214-0092-01-01_00

Vincent

R.F NOTE 91

NOV. 14,1983
J. VINCENT

TRANSREX CROWBAR UPGRADE

CONTENTS:

PROBLEM DEFINITION:

All channels fault lights and counters advance when one channel(any of which) is shorted. Initially the crowbar electronics mother board was suspect,but this was found not to be the problem.

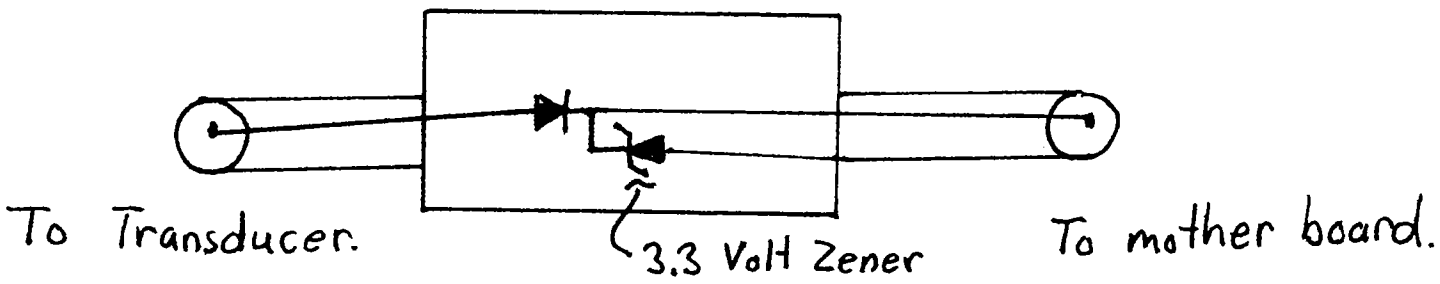
TEST PROCEDURE:

The mother board was re-installed with only one of the three channels fault input connected. A fault was generated and all indicators involved responded correctly. Each channel, both for local and remote, was alternately tested in the above manner. All channels responded correctly. These tests were run at 8KVDC. This seemed to prove the mother board was not at fault.

We then proceeded to check for cross-talk between the lines. This was found not to be the case for the remote lines,but a problem does exist for the local lines. The difference in results stems from the fact that the local transmission lines are twisted pairs; whereas, the remote lines are co-axial. During the test we also noted cross-talk between the current transducers. Again the transrex transducers were much worse then the remote ones.

INITIAL SOLUTION:

From the results of the tests, we concluded the crosstalk between current transducers were due to ground problems. We also decided to clamp the transmission lines at the transmitting end to inhibit wildly varying signals. Hence the following circuit was added to the transducer side of the fault lines.



Initially this circuitry was not added to the D.C. over current transducer and we found when the voltage level was increased to approximately 18KV we had additional problems. We determined that allowing any of the trigger signal levels to wildly vary on the mother board did indeed cause cross-talk between signal paths to occur. We eliminated the problem by clamping all signal lines to 3.3 Volts DC maximum. This fix seems to have eliminated the problems.

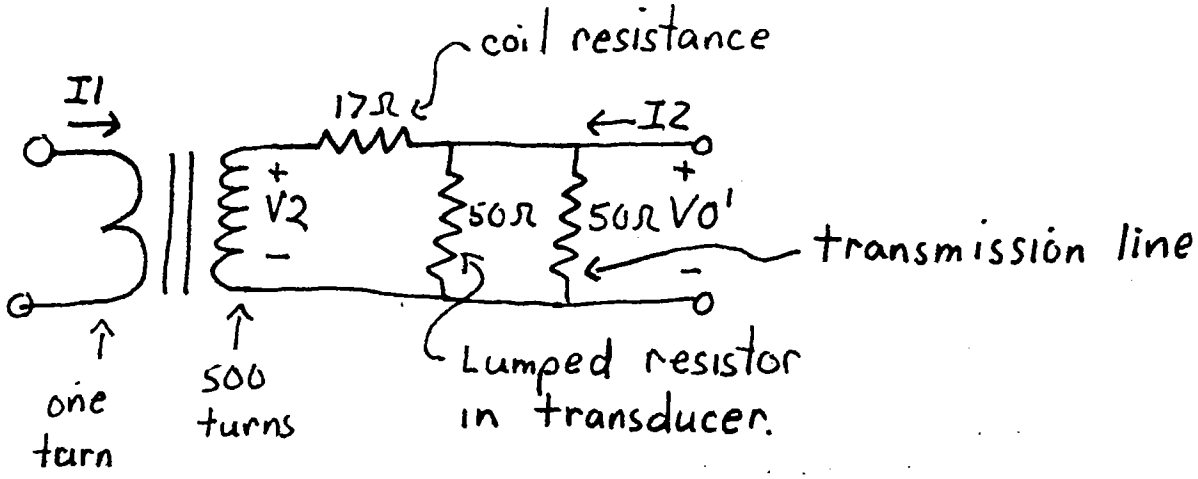
FINAL TESTS:

Upon completion of the aforementioned repairs we tested all signal paths for correct indications at various DC levels. Specifically we crowbarred all outputs at DC levels of 4,15,20 KVDC. Indicators all responded correctly and we are reasonably confident no problems should develop in the near future.

CROWBAR SIGNAL:

For the record Jack Reidel has requested that a graph of the crowbar waveform be included. This study and graph is included with the understanding that current magnitudes and durations change according to the type of short,output dc level,and particular transducer monitored. These graphs included at the end of this report should therefore be looked upon as typical. The turns ratio of the output coil to input coil on the transducers is 500:1. So an approximate calculation follows.

Apropriate topography for 1st. order calculation:



V2/V1 = N2/N1 = I1/I2 Coupling coefficient between coils assumed to be 1.

I2 = V2/Z2 = (transducer coil voltage)/(impedance seen by coil)

Hence: I1 = V2(N2)/Z2(N1) Where I1 is considered to be the actual maximum crowbar current.

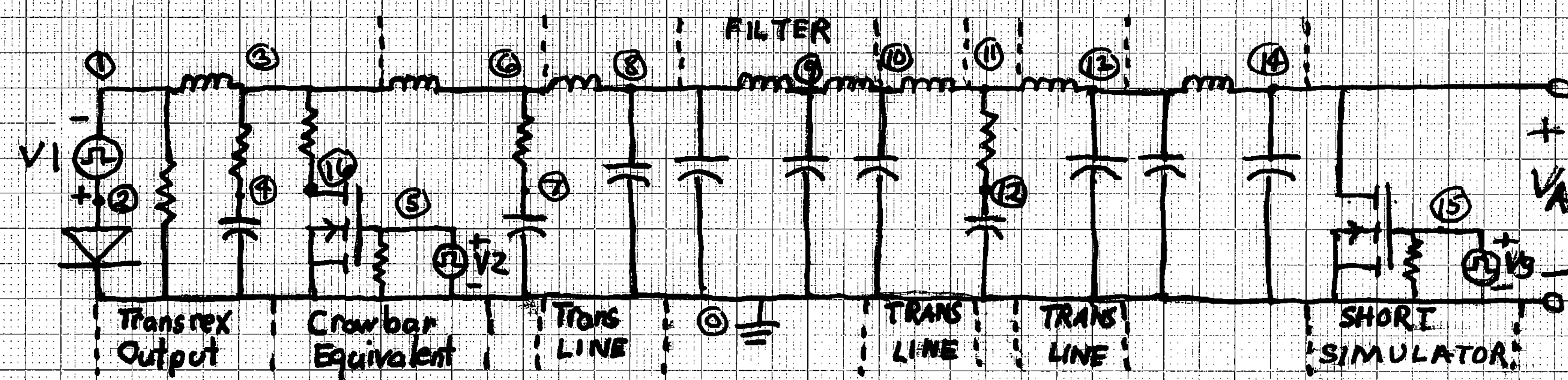
VO' = V2(50/50+17) hence: V2 = VO'(50+17)/50

therefore: I1 = V2(50+17)/50(42)(500:1) = 478.6 Amperes.

I therfore assume the current through the crowbar to be of the order of 500 Amperes. The next step was to model the actual circuitry from the transrex to the final anode. This model is included with this note. A spice analysis was performed and seemed to be in agreement with the first order calculation. The programs and outputs are included. Two were run, one shows the situation for no initial current(ZL= infin.) and the other for approximate normal operation(I=8 Amperes or greater). The transistors in the model are used as perfect switches.

END.

TRANSREX EQUIVALENT CIRCUIT
(ANALYSIS MODEL)



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*******11-NOV-83 *******  SPICE 2G.1 (15OCT80)  *******16:19:32*****


****      INPUT LISTING                    TEMPERATURE =   27.000 DEG C

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* TRANSREX CROWBAR SIMULATION

V1 1 2 PULSE(20E+3 0 2.1E-6 0 0 1)
V2 5 0 PULSE(0 20E+3 2E-6 0 0 1)
V3 15 0 PULSE(20E+6 0 1 0 0 1)
V4 16 17 DC 0
D1 0 2  ONE
.MODEL ONE D
R1 1 0 10E+6
L1 1 3 20E-3
R2 3 4 20
C1 4 0 13.5E-6
R3 3 16 20
M1 17 5 0 0 TWO
.MODEL TWO NMOS(UCRIT=1E+10 KP=1)
R4 5 0 10E+6
L2 3 6 5E-6
R5 6 7 50
C2 7 0 8000E-12
L3 6 8 8E-6
C3 8 0 2.95E-9
C4 8 0 2000E-12
L4 8 9 50E-6
C5 9 0 2000E-12
L5 9 10 50E-6
C6 10 0 177E-12
L6 10 11 480E-9
R6 11 12 50
C7 12 0 8000E-12
L7 11 13 1.2E-6
C8 13 0 472E-12
C9 13 0 2000E-12
L8 13 14 10E-6
C10 14 0 2000E-12
R8 14 18 2000
M2 18 15 0 0 TWO
R7 15 0 10E+6
.WIDTH IN=80 OUT=132
.TRAN  25E-6 500E-6 0
.PRINT TRAN I(V1) I(V4)
.PLOT TRAN I(V1) I(V4)
.END
```

$Z_L = 2000$

**** TRANSIENT ANALYSIS TEMPERATURE = 27.000 DEG C

****

$Z_L = 200\Omega$

TIME	I(V1)	I(V4)
0.000E+00	-1.000E+01	2.773E-08
2.500E-05	-1.101E+01	4.819E+02
5.000E-05	1.056E-08	4.558E+02
7.500E-05	7.247E-09	4.351E+02
1.000E-04	9.887E-09	4.153E+02
1.250E-04	6.921E-09	3.965E+02
1.500E-04	5.996E-09	3.785E+02
1.750E-04	8.230E-09	3.613E+02
2.000E-04	8.464E-09	3.448E+02
2.250E-04	5.583E-09	3.292E+02
2.500E-04	4.724E-09	3.143E+02
2.750E-04	6.996E-09	2.999E+02
3.000E-04	7.281E-09	2.863E+02
3.250E-04	4.474E-09	2.733E+02
3.500E-04	3.669E-09	2.609E+02
3.750E-04	5.970E-09	2.490E+02
4.000E-04	6.298E-09	2.377E+02
4.250E-04	3.553E-09	2.269E+02
4.500E-04	2.795E-09	2.166E+02
4.750E-04	5.117E-09	2.068E+02
5.000E-04	1.446E-09	1.973E+02

**********11-NOV-83 ********** SPICE 2G.1 (15OCT80) **********16:19:32**********

**** TRANSIENT ANALYSIS TEMPERATURE = 27.000 DEG C

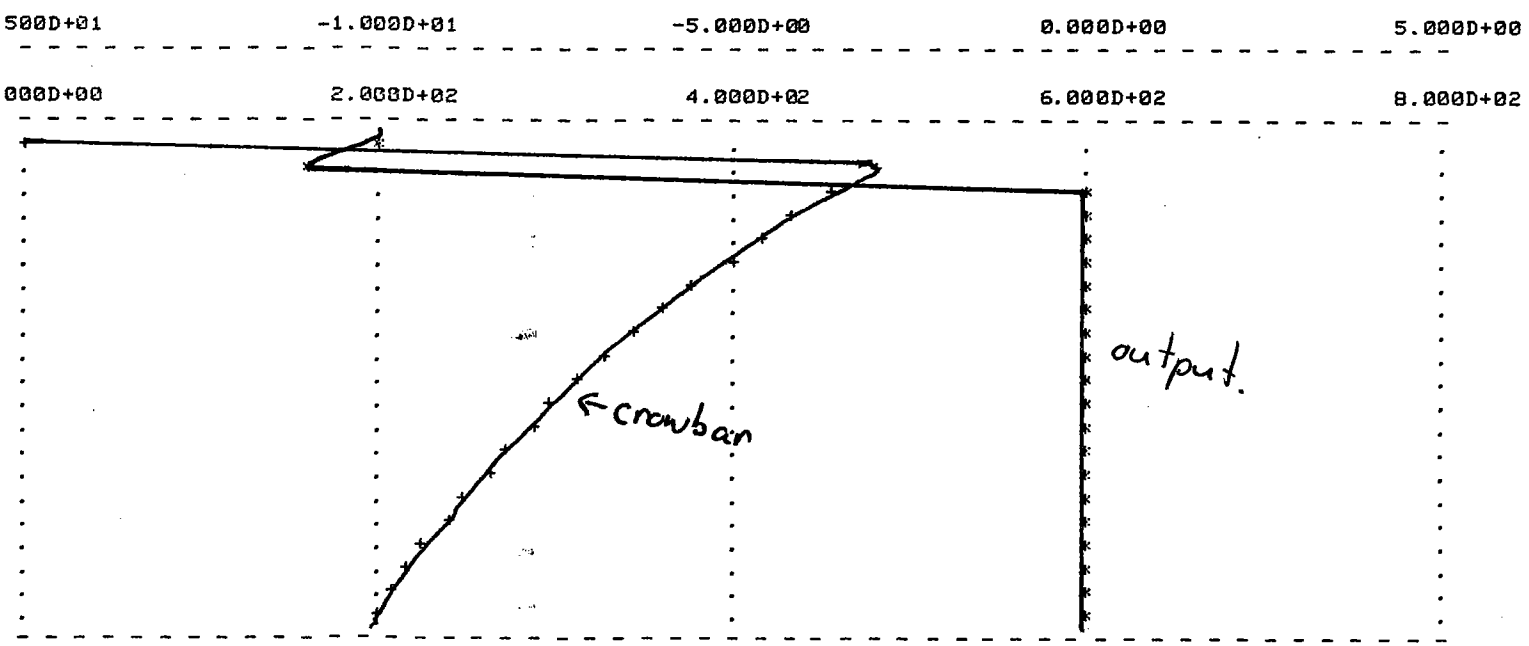
****

$Z_L = 2000$

LEGEND:

*: I(V1)
+: I(V4)

TIME	I(V1)
0.000D+00	-1.000D+01
2.500D-05	-1.101D+01
5.000D-05	1.056D-08
7.500D-05	7.247D-09
1.000D-04	9.887D-09
1.250D-04	6.921D-09
1.500D-04	5.996D-09
1.750D-04	8.230D-09
2.000D-04	8.464D-09
2.250D-04	5.583D-09
2.500D-04	4.724D-09
2.750D-04	6.996D-09
3.000D-04	7.281D-09
3.250D-04	4.474D-09
3.500D-04	3.669D-09
3.750D-04	5.970D-09
4.000D-04	6.298D-09
4.250D-04	3.553D-09
4.500D-04	2.795D-09
4.750D-04	5.117D-09
5.000D-04	1.446D-09



JOB CONCLUDED

	TIME CPU	TIME ELAPSED	PAGE FAULTS	DIRECT I/O	BUFFERED I/O
0:	0:24.52	0: 0:46.05	318	1	17

TOTAL JOB TIME 24.52

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*******10-NOV-83 *******  SPICE 2G.1 (15OCT80)  *******09:48:44*****


****      INPUT LISTING                    TEMPERATURE =   27.000 DEG C

******************************************************************************

* TRANSREX CROWBAR SIMULATION

V1 1 2 PULSE(20E+3 0 2.1E-6 0 0 1)
V2 5 0 PULSE(0 20E+3 2E-6 0 0 1)
V3 15 0 PULSE(0 20E+6 1E-6 0 0 1)
V4 16 17 DC 0
D1 0 2  ONE
.MODEL ONE D
R1 1 0 10E+6
L1 1 3 20E-3
R2 3 4 20
C1 4 0 13.5E-6
R3 3 16 20
M1 17 5 0 0 TWO
.MODEL TWO NMOS(UCRIT=1E+10 KP=1)
R4 5 0 10E+6
L2 3 6 5E-6
R5 6 7 50
C2 7 0 8000E-12
L3 6 8 8E-6
C3 8 0 2.95E-9
C4 8 0 2000E-12
L4 8 9 50E-6
C5 9 0 2000E-12
L5 9 10 50E-6
C6 10 0 177E-12
L6 10 11 480E-9
R6 11 12 50
C7 12 0 8000E-12
L7 11 13 1.2E-6
C8 13 0 472E-12
C9 13 0 2000E-12
L8 13 14 10E-6
C10 14 0 2000E-12
R8 14 18 1
M2 18 15 0 0 TWO
R7 15 0 10E+6
.WIDTH IN=80 OUT=132
.TRAN  2.4E-6 48E-6 0
.PRINT TRAN I(V1) I(V4)
.PLOT TRAN I(V1) I(V4)
.END
```

$Z_L = \infty$

**** TRANSIENT ANALYSIS TEMPERATURE = 27.000 DEG C

****

$Z_L = \infty$

TIME	I(V1)	I(V4)
0.000E+00	-2.000E-03	2.773E-08
2.400E-06	-1.853E-01	4.995E+02
4.800E-06	-1.981E-01	3.457E+02
7.200E-06	5.664E-09	2.756E+02
9.600E-06	3.617E-09	2.259E+02
1.200E-05	3.749E-09	1.918E+02
1.440E-05	3.801E-09	1.580E+02
1.680E-05	2.257E-09	1.344E+02
1.920E-05	1.795E-09	1.129E+02
2.160E-05	1.887E-09	9.589E+01
2.400E-05	1.619E-09	8.225E+01
2.640E-05	1.927E-09	7.088E+01
2.880E-05	1.184E-09	6.206E+01
3.120E-05	6.038E-10	5.461E+01
3.360E-05	1.029E-09	4.869E+01
3.600E-05	1.345E-09	4.381E+01
3.840E-05	7.425E-10	3.977E+01
4.080E-05	2.815E-10	3.655E+01
4.320E-05	7.260E-10	3.976E+01
4.560E-05	1.063E-09	3.158E+01
4.800E-05	1.265E-10	2.971E+01

**********10-NOV-83 ********** SPICE 2G.1 (15OCT80) **********09:48:44**********

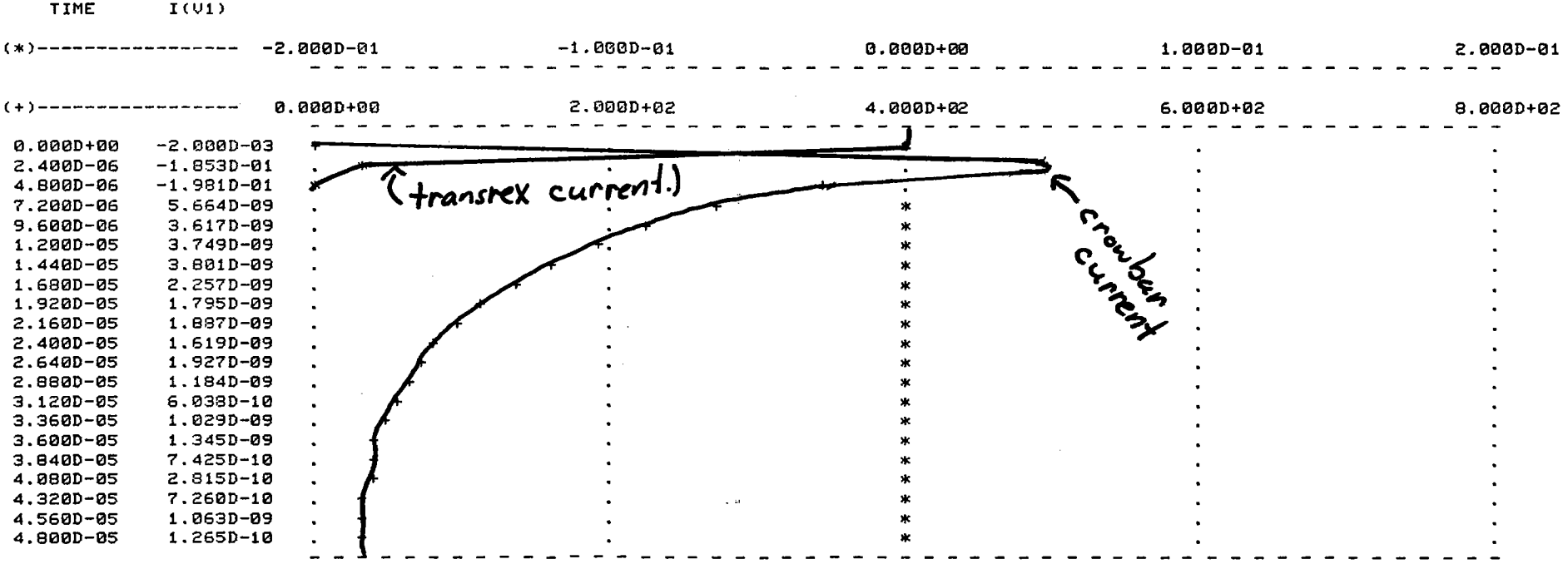
**** TRANSIENT ANALYSIS TEMPERATURE = 27.000 DEG C

****

$Z_L = \infty$

LEGEND:

*: I(V1)
+: I(V4)



TIME	I(V1)
0.000D+00	-2.000D-03
2.400D-06	-1.853D-01
4.800D-06	-1.981D-01
7.200D-06	5.664D-09
9.600D-06	3.617D-09
1.200D-05	3.749D-09
1.440D-05	3.801D-09
1.680D-05	2.257D-09
1.920D-05	1.795D-09
2.160D-05	1.887D-09
2.400D-05	1.619D-09
2.640D-05	1.927D-09
2.880D-05	1.184D-09
3.120D-05	6.038D-10
3.360D-05	1.029D-09
3.600D-05	1.345D-09
3.840D-05	7.425D-10
4.080D-05	2.815D-10
4.320D-05	7.260D-10
4.560D-05	1.063D-09
4.800D-05	1.265D-10

JOB CONCLUDED

	TIME		PAGE	DIRECT	BUFFERED
	CPU	ELAPSED	FAULTS	I/O	I/O
0:	0:19.74	0: 0:28.10	255	1	1

TOTAL JOB TIME 19.73