

THEORY OF OPERATION OF AR-317

The basic waveform of the AR-317 is the triangle. The sine and pulse waveforms are derived directly from it and the sawtooth frequency is determined by it even though the sawtooth waveshape is generated separately. The triangle is generated by the loop consisting of U2, Q4, U4, Q5, and Q6. U2 is an operational transconductance amplifier whose output current is determined by the voltage at pin 2 and the current into pin 5. To begin the loop explanation, assume that the voltage at pin 2 of U2 is positive which means that current is flowing into pin 6 from the integrating capacitor, C16. The voltage on C16 is therefore decreasing at a constant rate, as are the voltages on the gate and source of the source follower, Q4. The voltage on the source of Q4 is added to the voltage at the emitters of Q5 and Q6 at pin 3 of U4. So long as this sum is positive (i.e. the voltage at the emitters is more positive than the source of Q4 is negative), the output of U4 at its pin 6 will be positive. This voltage (the balanced emitter follower consisting of Q5 and Q6) and the voltage divider consisting of R18 and R17 will hold the pin 2 of U2 positive as in the initial assumption. When the voltage on the source of Q4 becomes sufficiently negative to overcome the output of the balanced emitter follower, pin 3 of U4 will become

negative and pin 6 of U4 will quickly switch to its negative condition. This makes pin 2 of U2 negative and reverses the direction of current in pin 6. C16 is now being charged and its voltage is rising at a constant rate. Notice that when the output of U4 reversed its polarity its contribution to its own input at pin 3 became such that it latched itself into that condition until the source voltage of Q4 rises enough to again overcome it in the opposite direction. When C16 has charged enough for the voltage at the source of Q4 to overcome the output of Q5 and Q6, the voltage on pin 3 of U4 will become positive, the voltage on pin 6 will become positive, and the voltage of pin 2 of U2 will become positive as in the initially assumed condition. The amplitude at which switching of this loop occurs is determined by the addition of the two voltages at pin 3 of U4. Since R20 and R19 are identical (1% resistors) and U4 is going to switch its output condition as its input is within a few millivolts of zero voltage, the circuit will switch when the voltage at the source of Q4 is very nearly identical to the voltage at the emitters of the balanced emitter follower. This voltage is accurately determined by a pair of voltage dividers (R23 and R24 in the positive direction-R26 and R27 in the negative direction) and the clamping diodes D1 and D2. These components combined with the balanced emitter follower transistors cause the emitter voltage to swing accurately between plus 5 volts and minus 5 volts. Corresponding to this, the triangle waveshape appearing at the source of Q4 swings accurately between plus and minus 5 volts. Since the amplitude is determined by the switching levels of the oscillating loop, the frequency is directly related to the charge and discharge currents in C16, which is the output current of U2.

The magnitude of this current (pin 6 of U2) is identical to the current injected into pin 5. To accurately preserve the linear relationship of 1 volt per octave at the input to the VCO, it is necessary to convert the linear input voltage levels into an accurate exponential current which flows through R13 into U2. This conversion is accomplished by a series of carefully selected and temperature compensated components which have been potted together as part of the printed circuit board. The effect of this potted block is to create exponential currents in R13 and R31 as a function of the voltage at the junction of R8, R10, and R11. U1 is an input operational amplifier which produces the proper amplitude of linear voltage variation for the input of the exponential converter. The triangle waveshape at the source of Q4 is inverted and isolated by U3 without changing its amplitude. It is then fed to the output connection through R54. It is also fed through Q10 and Q11 to the inputs of U6. By utilizing the base-emitter characteristics of the two transistors to roll off the peaks of the triangle, a waveshape closely resembling a sine wave is produced between the collectors. This is amplified by U6 and applied through R53 to the output connection.

The triangle is also fed through R55 to pin 2 of U7. Since U7 is operating without feedback its output at pin 6 is always at saturation, either positive or negative, depending on the polarity of the voltage between pins 2 and 3. When P4 is at its midpoint and there is no output to the PWM jack, the polarity at pin 2 will be the same as the polarity of the triangle wave and pin 6 will have approximately a square wave on it. If the pulse width control, P4, is moved in the positive direction, pin 2 will be positive for more than half of the period of the triangle and the output will become asymmetrical. Carried to the extreme, the control can overcome the contribution of the triangle input and the output will be held in one condition. Diode D4 prevents the output from going negative and R59 and R60 limit the output amplitude to 10 volts. An input voltage to the PWM connector also changes the relative voltage between pins 2 and 3 of U7 which changes the pulse width as before.

The sawtooth waveshape is generated by charging C18 with the second output of the exponential converter. The voltage on C18 will rise until a positive-going change occurs at the output of Q5 and Q6 which turns on Q8 and Q7. Q8 and Q7 hold each other in conduction until the voltage across them decreases to a small value at which time they both stop conducting. C18, then, starts to charge again until the next synchronizing pulse is produced by the main oscillating loop. The constant rate-charge and fast

discharge of C18 is the desired sawtooth waveshape which is passed through the source follower Q9 to the operational amplifier U5. The output of U5 is passed through R40 to the output connection.

If the VDC is to be synchronized by an external signal, the incoming voltage is amplified by Q12 and Q13 before being applied to three separate places. The signal applied to point "A" discharges C16 to prepare for the start of a cycle. The signal applied to point "B" drives pin 3 of U4 positive which then is latched by its own feedback--again ready for the start of a cycle. The signal applied to point "C" causes Q8 and Q7 to conduct and discharge C18 for the start of another sawtooth cycle.