

THEORY OF OPERATION...AR 314 VCF

The basic VCF circuit involves two feedback loops, two integrators, and two variable gain circuits. It is known as a state-variable filter. To help understand its operation, consider the block diagram. Part numbers refer to schematic diagram.

The two gain blocks are set by the exponential generator to have equal, but variable gains. So, an input signal will be fed to the first integrator, through the second gain block, and will appear out of the second integrator. The signal will be integrated twice. Thus, the overall gain at D.C. will be enormous, and would cause saturation, except for the low frequency feedback path. This causes the output to reach the same D.C. level as the input. Then, the two inputs cancel, resulting in no output from the gain block, and the system is stable.

Thus, the filter always unity gain at D.C. At very high frequencies, the gain of the integrators becomes very low (an integrator has a frequency response that falls off at 6 db. per octave, and always has a phase lag of 90 degrees).

So, very high frequencies will be attenuated by 12 db. per octave total, and shifted a total of 180 degrees.

Now, the frequency where attenuation starts depends on the gain of the gain blocks. If their gain is raised, then it takes a higher frequency to reduce the total forward gain, since the integrators must see a higher ^{FREQUENCY} to attenuate the signal by as much as the gain blocks have increased it.

There is one frequency where the forward gain equals unity. Now, since the integrators always provide a 180 degree phase shift, there will be positive feedback at the input equal to the output signal. At this frequency, the system would be unstable and oscillate, except for the "resonant frequency" feedback path. This provides negative feedback with a phase lag of 90 degrees. The total filter gain at the response frequency depends on the "Q" control setting. (Q is equal to the gain at this frequency).

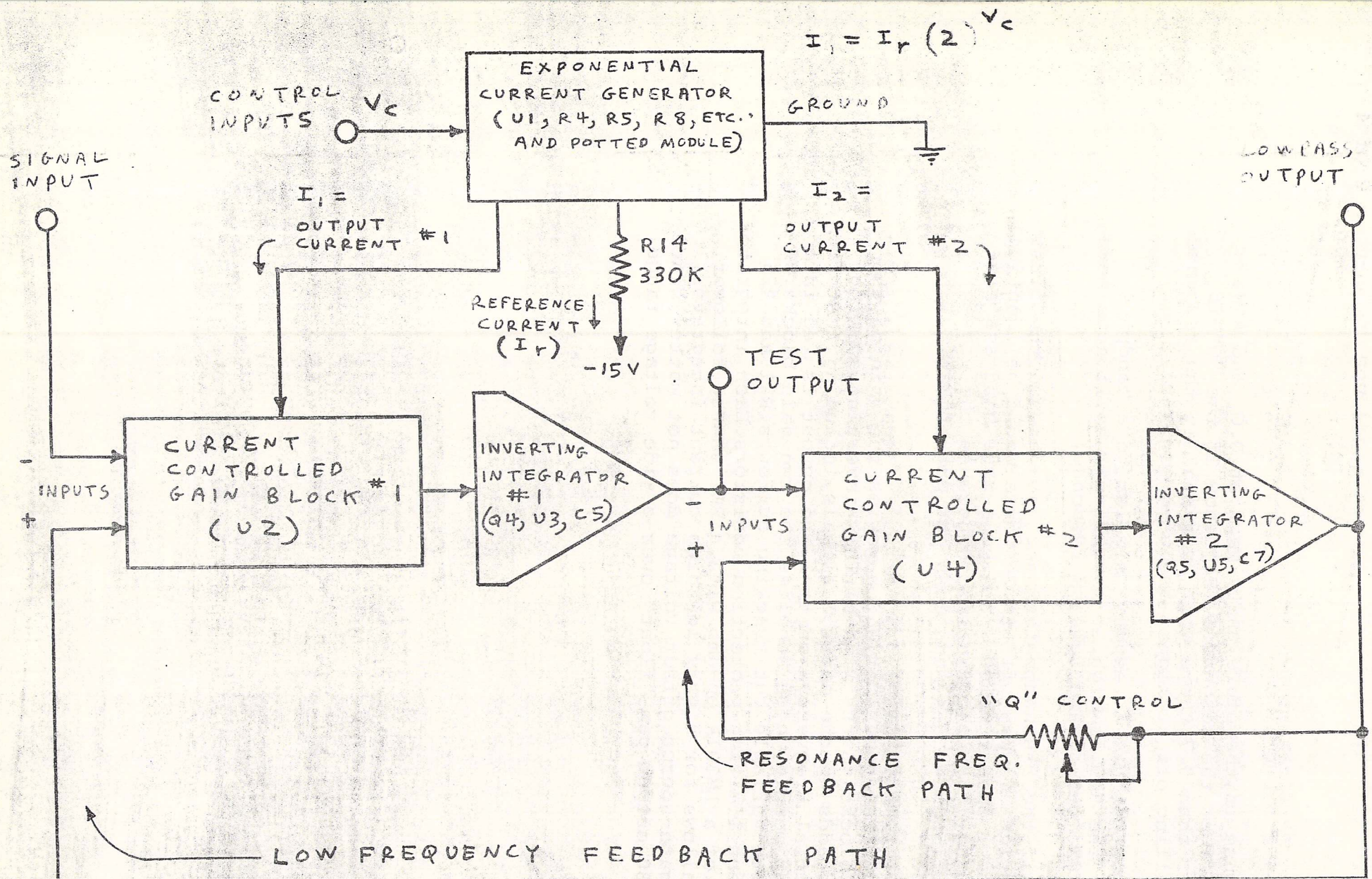
The response is, therefore, unity gain at D.C. and starts to roll off at the resonance frequency. If the "Q" is set higher than 0.7, there will be a peak in the response before falling off at higher frequencies.

The test output has a response similar to a bandpass filter if the "Q" is high. At low "Q" values, it acts more like a 6 db. per octave lowpass response.

Actually, if the resonance feedback were around the first integrator, the lowpass filter response would be identical but the test output point would be a true bandpass response. However, this was sacrificed because the present configuration provides much less output offset.

Now for some details:

The exponential generator, which varies the gain of the two gain blocks, starts with U1. This inverting, summing amplifier adds up the control signals, including that from the "Initial Frequency" control. The output is fed into the potted module, which supplies the two gain blocks, U2 and U4, with variable but tracking currents. R21 and R25 are current limiting protection resistors. Each integrator consists of a LM301A op-amp with a FET source follower. The FET allows for a very low bias current integrator, and its gate-source offset voltage does not matter, since the CA3080 output can "float" over a wide voltage range.



ARIES AR-314 VCF BLOCK DIAGRAM

Notes on the Exponential Current Generator

This is the potted module mounted on the board. It is encapsulated to insure freedom from drift due to temperature changes. Six connections are necessary:

1. Ground
 2. Control voltage summing input. Scale factor = -6 microamps per octave. When connected in series with 160k, scale factor = 1 volt per octave.
 3. Reference current terminal. Needs negative current source, for example 330K resistor to -15 v supply. Typical reference current = 40 microamps.
 4. Output Current #1.
 5. Output Current #2.
 6. Output Current #2 trim. If desired, this terminal is connected to a 10 ohm resistor to ground, and through a resistor of around 4.7K to a 10 K trimpot, which supplies -15v to +15v. This trims output #2 over the range from 1/3 to 3 times output #1.
- When trimmed for 1 volt per octave, the relationship is:

$$\text{OUTPUT CURRENT \#1} = \text{REFERENCE CURRENT} \times \left(\frac{\text{CONTROL VOLTAGE}}{1 \text{ volt}} \right)^2$$