Through-Line Detector for RF Power Measurement

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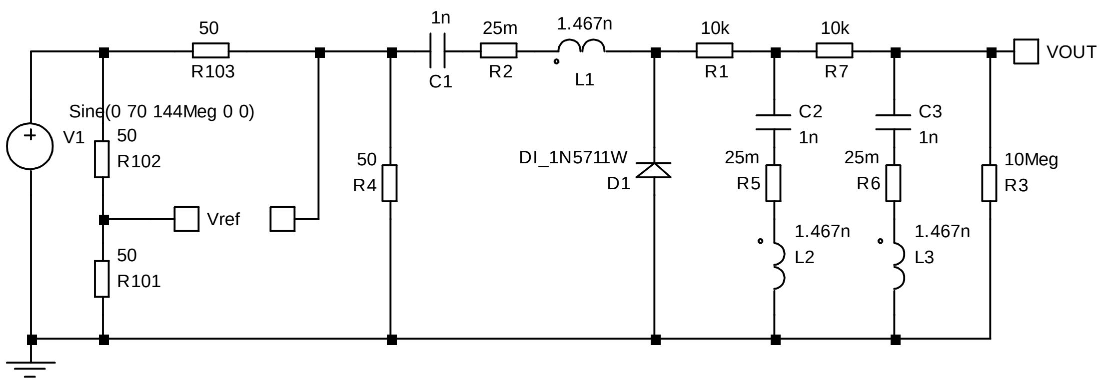
The detector is arranged such as to measure the RF voltage on a short piece of 50 ohm microstrip between two coaxial connectors. The source of RF power connects to one of the connectors and a 50 ohm load to the other. It was modelled using SPICE (SIMetrix) using the following model:



Some notes on components: The parasitic resistances and inductances shown for C1, C2 and C3 were obtained from Kemet Spice for 1206-size C0G 50V SMT capacitors. The capacitors used were of this type and size but were not made by Kemet. The model for the 1N5711 was obtained from Diodes Inc. and was actually for a surface mount device, whereas I used a leaded device (but with very short leads). R7 and C3 are used to reduce the ripple at low frequencies. Reverse breakdown of D1 (nominally at 70 volts) limits the RF power handling to a little over 10 watts.

The SPICE model showed the response to be quite flat with frequency between 1 MHz and 1 GHz, with a small drop off in sensitivity at 1 GHz. The response versus power was obtained by simulating at several source voltages at 144 MHz and then fitting a curve to these results. The output voltage (ignoring the voltage drops in R1 and R7, which are small) should be

$V_{out} = V_{rf}(peak) - V_{diode}$

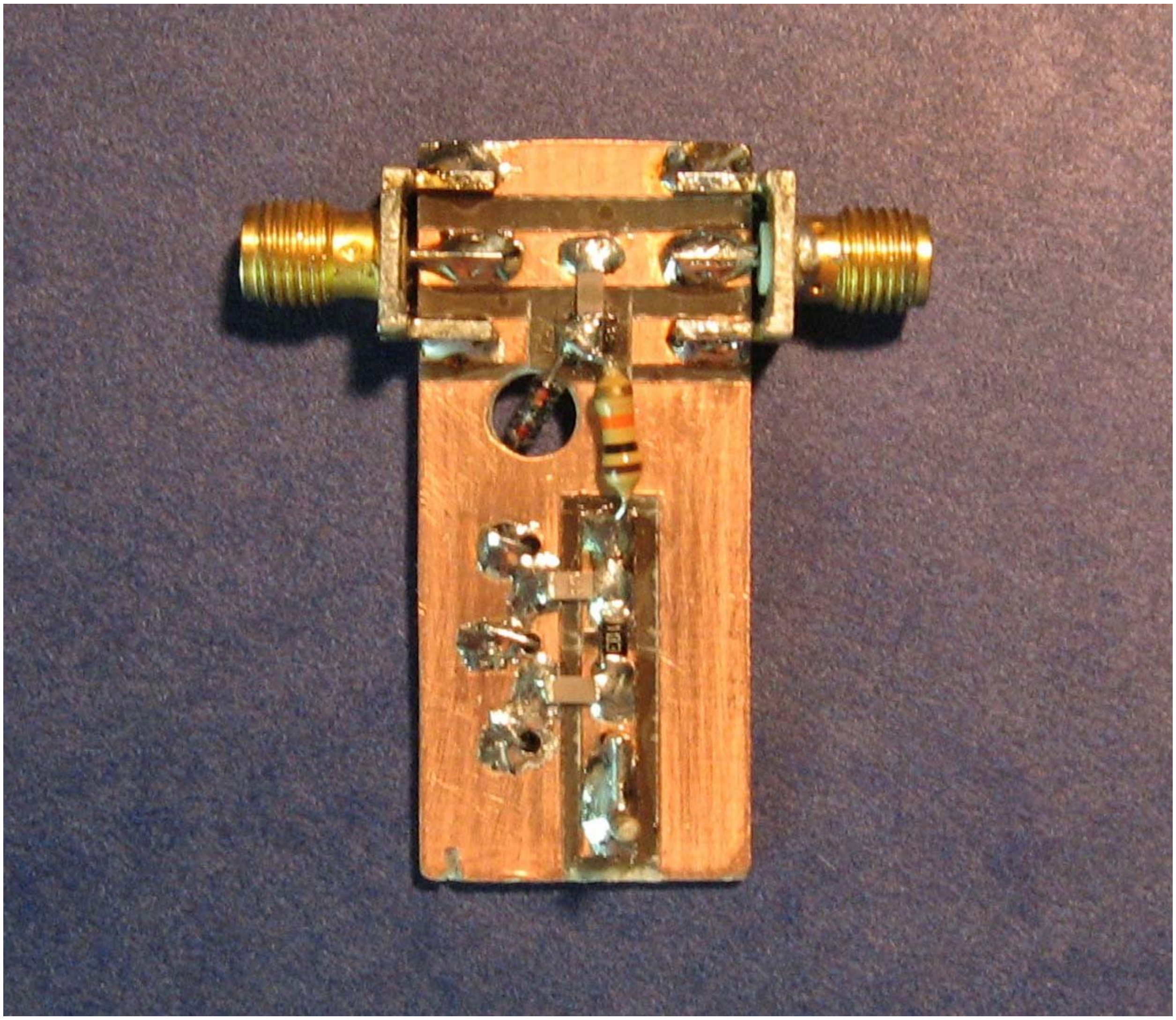
where$V_{rf}(peak) = sqrt(P_{rf} \times 50 ohms)$.

But the diode drop V_{diode} varies with current, which in turn varies with the applied power. An empirical formula was used to model V_{diode} so as to match the simulated results:

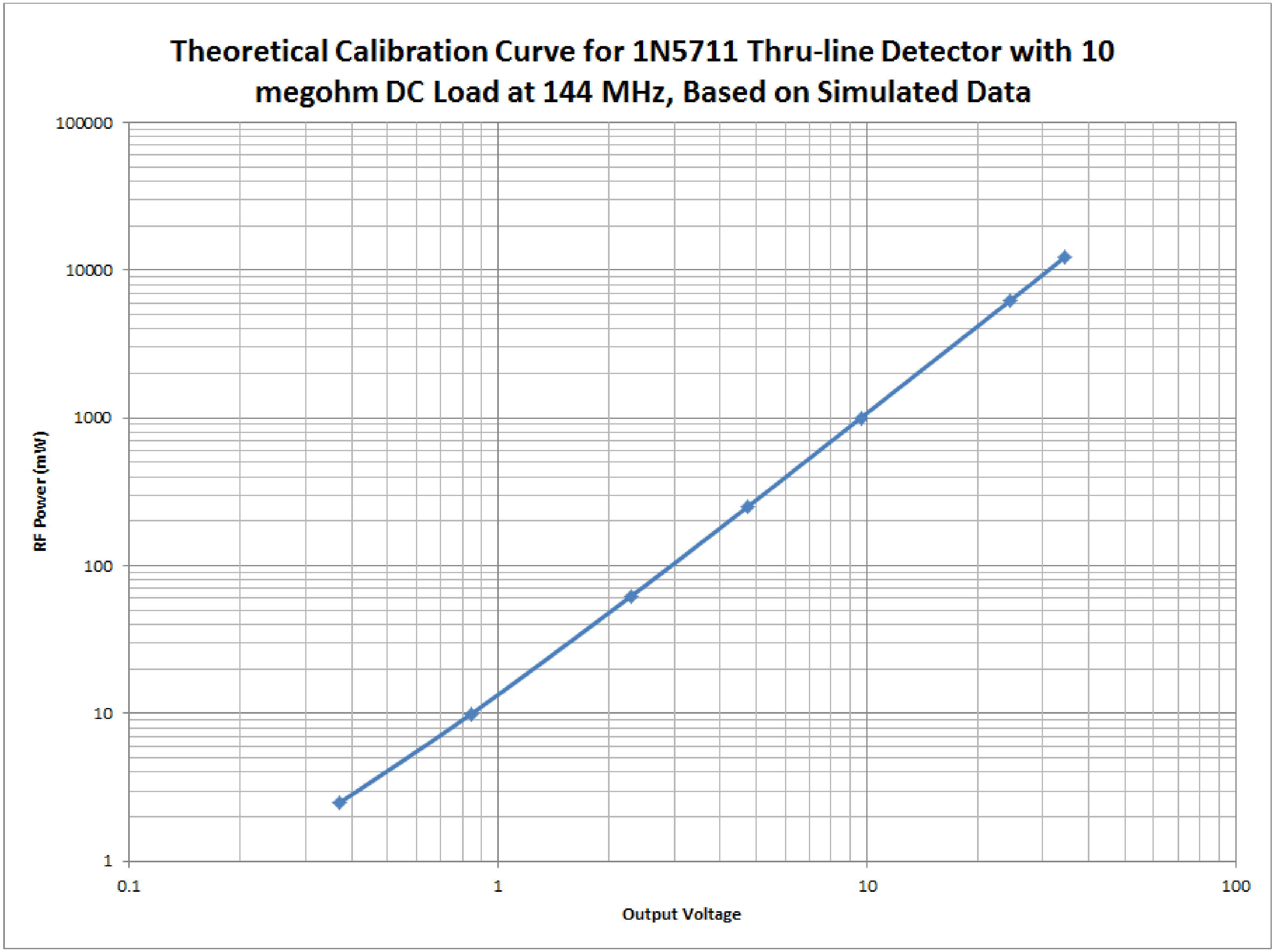
$V_{diode} = 0.335*LOG_{10}(2.01+V_{out})$.

This resulted in the formula for RF power (given the output voltage) matching the simulation at 144 MHz within 1% between 2.5 mW and 12 W of RF power.

The 10 MΩ load resistor R3 is not part of the detector assembly, but rather it represents the input resistance of a digital multimeter.



The above photo shows that the diode is mounted in a hole in the board, with the anode lead soldered directly to the ground plane to minimize lead length. Three pieces of wire are fed through small holes in the board near the bypass capacitors C2 and C3 (and soldered on top and on the bottom) to effectively ground these capacitors to the ground plane.



Theoretical Calibration Curve for 1N5711 Thru-line Detector with 10 megohm DC Load at 144 MHz, Based on Simulated Data
RF Power (mW)
100000
10000
1000
100
10
1
0.1
1
10
100
Output Voltage

Table of Voltage-to-Power Conversion for 1N5711 Detector at 144 MHz with 10 Megohm Load using Formula 3

Vout (V)	Drop	Power (mW)		Vout (V)	Drop	Power (mW)		Vout (V)	Drop	Power (W)
0.2	0.115	1.0		3.2	0.240	118.3		10	0.362	1.07
0.22	0.117	1.1		3.4	0.246	132.9		10.5	0.368	1.18
0.25	0.119	1.4		3.6	0.251	148.3		11	0.373	1.29
0.27	0.120	1.5		3.8	0.256	164.5		11.5	0.379	1.41
0.3	0.122	1.8		4	0.261	181.6		12	0.384	1.53
0.35	0.125	2.3		4.2	0.266	199.4		12.5	0.389	1.66
0.4	0.128	2.8		4.4	0.270	218.1		13	0.394	1.79
0.45	0.131	3.4		4.6	0.275	237.6		14	0.403	2.07
0.5	0.134	4.0		4.8	0.279	258.0		15	0.412	2.38
0.6	0.140	5.5		5	0.283	279.1		16	0.421	2.70
0.7	0.145	7.1		5.2	0.287	301.1		17	0.428	3.04
0.8	0.150	9.0		5.4	0.291	323.9		18	0.436	3.40
0.9	0.155	11.1		5.6	0.295	347.5		19	0.443	3.78
1	0.160	13.5		6	0.303	397.2		20	0.450	4.18
1.1	0.165	16.0		6.2	0.306	423.3		21	0.456	4.60
1.2	0.170	18.8		6.4	0.310	450.2		22	0.462	5.05
1.3	0.174	21.7		6.6	0.313	477.9		23	0.468	5.51
1.4	0.178	24.9		6.8	0.317	506.5		24	0.474	5.99
1.5	0.183	28.3		7	0.320	535.8		25	0.480	6.49
1.6	0.187	31.9		7.2	0.323	566.0		26	0.485	7.01
1.7	0.191	35.7		7.4	0.326	596.9		27	0.490	7.56
1.8	0.195	39.8		7.6	0.329	628.7		28	0.495	8.12
1.9	0.198	44.0		7.8	0.332	661.3		29	0.500	8.70
2	0.202	48.5		8	0.335	694.7		30	0.504	9.31
2.2	0.209	58.0		8.2	0.338	729.0		31	0.509	9.93
2.4	0.216	68.4		8.5	0.342	781.9		32	0.513	10.57
2.6	0.222	79.7		8.7	0.345	818.1		33	0.517	11.23
2.8	0.229	91.7		9	0.349	874.0		34	0.521	11.92
3	0.234	104.6		9.5	0.355	971.3		35	0.525	12.62