GENERAL RADIO COMPANY

engineering department

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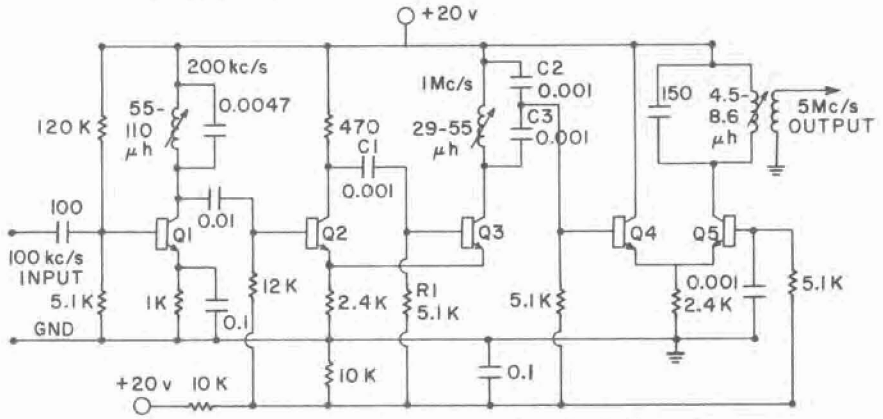
UNIQUE FREQUENCY MULTIPLIER

H. T. McALEER



ALL TRANSISTORS 2N 2714 — ALL RESISTORS ±5%, 1/4 WATT

Fig 1—Frequency multiplier.

Due to the increased availabilty of 5 Mc/s frequency standard oscillators during the past few years, many accessory instruments have been designed to operate from 5 Mc/s inputs. However, the 5-Mc/s reference is still often inconvenient to obtain, and, 100 kc/s remains as the most commonly distributed standard-frequency signal. What follows is a description of a simple transistor circuit that converts a 100-kc/s standard frequency to 5 Mc/s. The circuit was designed to operate a 10- to 500-Mc/s frequency converter that required a 5 Mc/s reference-frequency input, and was used in conjunction with a frequency counter that provided a 100-kc/s reference output.

Referring to Fig. 1, 100-kc/s input signals are doubled to 200 kc/s in the first stage (Q1) which functions as a Class-C multiplier. Input signals overdrive the transistor so that collector current flows in brief pulses. Collector voltage at 200 kc/s is in turn accentuated by the collector tank circuit and applied to the second stage. The base-return resistor and emitter resistor provide self bias and limiting action for the circuit so that it will operate over a wide range of input voltage—0.5 to 25 volts for the circuit shown.

The second stage, consisting of transistors Q2 and Q3, is a unique frequency quintupler which multiplies the 200 kc/s output of the first stage to 1 Mc/s. If a Class-C multiplier similar to the first stage had been used, the 1-Mc/s tank circuit would have had to filter a 1-Mc/s harmonic signal from a harmonic series containing strong adjacent fourth and sixth harmonics. A square-wave drive signal avoids this problem since a square wave contains no even harmonics. A few years ago I advocated the use of a Schmitt circuit for this purpose, but was constantly plagued by drift in the triggering point of the Schmitt circuit. Such drift causes a dissymmetry in the resultant square wave and negates the even-harmonic cancellation. The circuit of the second stage evolved from the Schmitt circuit.

To maintain the triggering point of the circuit at the zero crossings of the input signal and preserve the square wave symmetry, the base resistor of Q3 is returned to the same bias voltage as the base resistor of Q2, and the collector of Q2 is ac-coupled to the base of Q3 through capacitor C1. The circuit then becomes, in fact, an emitter-coupled free-running multivibrator. Free-running oscillations cause no difficulty if the C1-R1 time constant is large enough to keep the free-running frequency below 200 kc/s. The 200-kc/s drive signal synchronizes the oscillations and produces a 200-kc/s square wave of collector current in Q3. This current is filtered in the 1-Mc/s tank circuit. Tank-circuit voltage is stepped down by the C2-C3 divider to provide a better match to the input of Q4.

Q4 and Q5—representing the third stage—operates like the second stage to multiply a 1-Mc/s input to 5 Mc/s. In this circuit, however, there is no cross-coupling feedback. The second-stage multivibrator circuit produces a square wave with a rise time (and harmonic content) limited by the loading of Q3's base on the collector of Q2. Because of the fast-rise 1-Mc/s signal at the base of Q4 produced by the high-level output of the 1-Mc/s tank circuit, I found that I could obtain a higher 5-Mc/s output level by ac-grounding the base of Q5 and operating the circuit as a squaring amplifier rather than as a multivibrator. The square-wave current in Q5 is filtered by the 5-Mc/s tank circuit and stepped down to a 50-ohm impedance level by the coil secondary winding to provide the 5-Mc/s output signal shown in Fig 2. A decrement occurs in the output waveform because of the low loaded-Q of the 5-Mc/s tank circuit. If the application requires a cleaner waveform, a double-tuned filter can be used, either with or without a buffer amplifier stage. ■

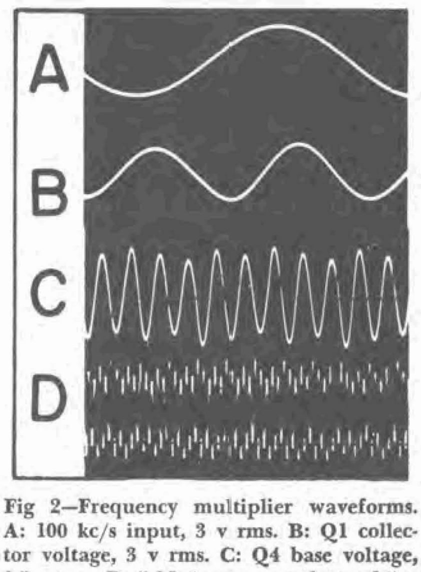


Fig 2—Frequency multiplier waveforms. A: 100 kc/s input, 3 v rms. B: Q1 collector voltage, 3 v rms. C: Q4 base voltage, 1.5 v rms. D: 5 Mc/s output voltage, 1.5 v rms. In all cases sweep speed is 2 μsec/cm.

Reprinted from the May/June 1964 issue of FREQUENCY

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