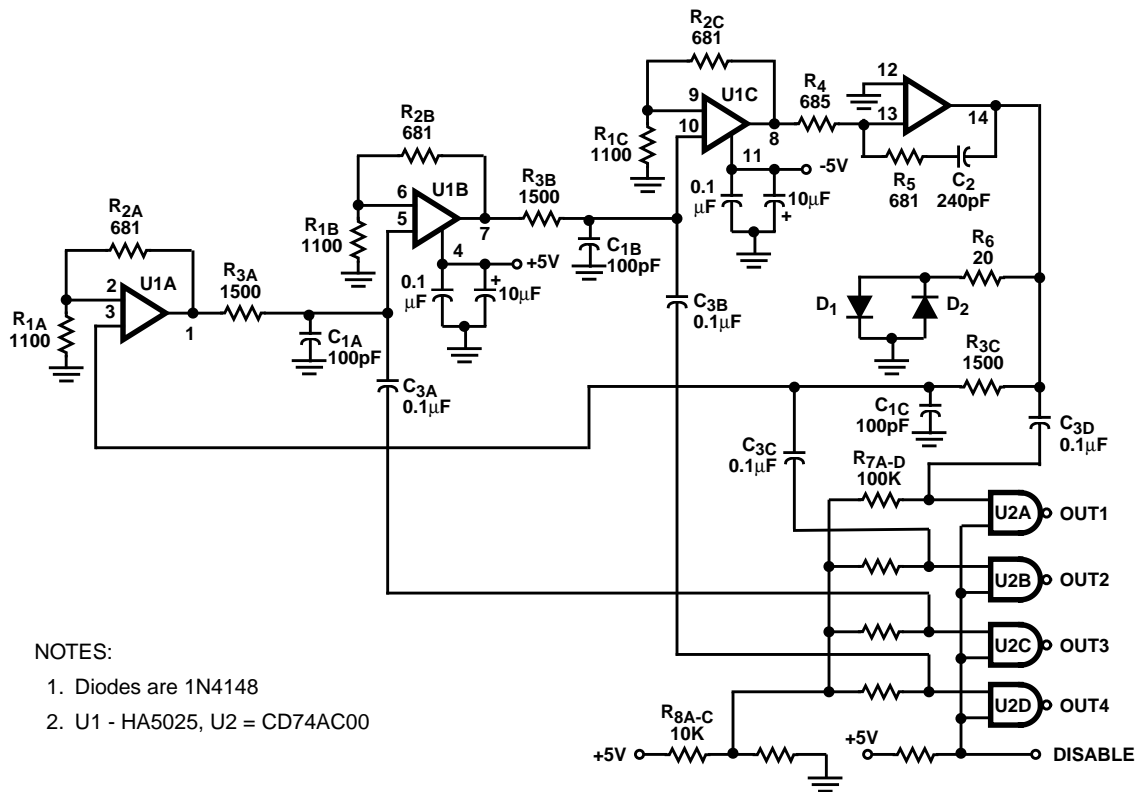


By employing a high-frequency quad current-feedback amplifier (the HA5025) as an RC oscillator, four quadrature sine waves can be generated, see Figure 1. The HA5025's four separate amplifiers generate the sine waves, while the quad NAND gate, U2, is biased at its threshold, so it acts as a sine-wave to square-wave converter when the sine waves are AC-coupled into its input.

The criterion for oscillation is that the open-loop gain be  $\geq 1$  when the feedback phase shift is zero. In this design, there are three noninverting phase-shifting stages and one inverting phase-shift stage (U1D); thus the phase shift of each stage must equal 45 degrees lag. This phase shift plus the 180 degrees introduced by the phase inversion of U1D equals 360 degrees or 0 degrees, resulting in in-phase feedback at the oscillation frequency.

Because the HA5025 features such high open-loop gain-bandwidth characteristics, amplifier phase shift is negligible in the low MHz range. Thus, each stage's phase shift is solely determined by the passive components. At  $\phi = 45$  degrees,  $R_3C_1 = R_5C_2 = 1/(2\pi f)$ ; the component values shown for  $f = 1\text{MHz}$ . The rate of change of phase shift with respect to frequency ( $d\phi/df$ ) is maximum at  $\phi = 45$  degrees for this type RC circuit. Therefore, the stability is highest for the four-RC configuration. The combination of good phase sensitivity with no active amplifier phase shift yields a stable RC oscillator whose temperature performance depends only on passive components.



**FIGURE 1. FOUR QUADRATURE SINE WAVES CAN BE GENERATED WITH THIS OSCILLATOR DESIGN, WHICH USES THE HA5025 HIGH-FREQUENCY QUAD CURRENT-FEEDBACK AMPLIFIER. THE FOUR SEPARATE AMPLIFIERS PRODUCE THE FOUR SINE WAVES**

Most RC oscillators described in the literature employ a lead circuit as the phase-shifting element. While that practice is fine for voltage-feedback amplifiers, it results in multiple frequency oscillations in current-feedback amplifiers because of their ideal gain flatness performance. The voltage-feedback amplifier's gain rapidly falls off at higher frequencies, preventing oscillation beyond the design frequency. This also is an indicator of the deleterious phase performance associated with the voltage-feedback amplifier.

Because the voltage gain of each RC network is 0.707, the noninverting amplifiers are arbitrarily set at gain of 1.6; the inverting stage over all gain also is slightly above one at 1MHz. By distributing the gain over four amplifiers, the resultant open-loop gain can be well controlled. As a result, with the aid of  $R_6$ ,  $D_1$ , and  $D_2$ , the amplitude limiting can be limited to minimize sine-wave distortion. Rather good sine-wave outputs are available across  $C_{1A}$ ,  $C_{1B}$ ,  $C_{1C}$ , and the output of U1D. This RC concept can be extended to well above 20MHz using the HA5025 with just a slight frequency drift. The quadrature sine waves are AC-coupled to a quad CMOS gate biased at its threshold by  $R_7$  and  $R_8$  to obtain quadrature square waves. If these square waves aren't exactly 45 degrees phase-shifted from each other, adjust the bias circuit or add independent bias networks.

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