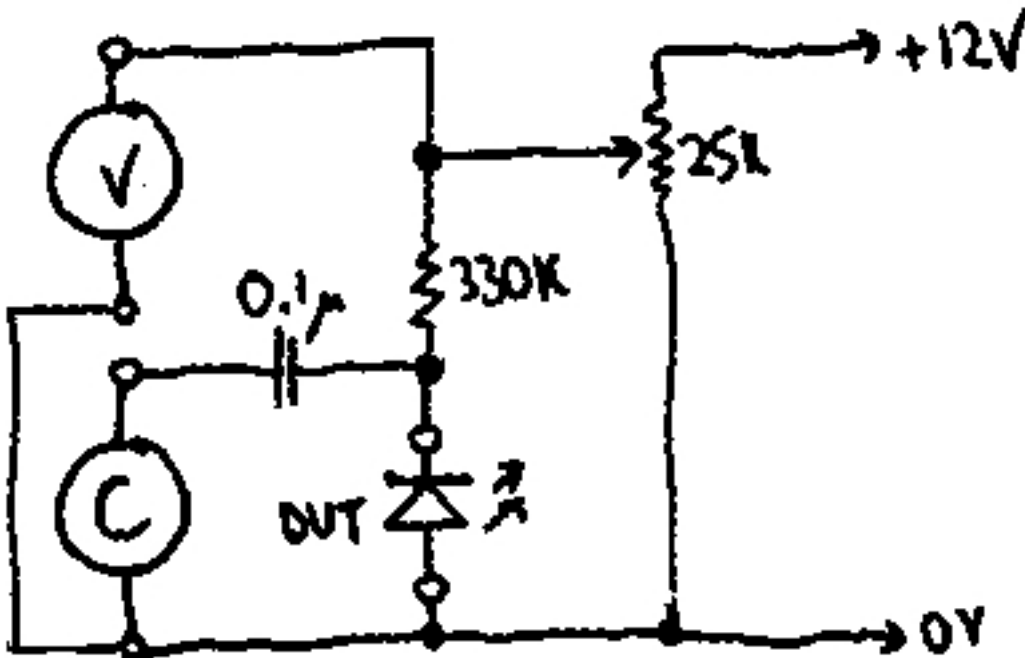


## Forward biased varicaps (varactors)

Written by Hans Summers

Tuesday, 01 September 2009 03:51 - Last Updated Wednesday, 06 July 2016 18:35

I discovered accidentally [A 100MHz 1N4148 Diode as a Varactor](#) picture & put it in the [Stable Voltage Reference](#) page.



The results show a strong increase in capacitance as forward voltage is increased. NOTE: the voltages measured are at the wiper of the potentiometer, which is NOT now the voltage across the diode junction, since current is now flowing in the diode.

If anyone has a theoretical explanation for the observed quite linear increase in variable capacitance as diode current is increased, please [send me an email](#). Likewise, does anyone know what undesirable effects might be introduced into a circuit by using a diode as varicap in this forward biased way? For example in an oscillator LC tank, would the current flow perhaps reduce the Q of the capacitor and therefore produce a more noisy oscillator? (SEE COMMENT BELOW)

The first graph (below right) shows the measurements on the two LED's [previously numbered](#) 1 and 10. These are a 5mm standard red LED, and 5mm high brightness LED respectively. This graph shows the capacitance of the LED's in both the classic reverse biased varicap configuration, and in the unusual forward biased situation. The upward sloping curves show forward bias. Note the very straight line above about 2V.

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The next graph (below left) shows the much larger forward biased capacitance of a 1N4007 rectifier diode. Note again the very straight line above about 2V.

{gallery}varicapfwd/charts{/gallery}

[CLICK HERE](#) for the spreadsheet.

**Wayne Cheng VE7HCW/VA7AT comments:** *I was reading your website on "Forwarded biased varicaps" and noticed that the measuring device (AADE L/C meter ) may have given an impression that the capacitance has increased with current flowing through the diode. my thought was that the meter is reading the ac voltage drop across the resistive conducting diode and translating the data output as capacitance.*

*The proper way to re-test is to couple the diode across an oscillator tank circuit and measure the shift in frequency. i do not own an AADE L/C meter but own an BK Precision 810A capacitance meter which uses the AC drop method of measuring capacitance.*

*My thought was also that you have measured the voltage drop across a network RC ( 0.1uF capacitance in series with a voltage sensitive resistive diode )*

**My reply...** I have quite accidentally found that forward biasing diodes does result in a genuine frequency shift. That's what started me on that measurement in the first place. Up until that time, 100% of LED's I had ever come across could have their polarity identified by holding them up to the light, and observing which of the electrodes inside was the biggest. This is then connected to the negative rail to get the LED to light normally, or the opposite way around if you want a varicap. But I did not realise that this is not a rule! It is nearly always like that, but not "always"! I came across one then which had the largest electrode the other way around. I used it in a VFO circuit, and I noticed a faint glow coming from the diode (even through a 220K resistor). It was then that I realised that the diode was connected the right way round (for normal lighting) not reverse biased. Yet, I hadn't realised that before because it was tuning the VFO just fine! So there is definitely a real effect going on there, of some sort.

**Ken Greenough G8BEQ comments:** *Hello Hans, I was just looking at your web pages [ very interesting] when I read your item on forward biased LEDs as varicaps. Two things came to*

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*mind,*

*1/ The voltage applied to the LED is very low due to the 330K series resistor therefore the turn on voltage of the diode may not be being reached, this would reduce the "insulation band" between the two layers of the diode and indeed result in a large increase in capacitance. The down side being that a small RF voltage would cause the diode to conduct.*

*2/ I wonder if the diode is actually acting as a variable resistor, diodes are used this way as attenuators, and is actually just letting you read the 0.1uF series cap' through a high series resistance. As you increase the volts the resistance of the diode goes down and lets you read "more" of the 0.1uF . A high value variable resistance in place of the LED might give the same results.*

*Just my thoughts for what they're worth*

**Adam SQ5RWQ (see <http://sq5rwq.pl/> ) provides the following explanation for why forward biasing varicaps works:**

*: It simply works because of the charge  $Q_j$  placed in P-N junction in forward mode - together with the voltage  $V_j$  at the ends of this junction. While  $C_j = dQ_j/dV_j$ , and  $Q_j$  almost proportional to  $I_{fwd}$  (which grows up with the applied by the resistor voltage), one may observe almost linear growth of  $C_j$  with growing  $V_j$ . The obvious disadvantage of such a use of diode as varactor (in forward mode) is fall of Q-factor as  $C_j$  grows up with  $I_{fwd}$ , but with  $I_{fwd}$  also falls dynamic resistance  $R_d$  of P-N junction.*