Tuned Circuits

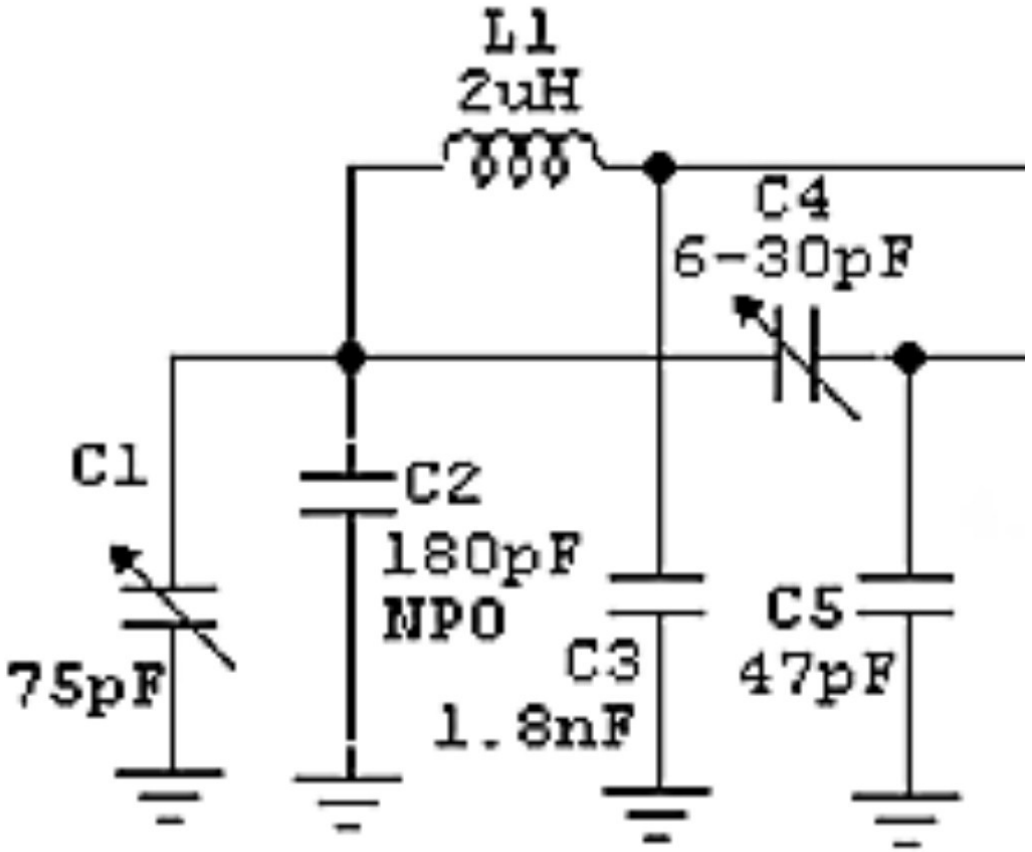
Tuned circuits or resonant circuits come in all sorts of shapes and sizes...

(C) John Brock ZS6WL 2018

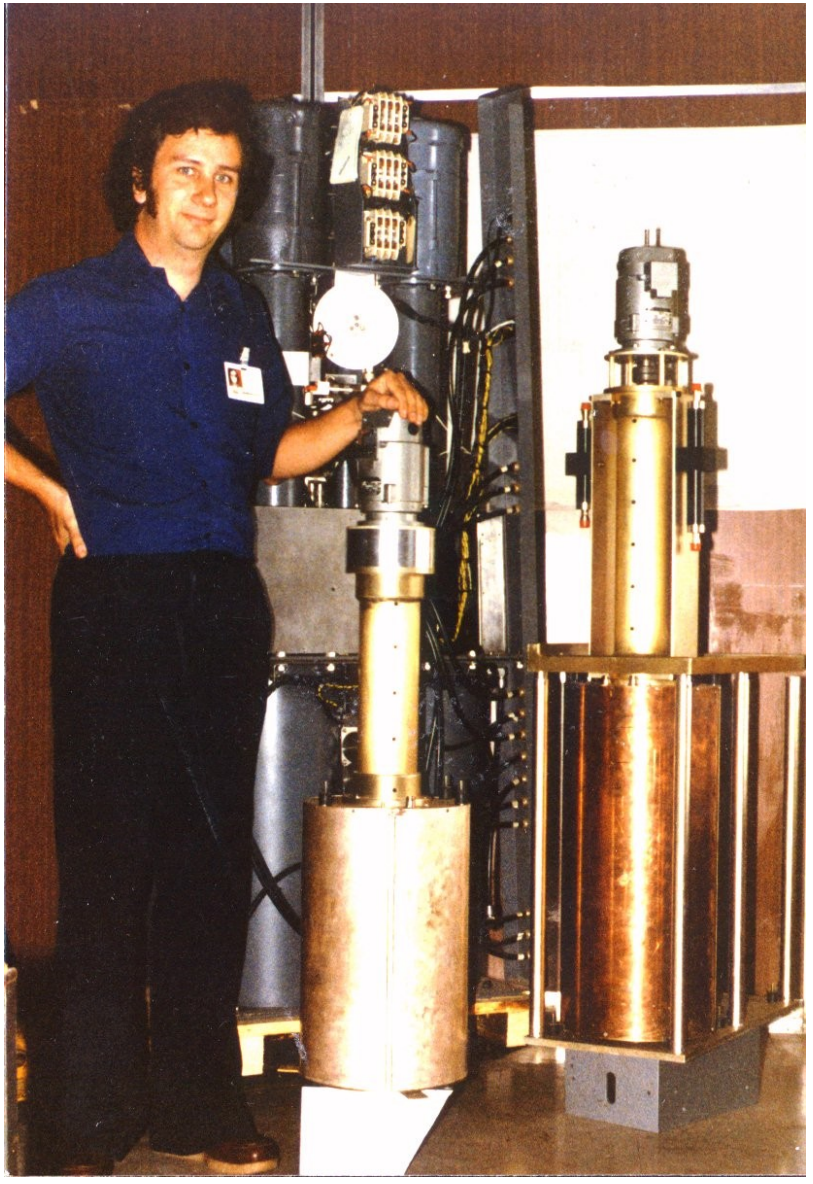
Some of them...

- Coil and capacitor circuit
- Cavity or Helical Resonator
- Transmission Line filter
- Long Wire Aerial [antenna if you are in the US.]
- A Crystal ‘cut’ to the frequency ‘you’ desire.

Here's one...



These are ‘cavity resonators’ another form of ‘tuned circuit’.



Here's a circuit using one...nope two tuned circuits.

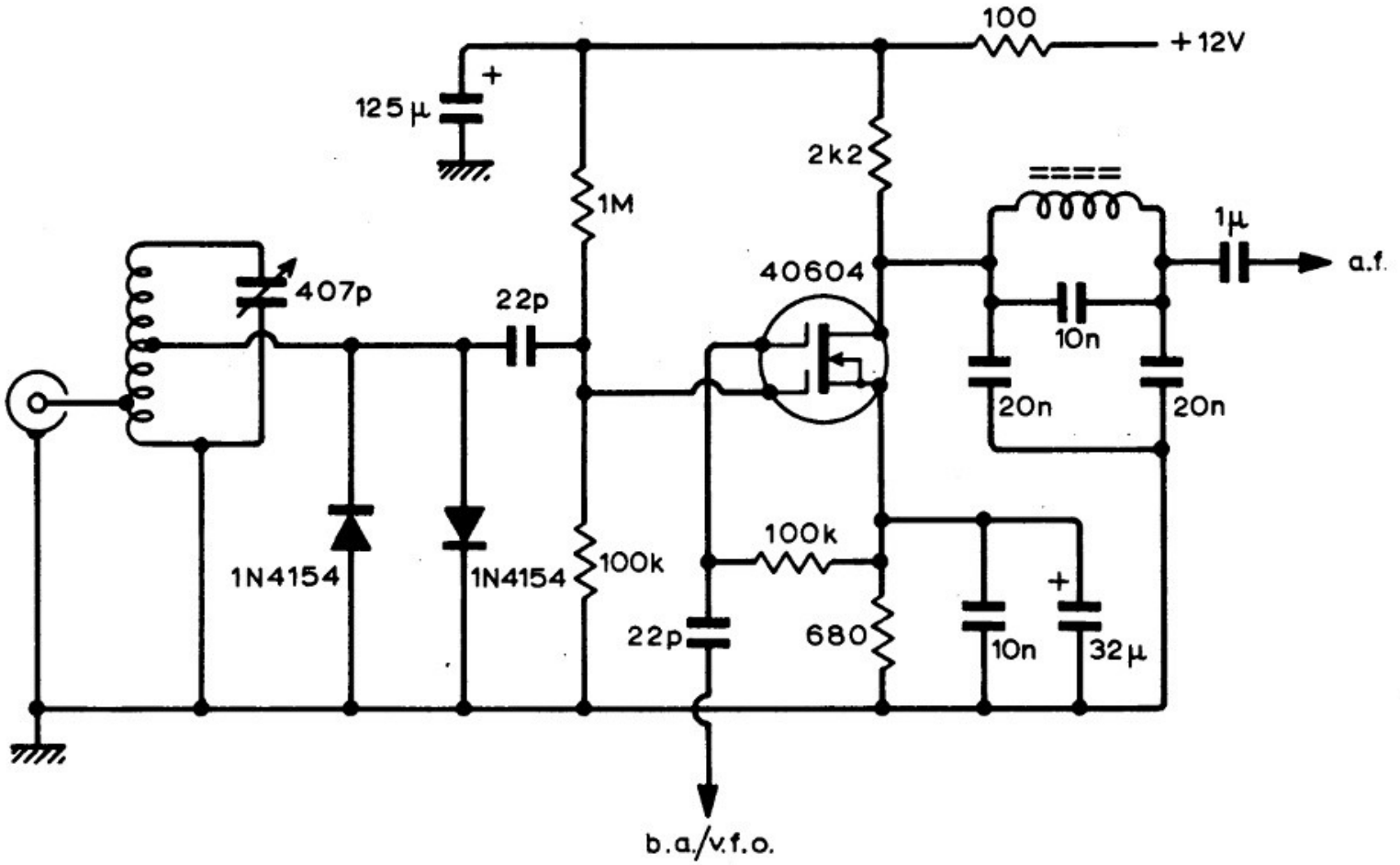
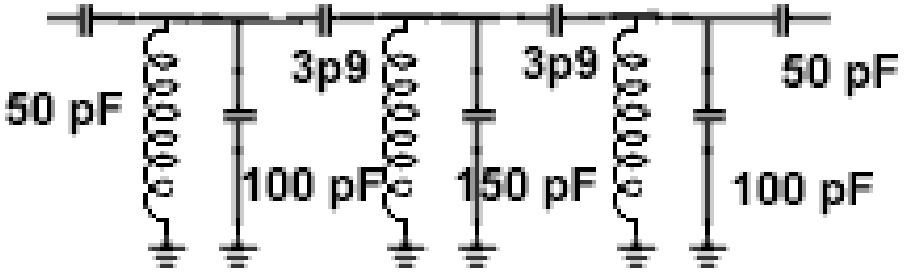


Fig. 7. High performance audio filter designed by P. G. Martin for use in direct-conversion receiver.

Here are three in a row...



This is a “Band-Pass Filter. Three tuned circuits in a row.

Here's another...

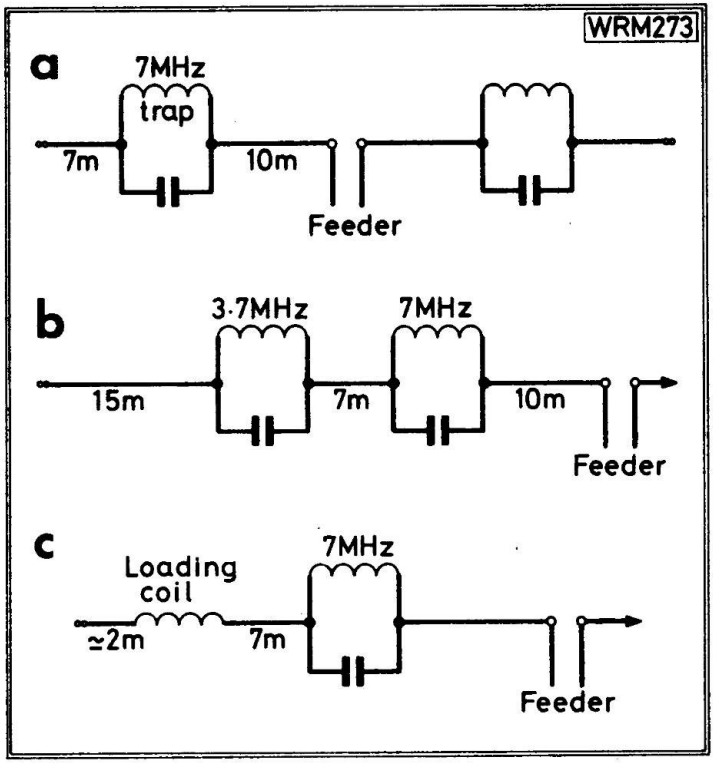
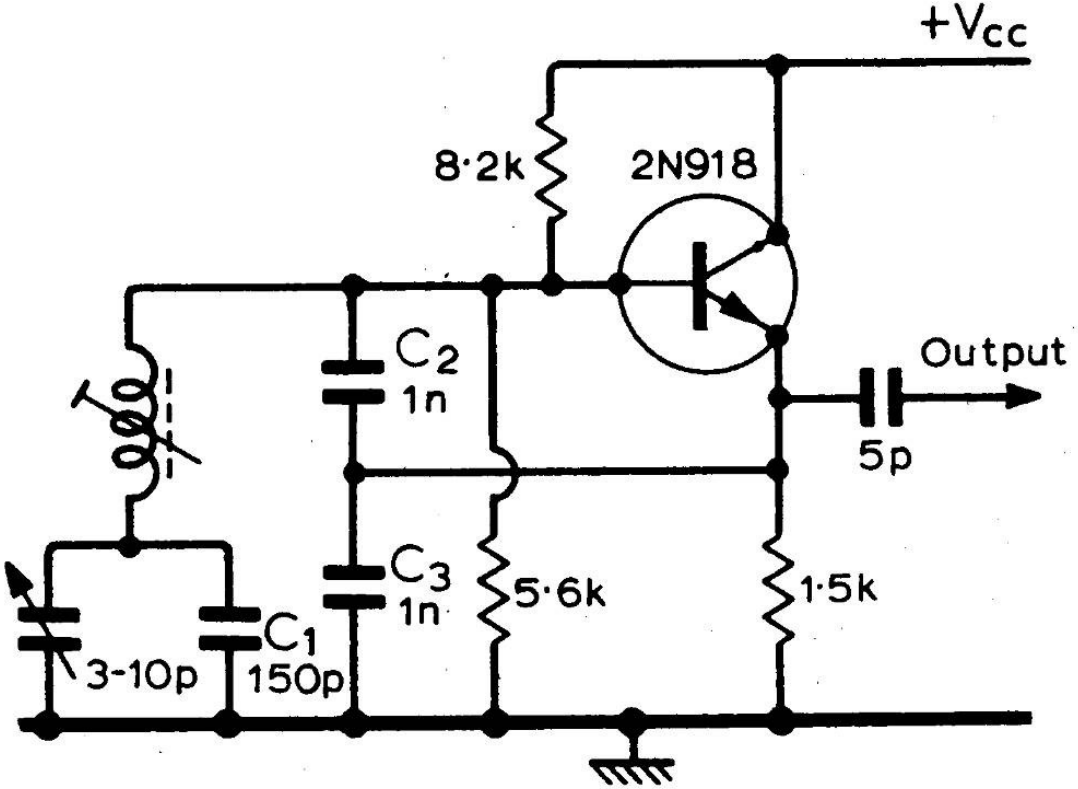


Fig. 1: (a) Approximate dimensions of trapped dipole covering 3·5 to 28MHz, fed with low impedance coaxial cable. (b) Same as (a) but with additional traps at 3·7MHz and end wires but now extending coverage to 1·8MHz. (c) The use of a loading coil instead of a trap considerably reduces length of end wires for coverage of the h.f. and l.f. bands

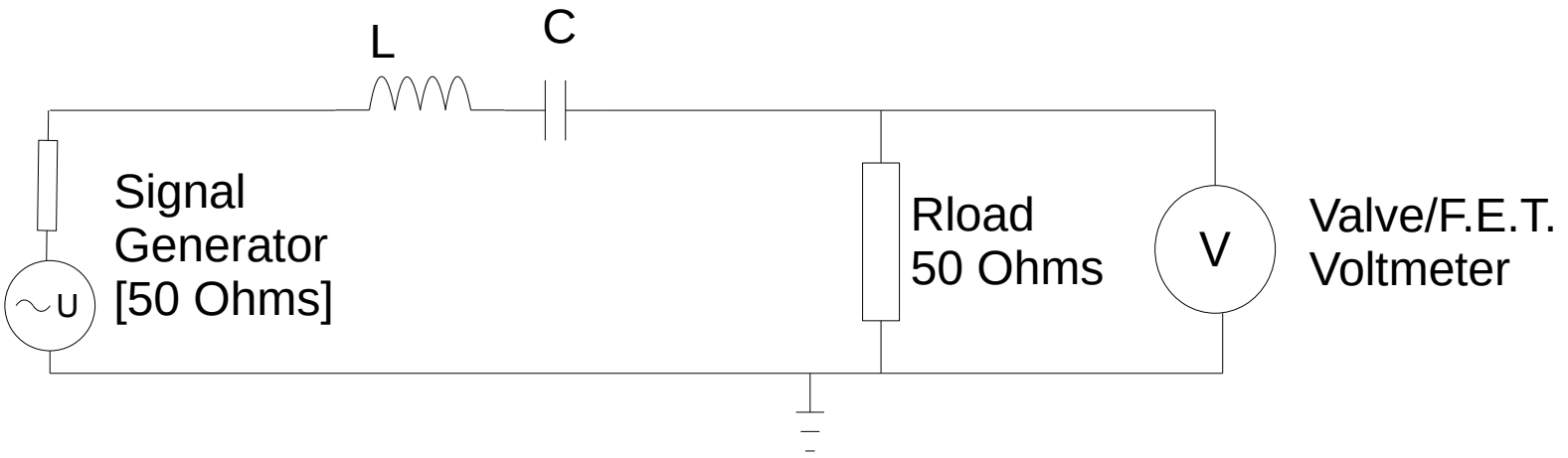
Here's one...it has escaped from the next session.



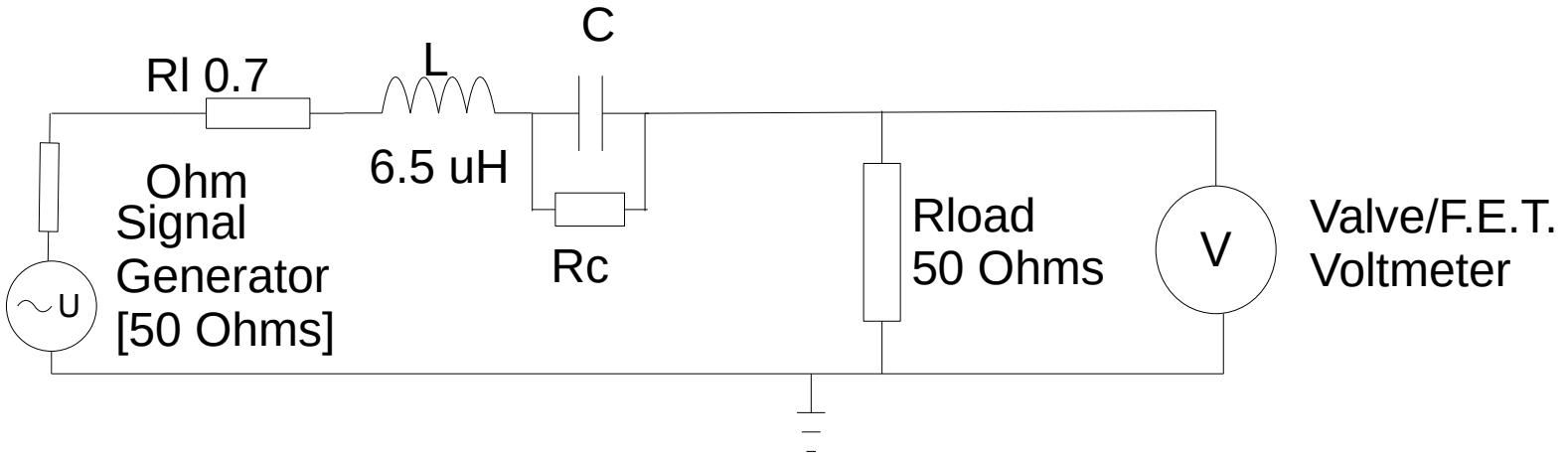
In this Gouriet-Clapp oscillator overall temperature coefficient was reduced to +3 p.p.m./deg C by using the simple equations in this article and making C_1 a parallel combination of a silvered mica capacitor and a polystyrene capacitor.

Series Tuned Circuit Testing

Theoretical Circuit



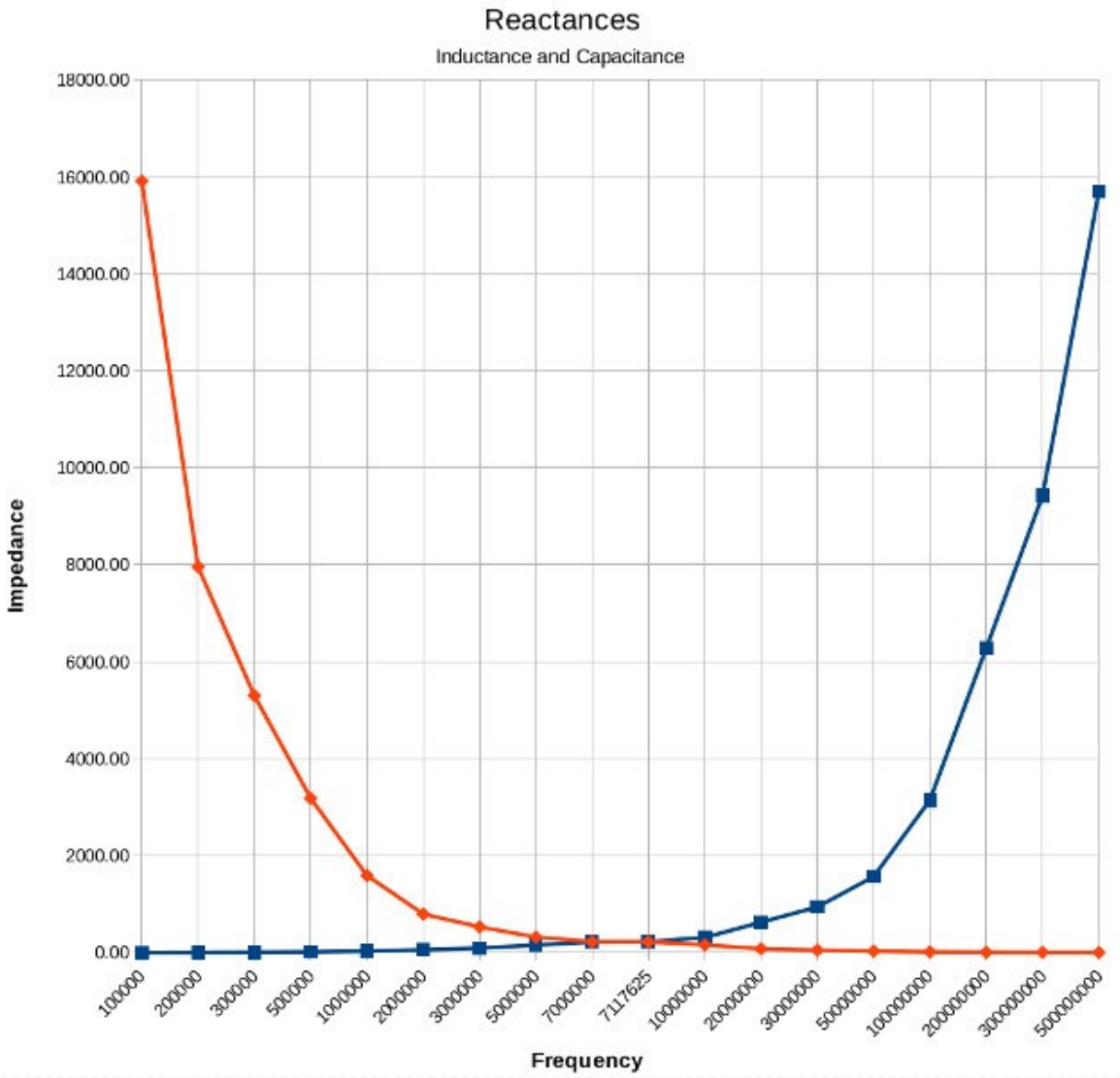
Practical Circuit



A Series Tuned Circuit
[Spreadsheet]

Frequency	L [inductance] 5 micro Henries 5E-06 XL	C [capacitance] 100 picoFarads 1E-10 XC
100000	3.14	15915.49
200000	6.28	7957.75
300000	9.42	5305.16
500000	15.71	3183.10
1000000	31.42	1591.55
2000000	62.83	795.77
3000000	94.25	530.52
5000000	157.08	318.31
7000000	219.91	227.36
7,117,625	223.61	223.61
10000000	314.16	159.15
20000000	628.32	79.58
30000000	942.48	53.05
50000000	1570.80	31.83
100000000	3141.59	15.92
200000000	6283.19	7.96
300000000	9424.78	5.31
500000000	15707.96	3.18

7,117,625 Hertz

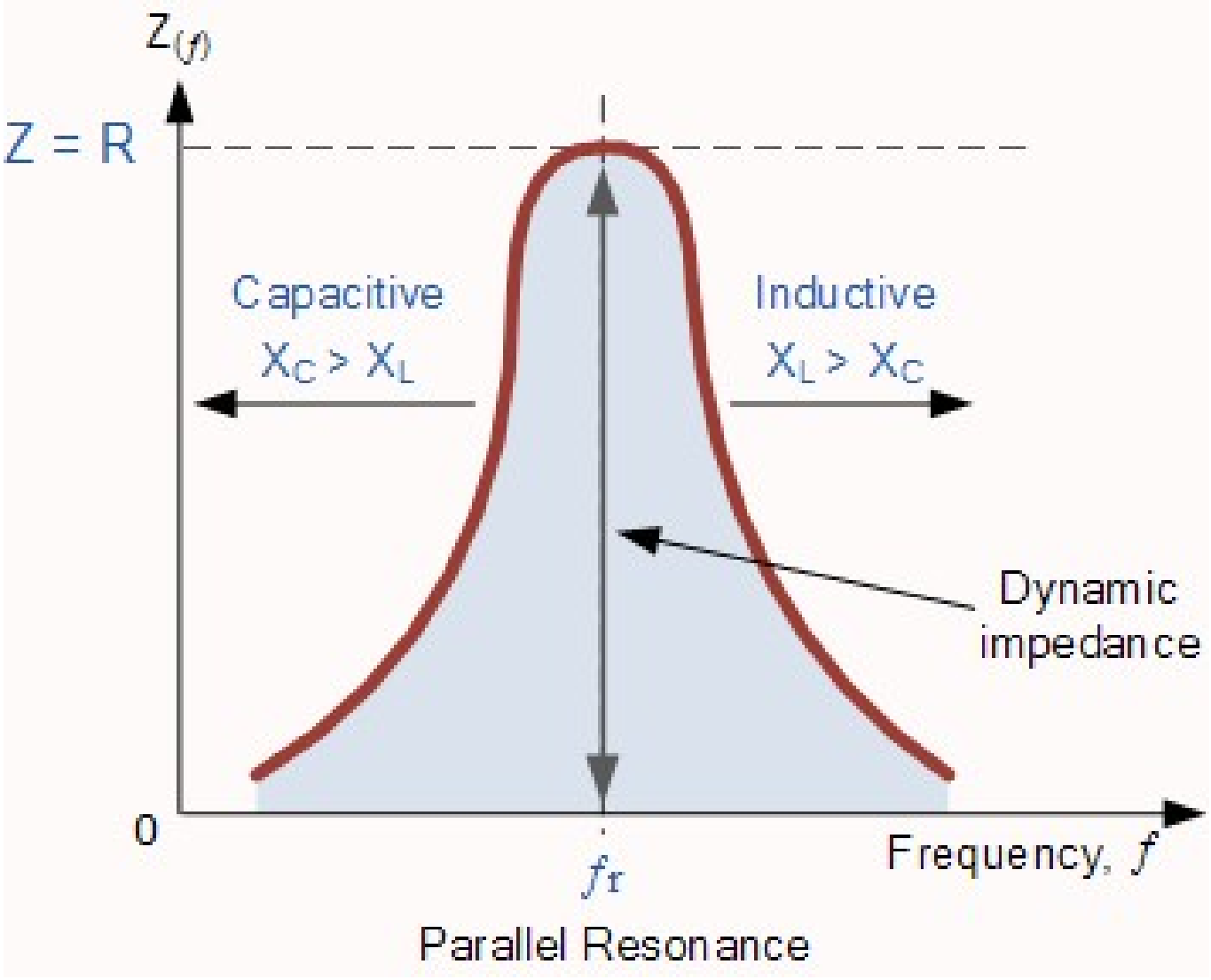


In the ‘old days’ we would have to do all this by hand. A signal generator and a meter, making notes in a book...

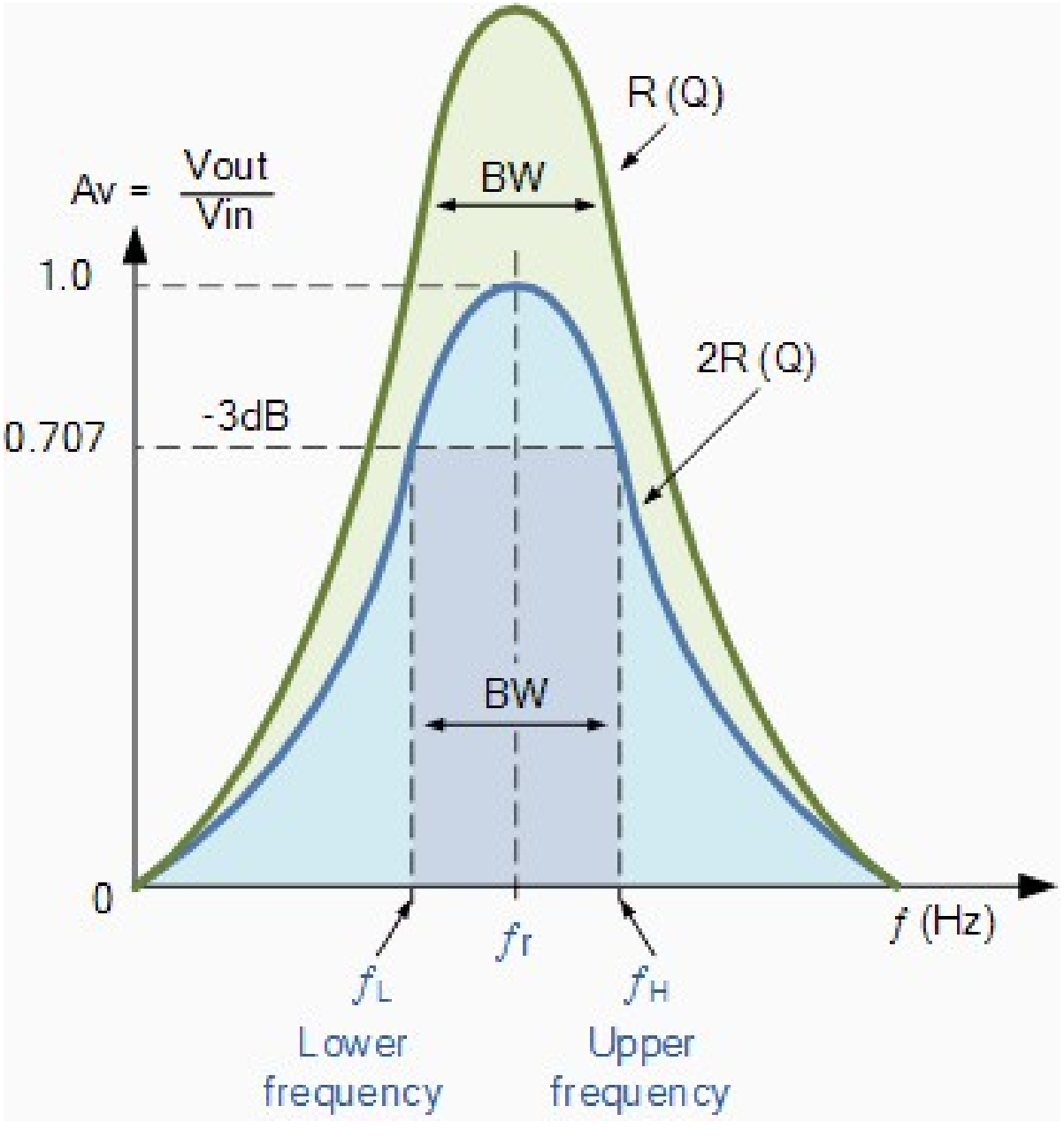
“Q” The Quality Factor

- Coil has resistance in wire
- Capacitor has conductive dielectric. It may be MegOhms but its still there.
- Coil may have ‘skin effect’
- ‘Self Inductance’ of capacitor
- ‘Self capacitance’ of coil
- Lead inductance and capacitance

Frequency Response

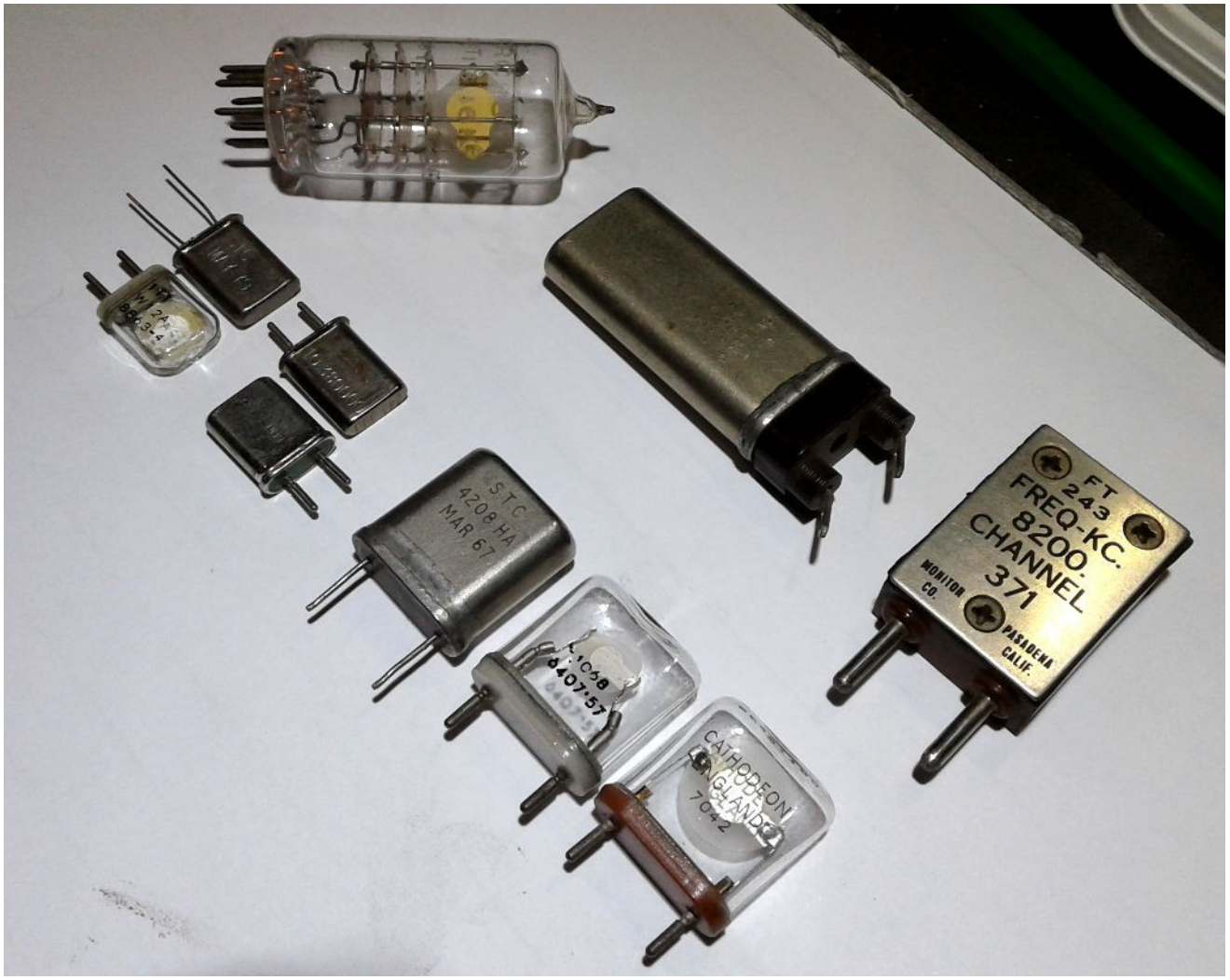


Frequency Response

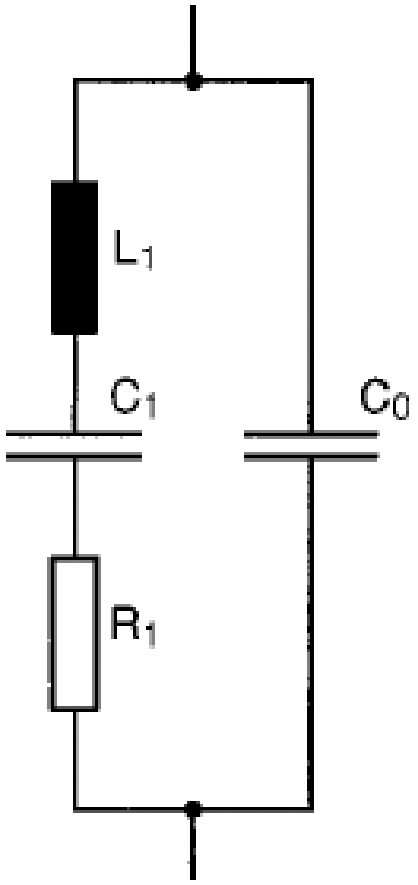


When you need a ‘Q’ of thousands...

- Use a crystal



“Q” of Thousands!



typical values

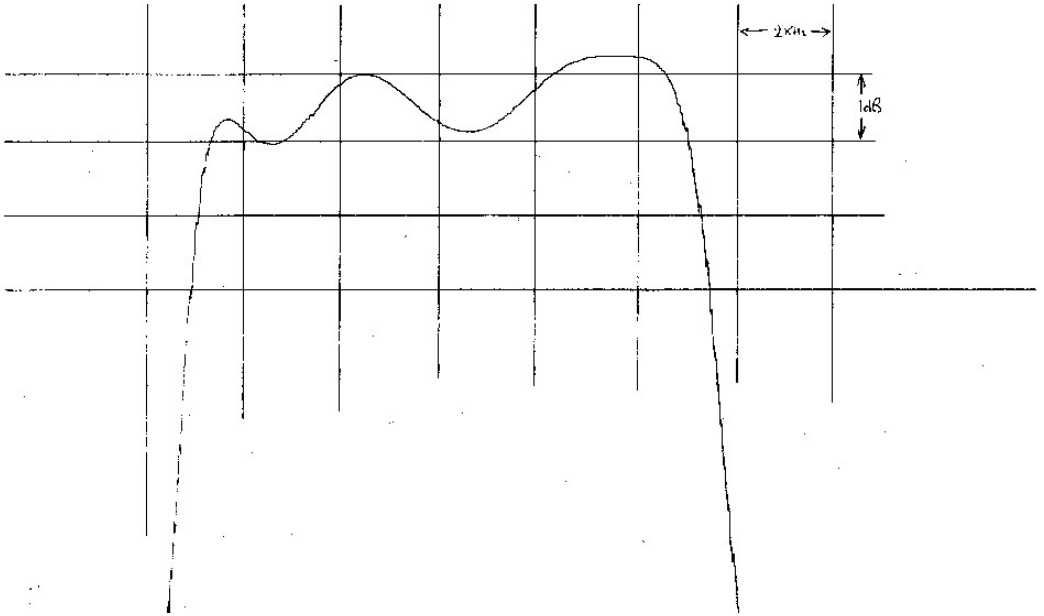
$C_0 = 20$ pF

$C_1 = 3.7$ fF

$R_1 = 50\ \Omega$

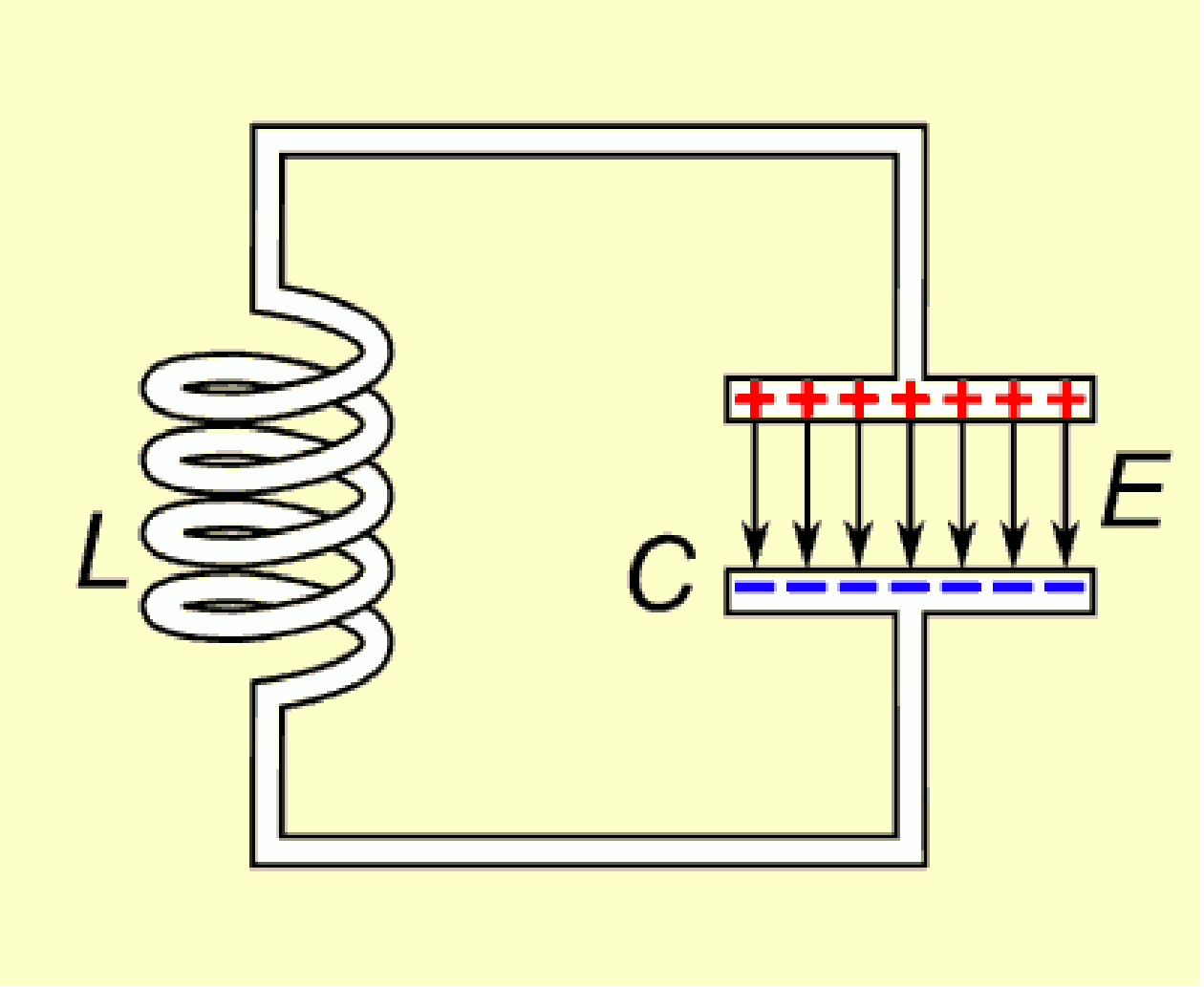
$L_1 = 200$ mH

Crystal Filter response
X division is 2 kHz
Y division is 1 dB



6 MHz Crystal values
Co [parallel] 20 pico Farads
C1 is 3.7 femto Farads
L1 is 200 milliHenry

Parallel Tuned Circuit

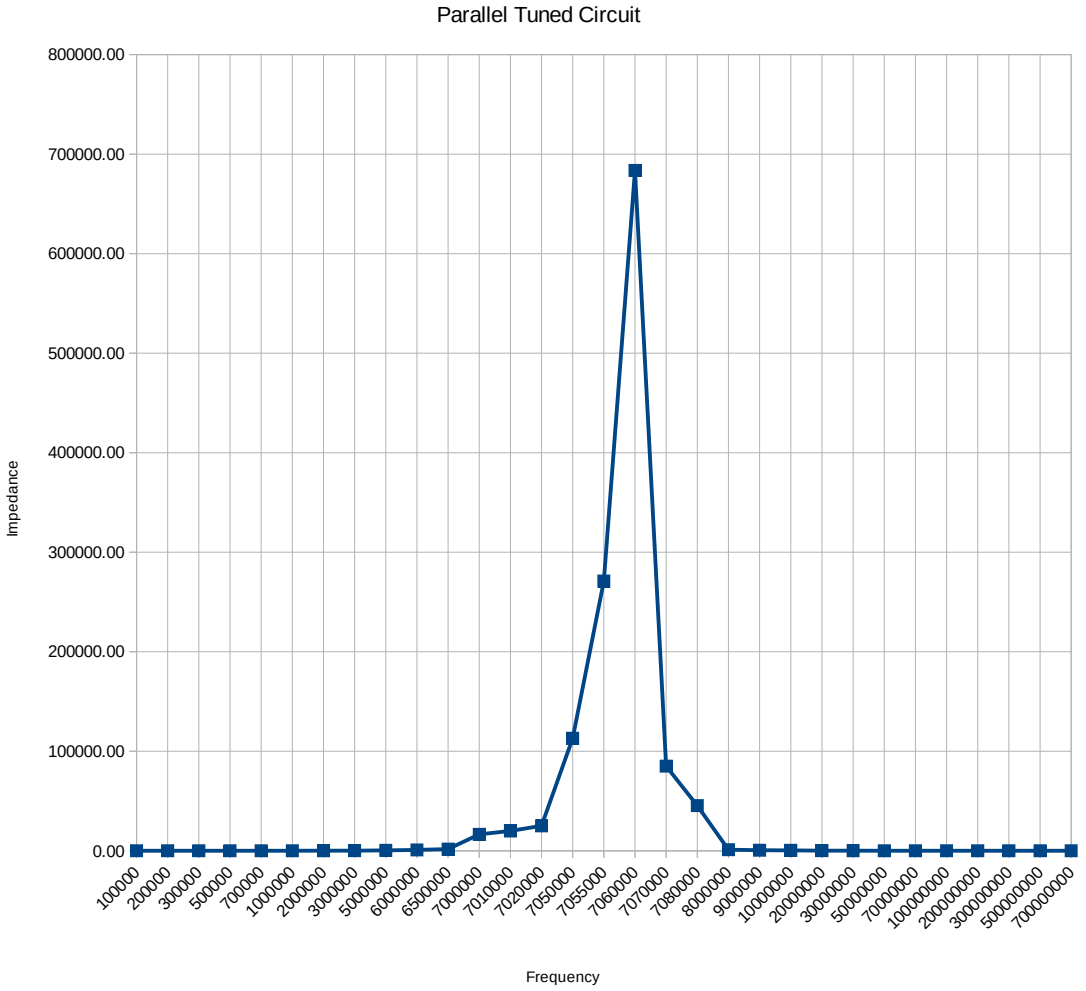


Parallel Tuned Circuits

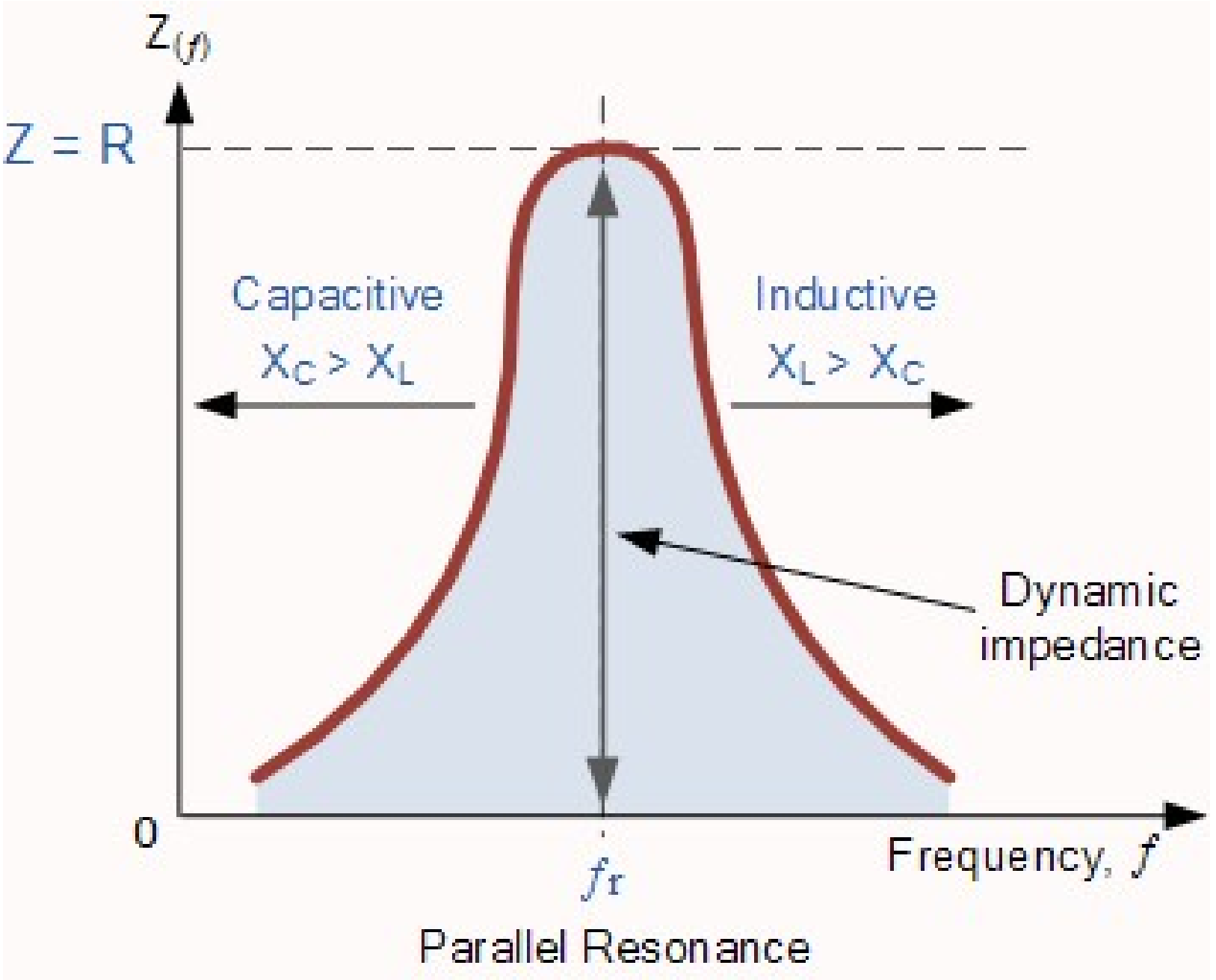
		L [inductance] 6.2 micro Henries		C [capacitance] 82 picoFarads	
	Absolute Value	6.2E-06	XL.XC	8.2E-11	
Frequency	of XL.XC	XL	combined	XC	
100000	3.90	3.90	3.90	19409.14	
200000	7.80	7.79	7.80	9704.57	
300000	11.71	11.69	11.71	6469.71	
500000	19.58	19.48	19.58	3881.83	
700000	27.54	27.27	27.54	2772.73	
1000000	39.75	38.96	39.75	1940.91	
2000000	84.71	77.91	84.71	970.46	
3000000	142.63	116.87	142.63	646.97	
5000000	390.94	194.78	390.94	388.18	
6000000	842.44	233.73	842.44	323.49	
6500000	1665.79	253.21	1,665.79	298.60	
7000000	16497.23	272.69	16,497.23	277.27	
7010000	19907.36	273.08	19,907.36	276.88	
7020000	25085.27	273.47	25,085.27	276.48	
7050000	113033.92	274.64	113033.92	275.31	
7055000	270984.67	274.83	270984.67	275.11	
7060000	**683641.31**	**275.03**	**-683641.31**	**274.92**	
7070000	85049.76	275.42	-85,049.76	274.53	
7080000	45375.42	275.81	-45,375.42	274.14	
8000000	1095.29	311.65	-1,095.29	242.61	
9000000	560.30	350.60	-560.30	215.66	
10000000	386.82	389.56	-386.82	194.09	
20000000	110.85	779.11	-110.85	97.05	
30000000	68.49	1168.67	-68.49	64.70	
50000000	39.61	1947.79	-39.61	38.82	
70000000	28.01	2726.90	-28.01	27.73	
100000000	19.51	3895.57	-19.51	19.41	
200000000	9.72	7791.15	-9.72	9.70	
300000000	6.47	11686.72	-6.47	6.47	
500000000	3.88	19477.87	-3.88	3.88	
700000000	2.77	27269.02	-2.77	2.77	

Frequency of Resonance		XL.XC combined	
7,058,580	274.97	**3,069,952,591.33**	274.97

7,058,580 Hertz



It doesn't really look like this...



Parallel Tuned Circuit with F.E.T.

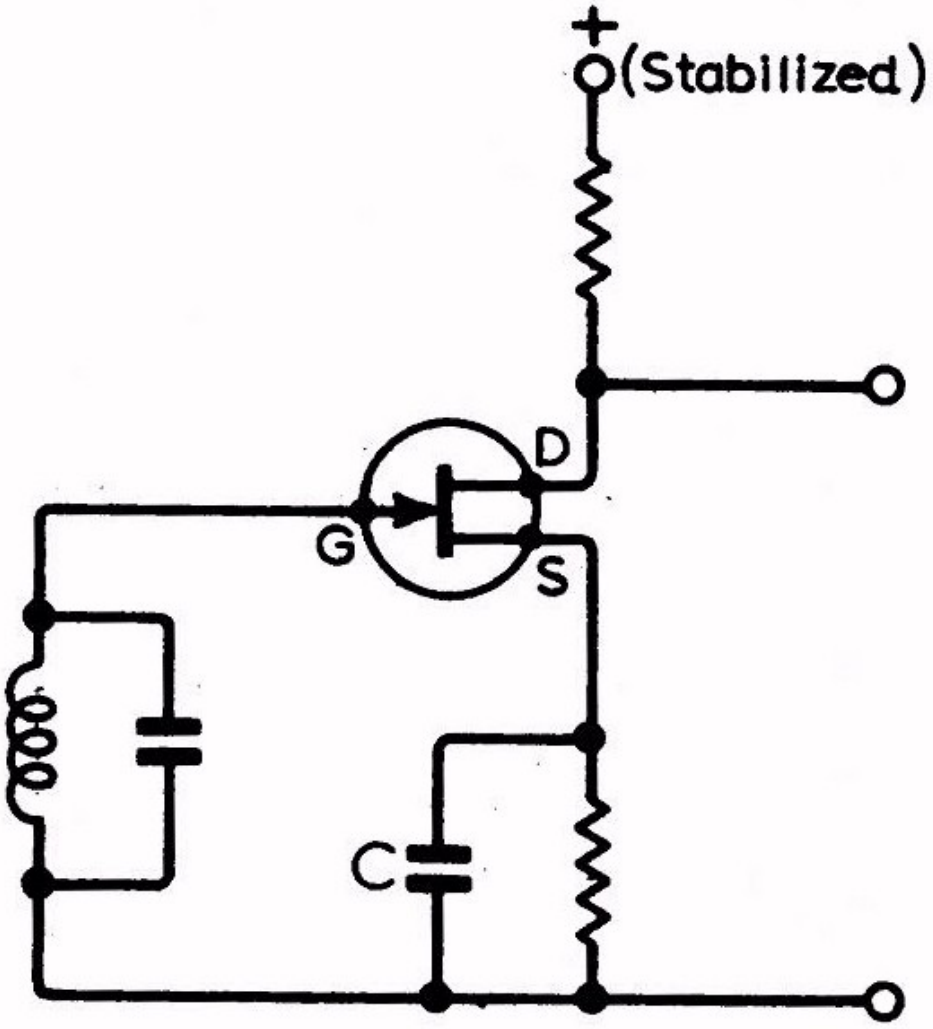
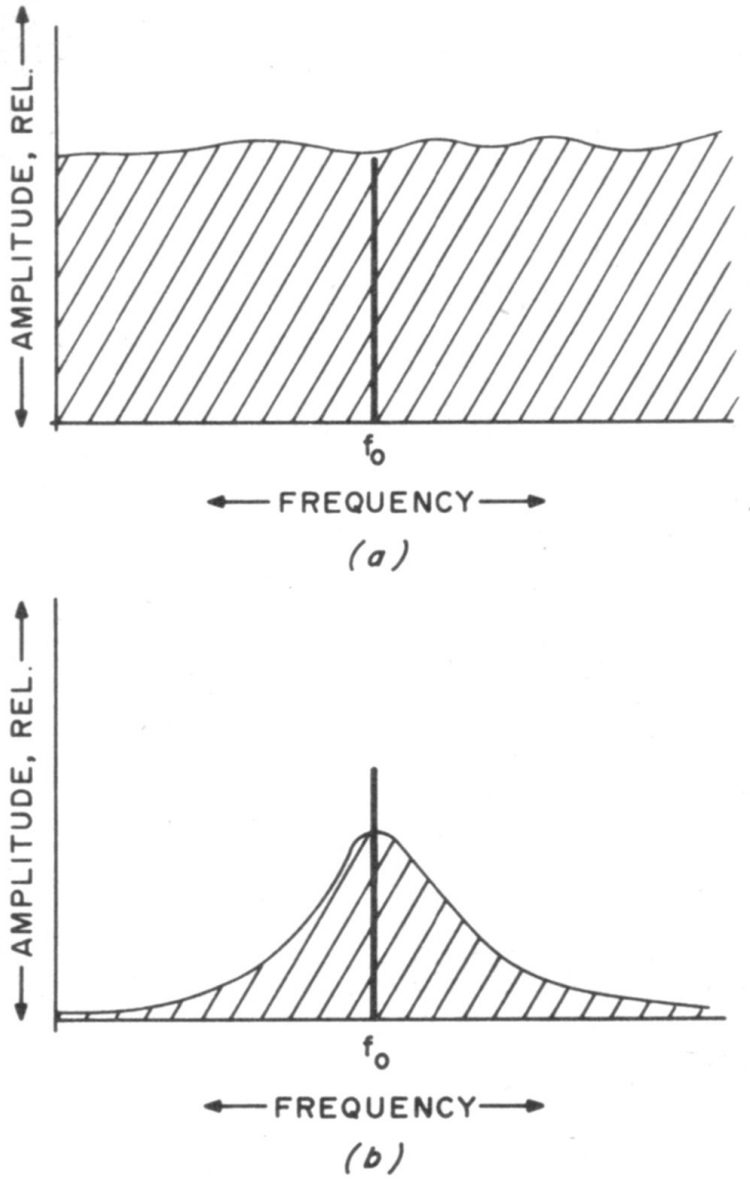


Fig. 1. F.E.T. as Q multiplier.

Effect of increasing the Q of an antenna system.

Fig. 3. Effect of increasing the Q of an antenna system. (a) The antenna system has essentially no selectivity. The signal, at frequency f_o, is buried in the noise. (b) A selective circuit is used in the antenna system. The total amount of noise (area under the curve) is smaller and this results in fewer high-order mixing products, which actually reduces the noise level at f_o. But the signal level remains unchanged, improving the signal-to-noise ratio.



Low Q Factor = Loss in coil

So what can it be used for?
What can you use a “lossy” [lousy] coil for?
Ferrite bead - suppression of high frequencies.

Loading across Capacitor = Loss

What can you use a “lossy” Capacitor for?
To stop “ringing” of supply lines by current pulses.

Feed-through capacitor filters on power supply rails.
Use Tantalum capacitors for noise suppression on digital circuit power supply rails.

Direct Conversion Receiver

[using three tuned circuits]

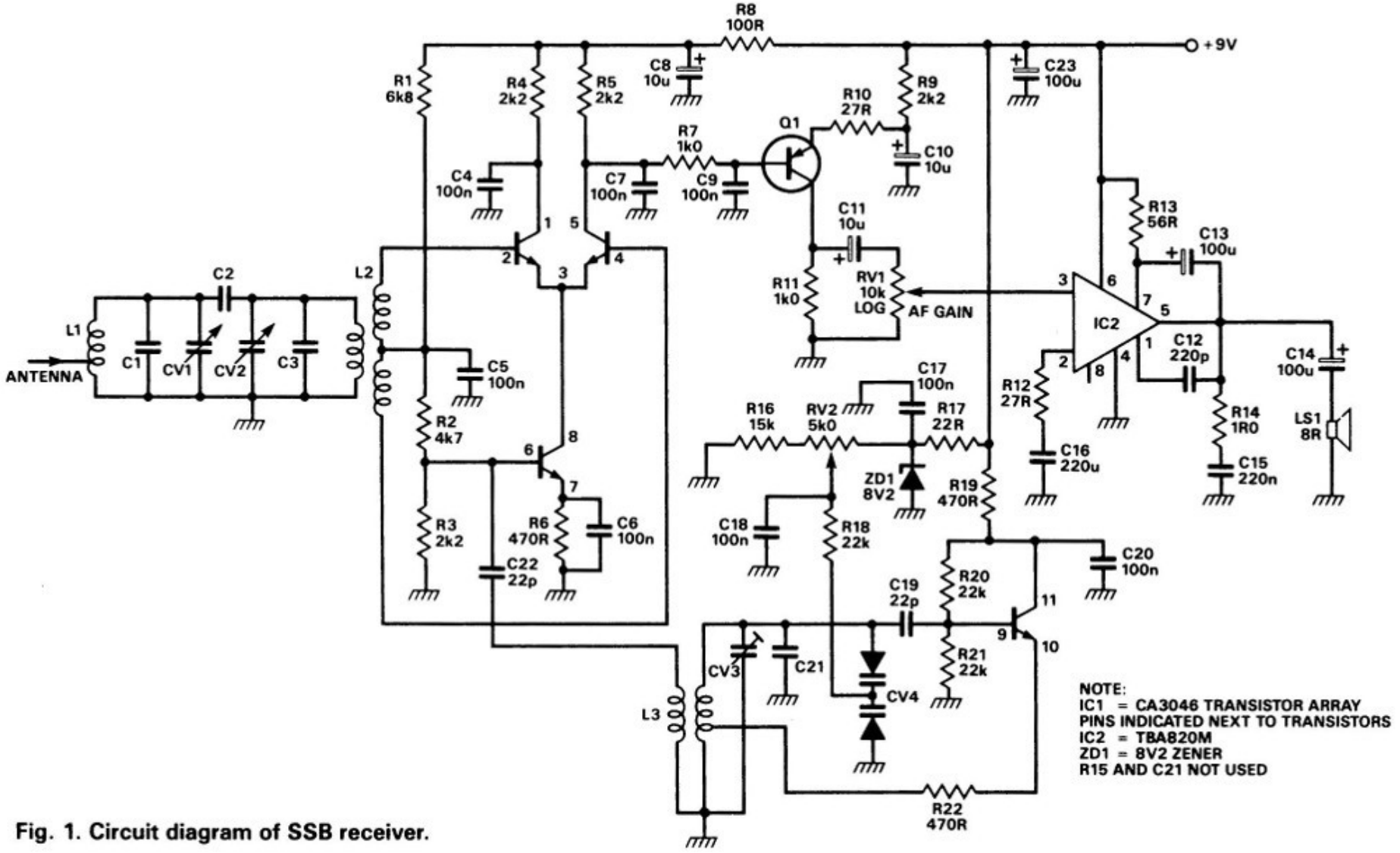


Fig. 1. Circuit diagram of SSB receiver.

ETI MARCH 1991

Summary

The series tuned circuit has a low reactance near its resonant frequency and a high reactance at other frequencies. Series tuned circuits are often used to allow signals near the resonant frequency to pass, while blocking signals at other frequencies.

[A "Band-Pass Filter]

The parallel tuned circuit has a high reactance near its resonant frequency and a low reactance at other frequencies. Parallel tuned circuits are often used to block signals near the resonant frequency, while allowing signals at other frequencies to pass.

[A Band-Stop Filter]

The resonant frequency of a series or parallel tuned circuit may be calculated as

$$f = 1 / (2 \pi \sqrt{L * C})$$

The Quality Factor ("Q") is defined as the reactance of either the inductor or the capacitor at resonance divided by the circuit resistance. A tuned circuit with a high Q is more **selective** than a tuned circuit with a low Q.

The **circulating current** in a **parallel tuned circuit** may be many times the current drawn by the tuned circuit. The ratio between the **circulating current** and the current flowing into the tuned circuit is the same as the Q.