Experiment #51 -- Filter Design #2

Ed Wetherhold W3NQN caught your editor crossing his terms: "Return coefficient" is incorrect. What was meant is, of course, "reflection coefficient". Return loss is another way of measuring transmission line mismatches.

Ed also correctly points out that the conversion from low-pass to high-pass requires that *reciprocals* of the normalized values be used. That means the when the components are interchanged, L for C and vice versa, the normalized values are replaced by their reciprocals. For example, the transformed value of C1 that replaces the original L1 is not 0.7654, but rather 1/0.7654 = 1.3065. Follow the math through and you'll wind up with the 6 uH inductor replacing the original capacitor for the shunt-input design. Thank you, Ed!

In the band-pass section of the column, in Figure 3 there should have been a resonating capacitor across the 44.2 uH inductor with a value of 11.2 pF. In this design, every series or shunt connection should be a parallel or series LC-circuit.

And W3NQN also clarifies that the "alternate type of Chebyshev" (note the -shev spelling, widely used) is also known as an "elliptic" filter because of the equations used in its design. This filter type has attenuation troughs and peaks in the stopband, where the Chebyshev has ripple in the passband.

Experiment #53 -- RF Peak Detector

Clarifying how Rd of the detector diode is calculated (referring to the fifth paragraph of the section "The Envelope Detector") - The forward resistance for the diode, Rd = change in Vf / change in If. (See the third sentence of the paragraph.) To find the amount of change for voltage and current , pick two points from the data sheet at which Vf and If are known: Vf=0.52 V & If=0.1 mA and Vf=0.62 V & If=1.0 mA.

Change in Vf = 0.62 - 0.52 = 0.1 V
Change in If = 1.0 - 0.1 = 0.9 mA
Rd = 0.1 V / 0.9 mA = 111 ohms

Experiment #54 -- Precision Rectifiers

Earl N8ERO wrote to ask why some authors show the precision rectifier with a small (30 pF or so) capacitor across the diode to prevent oscillation. The oscillation occurs sometimes when the diode is cut off (in a high-impedance state) and the circuit is in a high-gain mode. It depends a lot on the layout and the particular op-amp. Similarly in the full-wave circuit, if the diodes have identical characteristics, it's possible for the circuit to have a short period during which both diodes are in a medium impedance state, upsetting the gain of the circuit until one diode starts to turn on more. It's obscure, but if one plans on manufacturing a product with the circuit, it could be important.

Experiment #55 - Current/Voltage Converters

Art KN3U sent the following notes about color codes and part marking:

"Parts with 5, 10, or 20% tolerance are usually marked with three digits. Precision parts (1% or better tolerance) are generally marked with four digits, giving them an extra significant digit. For example, a resistor from your junk box marked "4994" is "499" followed by four zeroes, or 499 0000. Rearrange the spaces and you have 4 990 000, or 4.99 megohms. There is a catch for values less than ten ohms, picofarads, etc. The system described above has no provision to encode such low values. For example, "680" is 68 with no zeroes after it, or 68 ohms, picofarads, or microhenries. What does one do if one has a 6.8 ohm resistor? One solution is simply to print the value, "6.8 ?". But it is easy to overlook the decimal point. So it has been customary to use the letter "R" as a proxy for the decimal point when the value is less than 10 ohms (less than 100 ohms in the case of a 1% resistor). The code for a 6.8 ohm 5% resistor under this scheme would be "6R8", and the code for a 6.81 ohm 1% resistor would be 6R81. If the resistor is marked using color bands, the decimal point is usually represented by a gold band."

Experiment #56 - Design Sensitivity

Louis VE2EZD noticed an error in my capacitor value explanation. The marking "103" actually means 10 x 10^3 pF, not 1 x 10^3 pF. The value is 10,000 pF = 10 nF = 0.01 µF.

Lynn NX6B reminded me of another type of value - the "available value"!
(Also known as the "junk box value".) This is the value of a component that you can actually obtain, as opposed to what you wanted. You may want a 4.3 kohm resistor, but you can't seem to find one at your favorite parts store and the junk box only has 4.7 kohm resistors - so that's what you use.

Lynn's note reminded me of several similar values:

- Intended value - this is the value you meant to use when constructing the device, as opposed to what you actually soldered in there.
- Mis-read value - this is the value you thought was printed or painted on the component, but due to miniscule print or orange that looks like red, it's really something far different.
- Assumed value - this is the value you assumed for the component, but later realize it wasn't.
- Post-Overload value - common in resistors, this is the value after the component has suffered a severe overload, but not enough to actually short or open up.

Experiment #57 - Double Stubs

The equation printed for the open stub's impedance is incorrect.
The correct equation is $X_C = Z_O \cot (L_E + 90)$ or $X_C = -Z_O / \tan (L_E)$. A complete discussion of both equations is included in experiment #58.

George W2VJN notes that "double stubs" is usually taken to mean a pair of identical stubs used as filters to give more attenuation than a single stub. He also cautions the user to be sure that the proper velocity factor is used for the actual coaxial cable used - check with the manufacturer if you are unsure.

The best way to connect the double stubs is to avoid a direct common connection as shown in Figure 3 of the experiment. He recommends that each stub be cut individually first, then a separate T-adaptor be used to connect each stub to the transmission line. (This is fully described in George's book "Managing Interstation Interference" http://www.qth.com/inrad/book.htm. Look for Figure 28 and the associated text.) Doing so prevents unwanted interactions in the stubs.

The original tutorial reference for Lissajous figures has "gone dark". A similar on-line reference can be found at http://www.visionics.ee/curriculum/Experiments/Electronic%20Measurement/LissajousPattern1.html.

In addition, in the text on making the measurements, the instruction to "center the ellipse on the horizontal axis" means "center the ellipse vertically". This could be mis-read. Here are the same instructions, reworded for clarity: "You'll see an ellipse instead of a straight line because the output signal is not an exact replica of the input. It's delayed a few microseconds by the R-C circuit and somewhat lower in amplitude. With the ellipse centered on the oscilloscope's graticle scales, measure both the outside height and where the ellipse crosses the center scale. Convert these measurements to a phase difference with [the arcsin equation]" You may be more familiar with the arctan formula that uses the ellipse's scale crossings on both axes. This method is a little easier to use, but both methods are equivalent.

Experiment #58 - Double Stubs II

Table 1 was generated with minus and plus signs reversed. A correct version of the table can be downloaded here.

Experiment #58 reminded John K4ERO of some work he did a few years ago for notching out ANY frequency, whether it is any harmonic or not. With the way to arrive at the appropriate lengths being simple, even those not familiar with the Smith Chart can cut the lines to the correct length. It works like this:

If the notch frequency is above the pass frequency, begin with a quarter-wavelength of coax at the pass frequency. Cut enough off this quarter-wavelength to make a quarter-wavelength at the notch frequency. This piece is left open, and the leftover piece is shorted. The two pieces in every case will be such as to cancel each other at the pass frequency, just at the two examples in the QST article demonstrated. If the notch frequency is less than 105% of the pass, losses may be high, since the shorted section will be very short at the pass frequency. There is no upper limit on the notch frequency.

If the notch frequency is to be lower than the pass frequency, begin with a half-wavelength of coax at the pass frequency. The coax is then cut to a quarter-wavelength at the notch frequency, and the two stubs installed, with both of them being open. This works for a notch frequency down to 1/2 of the pass frequency, and up to about 95 percent of the pass frequency before the losses get out of hand.

The stubs are then both installed directly on the feed-line.

For even lower notch frequencies, this method can be extended by using either 3/4 or 1 wavelength at the pass frequency and leaving the two pieces either open or shorted as appropriate. All these methods make some other "extra" notches, which are typically not a problem and may be useful. The smallest difference between the pass and notch frequencies depends on the quality of the coax and the allowable loss. The 5% value is chosen somewhat arbitrarily.   For receive only, loss is hardly a problem.

He has used this method to notch out broadcast QRM from very powerful nearby stations that were causing front end overload. It was used to notch 15.115 MHz transmissions out of a 20 meter band receiver with hard line coax. This method is used in commercial short-wave diplexers made entirely of transmission line, for example to put two transmitters on one broadband antenna, or to put the output of one transmitter on either of two antennas without switching. (Each antenna on a different shortwave band). In these high power applications the lines are often open lines, and the frequency separation 20% or more.

Experiment #59 - Smith Chart Fun I

The construction of the circle on the Smith Chart also illustrates why adding transmission line will not change SWR. As line is added or subtracted, the impedance point will move around the chart at a constant radius from the central point, but never get any closer (or farther away).

Feedline loss does eventually make the point spiral in towards the center, but quite slowly. The reason changing feedline length may allow a tuning unit to achieve a match is that the impedance point has been moved into a region of the chart in which the impedances are easier to match. This depends on the circuit of the tuning unit and the values of its component.

Another reason may be that there is RF current flowing on the outside of the coax, upsetting the sensing circuits in the tuning unit. In this case, changing the feedline length also changes the amplitude of the current on the outside of the line, changing conditions inside the tuning unit, as well.

Experiment #60 - Smith Chart Fun #2

Jim Summers, KD7F, notes that the labeling on many of the Smith Charts that can be downloaded from the Web have an error. The top half of all Smith Charts (everything in the "northern hemisphere" above the resistance axis) is inductive - whether reactance or susceptance. This error tripped up the HOR author, as well, who ignored the little voice in his head yelling "Capacitance in parallel moves south, not north!"

Jim writes, "In (the original article's) Figure 2, it takes shunt inductance (not capacitance) to move from point A to point E. All points above the line of zero reactance on the chart are inductive, and all points below are capacitive. These charts would seem to say that the top half of the chart represents inductive reactance or capacitive susceptance - which makes no sense. A series R and L will have an impedance which when converted to an admittance can be represented as a parallel R and L - not a parallel R and C!

"The confusion probably arose from the method used to convert impedance to admittance using a Smith chart with impedance coordinates only - reflecting the reflection coefficient vector through the origin. When you do this, an inductive reactance in the top half of the chart becomes an inductive susceptance in the bottom half of the chart - but in this case the circles don't move - they still look like the impedance chart but now represent admittance.

"This isn't what is going on when both admittance and impedance circles are on the same chart. The admittance circles are already reflected through the origin (effectively rotating the chart 180 degrees) so inductive reactance and inductive susceptance are in the same region of the chart. The points above the zero reactance/susceptance line have positive reactance and negative susceptance (which is inductive in both cases). The points below the line have negative reactance and positive susceptance (which is capacitive in both cases). A "real" Smith chart (from the Analog Instruments Company, PO Box 950, New Providence, NJ 07974) with both sets of circles states this clearly." Thanks for clearing that up, Jim!