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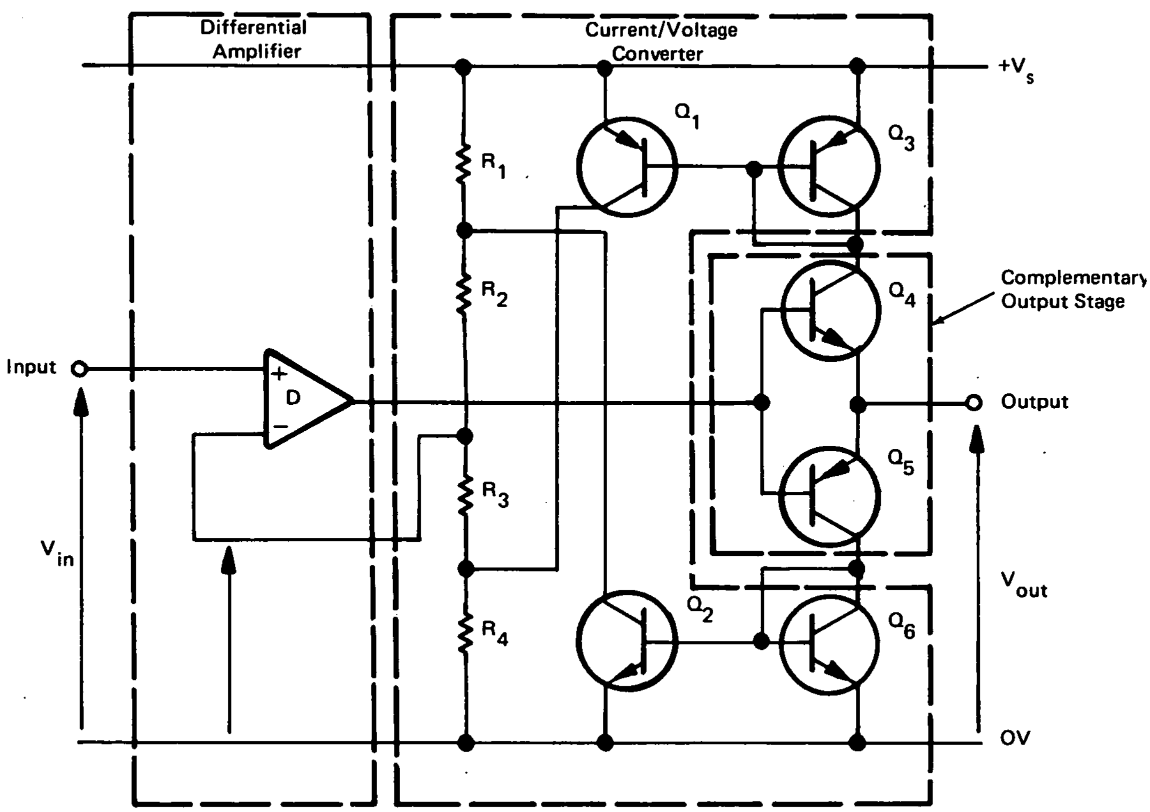
Integrable Power Gyrator



Simplified Circuit Diagram Of The Noninverting VCCS

The problem:

Gyrators have been in existence for some time now. Synthesis of gyrators by different methods such as a voltage-controlled current-source (VCCS) approach, decomposition of the Z-matrix, approaches using operational amplifiers, etc., has produced gyrators having very low efficiency on the order of 1%. The result has been that these gyrators cannot handle signals above several milliwatts without excessive dissipation of dc power.

The solution:

A further study of the Y-matrix (VCCS approach) and the Z-matrix configuration has led to development of efficient, dependable high-quality gyrators.

How it's done:

The basic configuration used for the Y-matrix gyrator comprises two essentially similar VCCS's in a loop with one producing a 180° phase reversal and the other producing zero phase change. This circuit is reciprocal, and the input signal may drive either the amplifier with phase reversal or the one without.

(continued overleaf)

The basic circuit of the noninverting VCCS is shown in the figure. It consists of the differential amplifier, the complementary output stage, and the current/voltage converter connected in a feedback loop. The current/voltage converter performs the same function as the ordinary gyration resistor in conventional gyrators: it produces a voltage that is proportional to the output current. This voltage is fed back to the differential amplifier. This type of feedback is called current proportional voltage feedback which stabilizes the VCCS transconductance and, at the same time, enhances the output resistance of the output stage and the input resistance of the differential amplifier. The configuration provides stable transconductance and high input and output resistances which are all necessary for a high quality Y-matrix gyrator.

In general, high efficiency of the circuit is provided by the following:

1. Class B output stage
2. Small current flow through gyration resistors R_1 and R_4 as compared with the output current
3. Current flow through the differential amplifier and of the transistors Q_1 and Q_2 is small compared to the output current.

Performance of this current with a 10-V supply voltage may be summarized as follows:

1. Voltage amplification factor = 600
2. Transconductance = 1.8 millisiemens
3. Output resistance = 300 kilohms
4. Input resistance $\gg$ output resistance
5. Efficiency = 38%.

The inverting VCCS is essentially similar to the noninverting one. However, to invert the phase, the inputs of the differential amplifier have to be interchanged. Since the feedback has to stay negative, further phase reversal in the feedback path is necessary. This is accomplished by insertion of another differential amplifier connected as an inverter (amplification factor = −1). Because the efficiency of the inverting VCCS is also 38%, efficiency of the complete circuit is 19% – a significant improvement over the previous 1%.

The Z-matrix gyrator incorporates the same basic building blocks of the Y-matrix type but combines them in a different way. As in the case of the Y-gyrator, the output of each differential amplifier is connected to a complementary output stage which in turn is connected to a current/voltage converter. The current/voltage converter produces a voltage that is proportional to the current flowing into the corresponding port (input or output) of the gyrator (see figure). This voltage, however, is not fed back to the differential amplifier, but drives either directly or by insertion of an inverter (voltage gain = −1). to the noninverting input of the other differential amplifier. In order to ensure a low output resistance and a high input resistance, the output voltage at each port of the gyrator is fed back to the inverting input of the corresponding differential amplifier.

Results from either approach have been favorable. With further improvements in design details, efficiency of the new gyrators may now approach the theoretical limit of 78.5%. This will allow handling of signals of considerable power with moderate dc power dissipation. Improvements in quality factor Q have reached 300 for Y-matrix and 1300 for Z-matrix gyrators. Finally, both designs are comparatively easy to integrate by implementing the same technology as used with conventional operational amplifiers.

Note:

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