produced this result, and similar results were produced using another HP probe and a 100x probe. In some cases, however, such as seen in figure 2 (using "Tektronix probe #1"), the curve shows a very obvious "smoothing" at the top of the initial rise. A second Tektronix probe produced a similar trace. (This data is from the ringing of a 1m coil, 1M-50-230, and is used here only as an illustration of the varying results.)

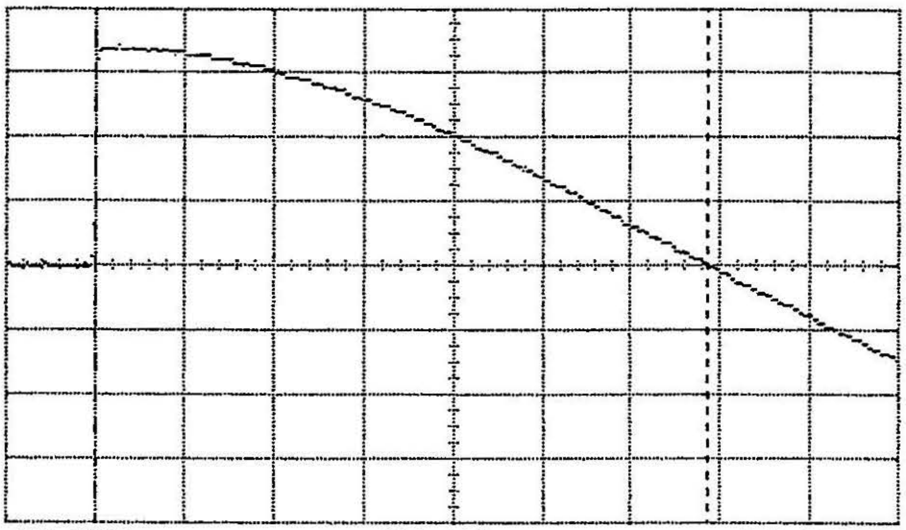
The results of ringing magnet DCA313 are shown in figure 3. Looking at the initial rise of the trace, it can be seen that there is not a sharp break into the ringing waveform, but rather a smooth curve into it. Using the ECA-2 circuit analysis program, this setup was modelled, including a simple RL representation of the magnet, a 60uF charging capacitor, and an equivalent circuit for the probe/oscilloscope network. Figure 4 shows the model of the ringer/magnet network with a 100x compensated probe connecting the magnet under test to the oscilloscope. This model produced the expected sharp rise of the waveform (figure 6) as was seen in the actual measurement with the HP probe (figure 1). This model seems to accurately describe the situation in which the HP probe was connected to the magnet leads and then *directly to the front panel input* of the digitizing oscilloscope.

At this point, a difference in probe setups must be noted. When using the HP probes and the 100x probe, the probe cable was connected directly to the front panel of the oscilloscope. However, when using the Tektronix probes, additional coaxial cable was used to connect the probe (located inside the ringer apparatus, at the high-voltage output contact) to the oscilloscope input. The probe cable was connected through a grounded splice to a piece of coax cable which ran to another splice at the front of the ringer cabinet. This second splice connection was then finally connected to the oscilloscope input. Since the capacitance added by this extra cable may very well have had an effect on the waveform as seen by the scope, this connection was modelled by adding a capacitive element to ground in parallel with the scope input. This setup is illustrated in figure 5. The resulting trace generated by this model (figure 7) shows the smoothed rise into the waveform that was seen in the traces using the Tektronix probes.

In conclusion, it would seem that the cause of the rounded waveform problem can be traced to the capacitance added by the connection scheme between the probe and the scope. Even a fully compensated probe would have produced inaccurate results due to this extra capacitance.

HP PROBE #1
IM-50-230

hp stopped



1 30.0 V/div
offset: -6.500 V
1000 : 1 dc

-50.0000 us 200.000 us 450.000 us
50.0 us/div

stop marker: 343.000us
start marker: 0.00000 s
delta t: 343.000us
1/delta t: 2.91545kHz

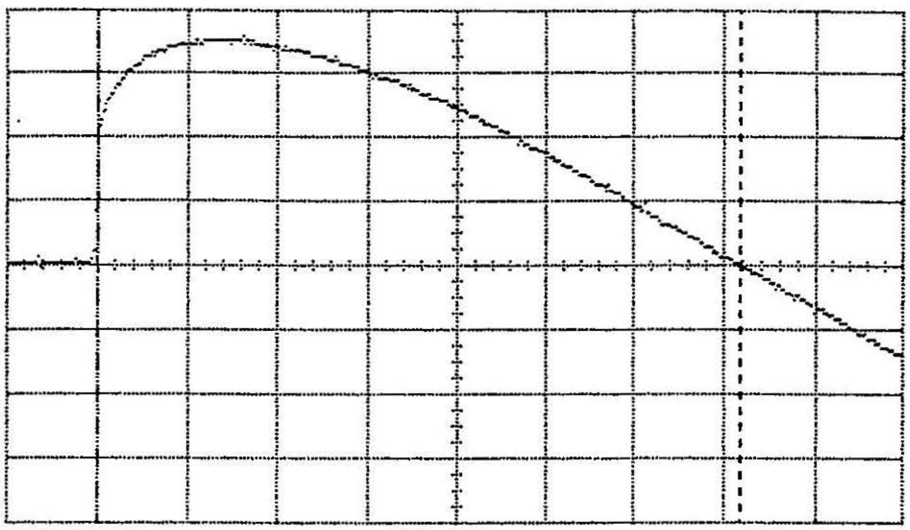
1 ⨍ 30.00 V

729

Figure 1

Tek Probe #1
1M-50-230

hp stopped

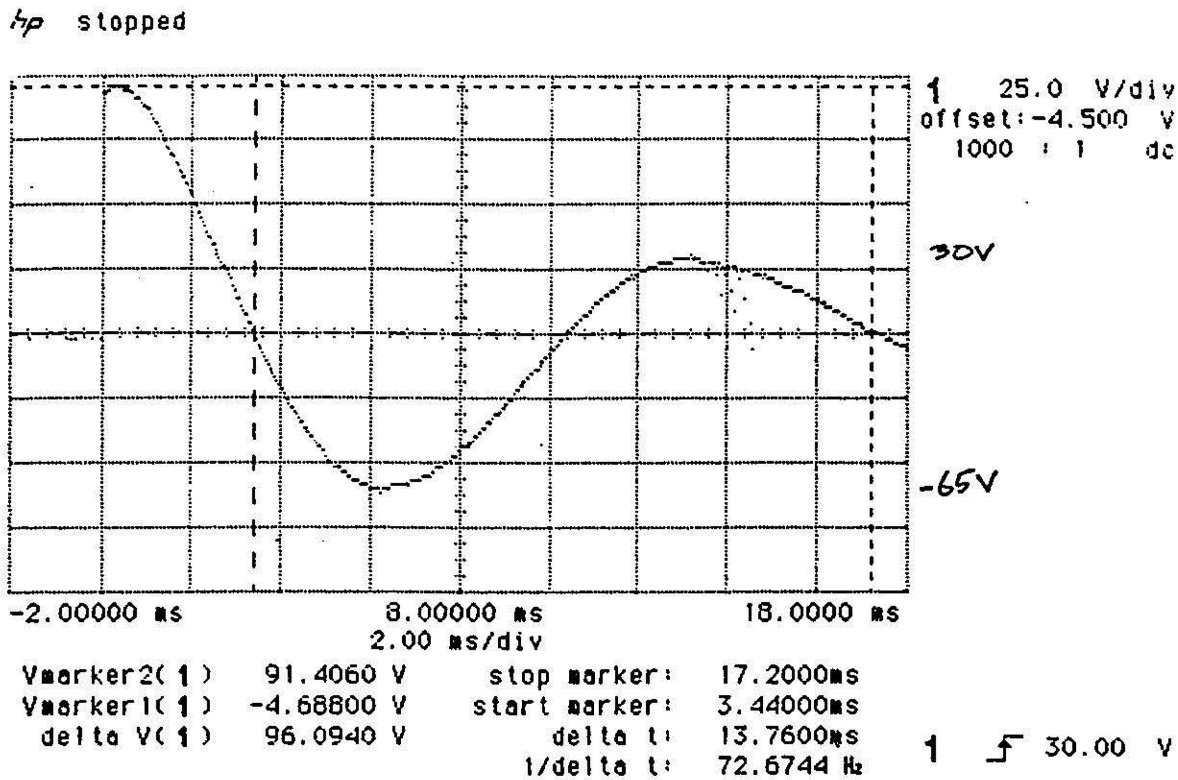


696

Figure 2

DCA 313 12-9-91

100V



f_{PRED} : 75.67Hz ⟶ 13.2ms

f_{MEAS} = 72.67Hz ⟶ 13.76ms

Figure 3

FERMILAB ENGINEERING NOTE

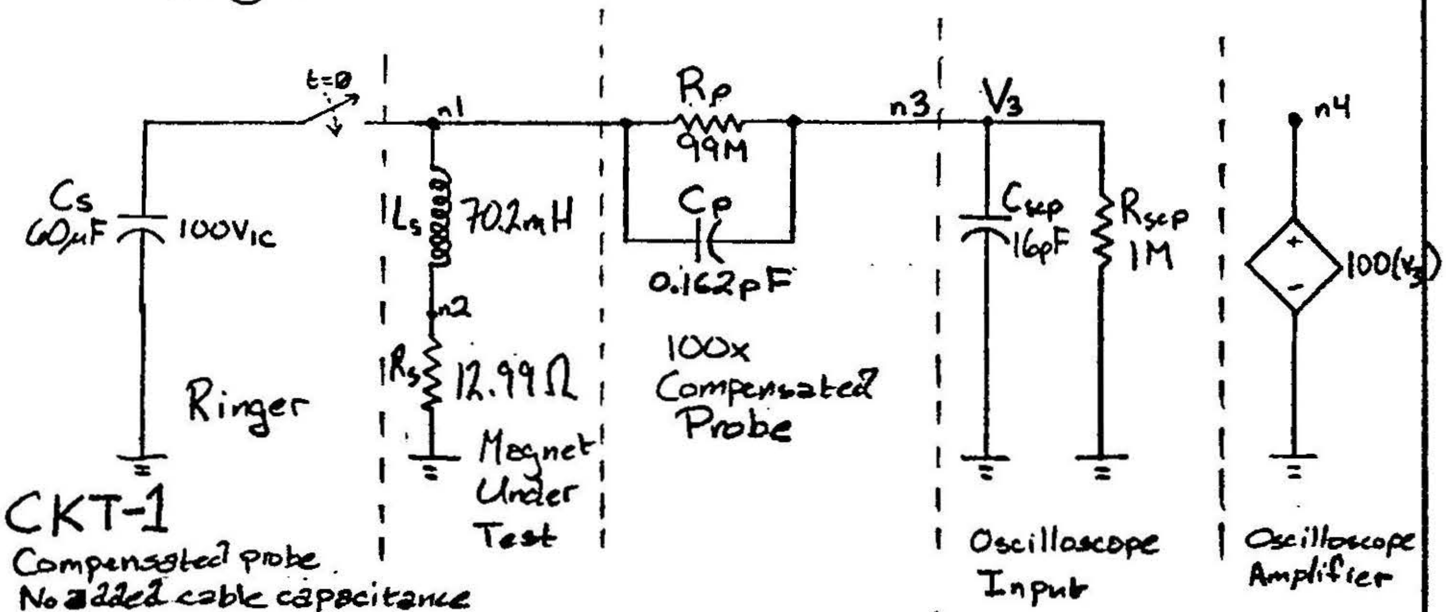
SECTION	PROJECT	SERIAL-CATEGORY	PAGE

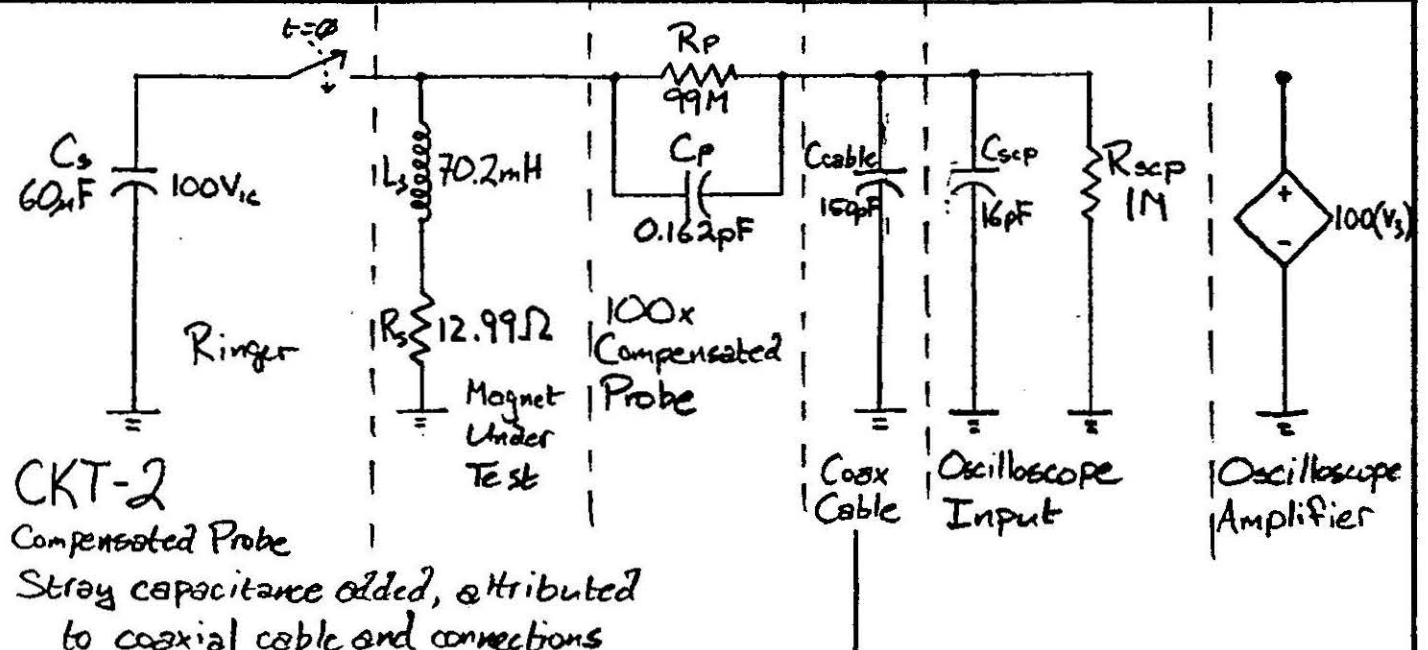
SUBJECT

NAME

DATE | REVISION DATE

Figure 4





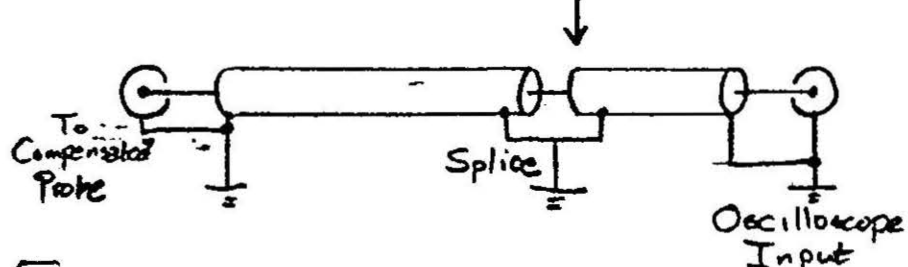


Figure 5

546707

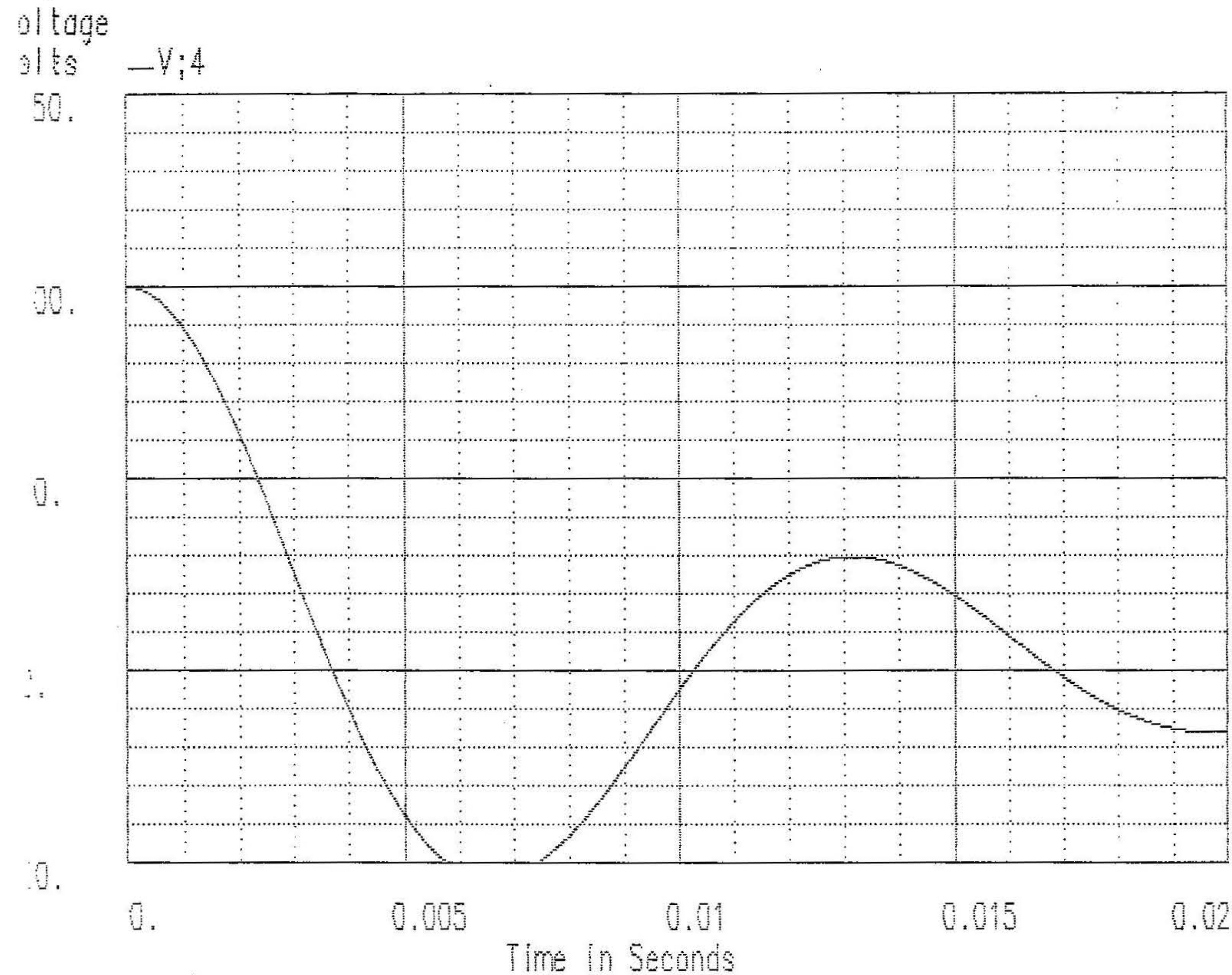


Figure 6: c50100x.ckt

CKT-1
Compensated Probe
No added cable capacitance

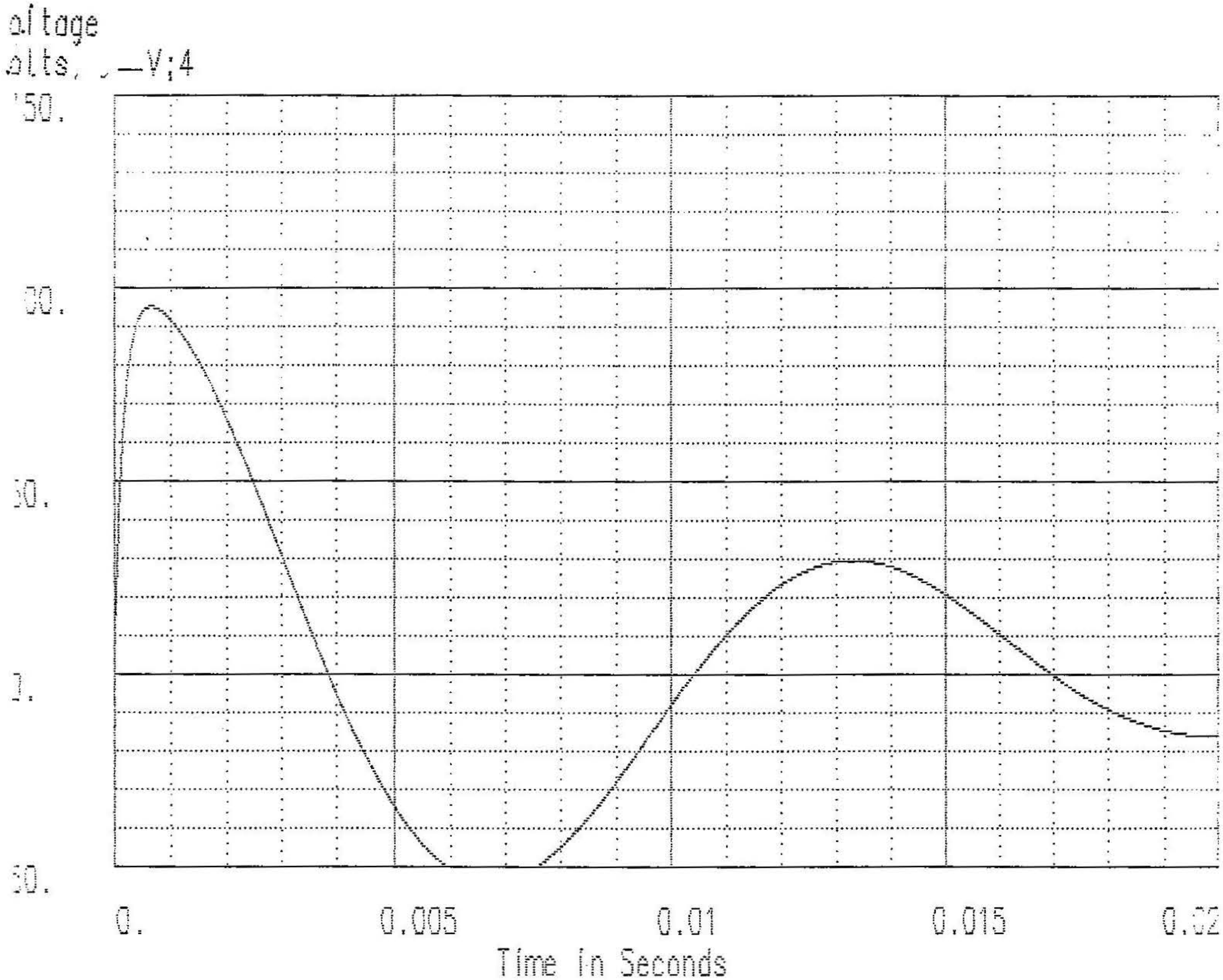


Figure 7: c50100xc.ckt

CKT-2

Compensated Probe
Stray capacitance added across o-scope input, attributed to coaxial extender cable and connections