NASA TECH BRIEF

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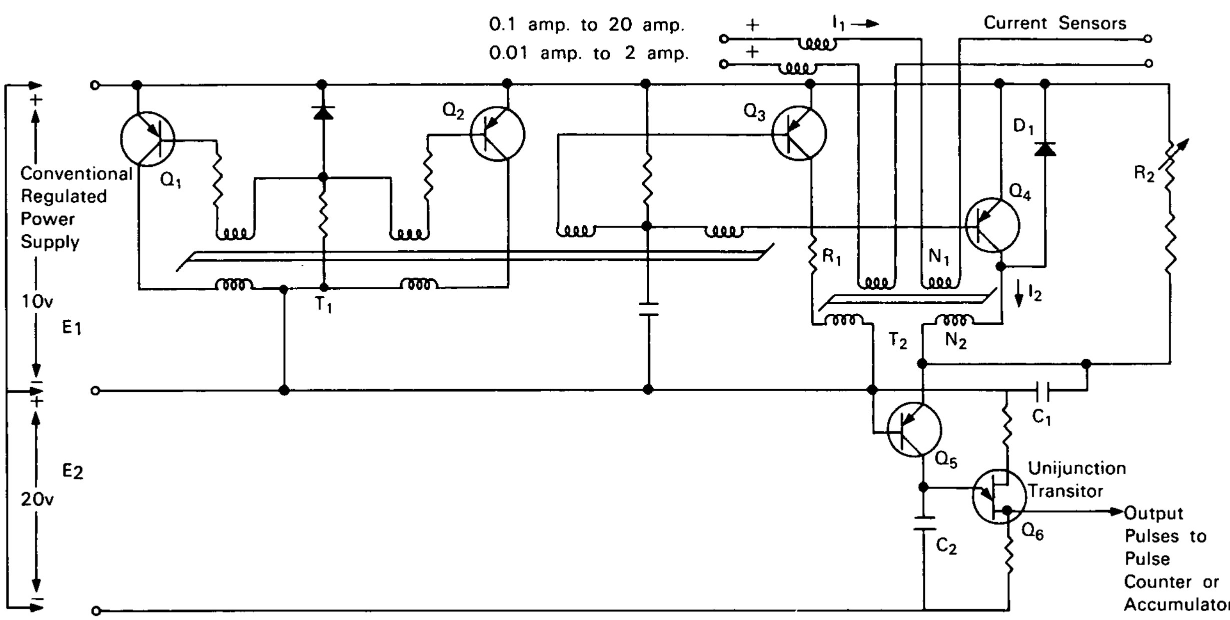
Electronic Ampere-Hour Integrator is Accurate to One Percent



The problem: Normally, ampere-hour integrators are mechanical devices, such as a ball and disc, which operate on information from a recorder. They have the inherent disadvantages of large physical size, dependence on the accuracy of the recorder, and mechanical wear which results in drift requiring frequent calibration.

The solution: A solid state, dual-range electronic ampere-hour integrator based on current-to-frequency conversion. The integrator operates on low power, and is accurate to within 1 percent from a 10 milliampere rate to a 20 ampere rate.

How it's done: The circuit shown is based on the reflected impedance of transformer T_2. A square wave oscillator circuit, using transistors Q_1 and Q_2, alternately drives transistors Q_3 and Q_4. Each time transistor Q_3 is turned "on", saturable transformer T_2 is reset to its negative saturation state. When transistor Q_4 is turned "on", the reflected current from the sensing circuit causes a proportional current to flow through transistor Q_5 to charge pulse rate capacitor C_2. The reflected current I_2 is directly proportional to the input current I_1 and is given by $I_2 = I_1 (N_1/N_2)$ where:

I_1 = current to be sensed
I_2 = reflected current
N_2 = primary turns of T_2
N_1 = secondary turns of T_2

When C_2 has accumulated sufficient charge to cause

(continued overleaf)

unijunction transistor Q_6 to conduct, an output pulse is applied to the accumulator and, simultaneously, C_2 is discharged. Thus the circuit converts the current rate to pulse rate. The accumulator indicates the total ampere-hours and consists of a simple counter. The magnetizing current required by T_2 during conduction of Q_4 causes an undesirable error at low current levels; however, its effects can be minimized by utilizing the stored energy of the square-loop core. Energy is stored during conduction of Q_3 and its level is determined by R_1. When the driving source to Q_3 is removed the energy is transferred to the capacitor C_1 via diode D_1 and the power source E_1. Thus capacitor C_1 is capable of supplying the required magnetizing current during conduction of Q_4. Resistor R_2 is adjusted to drain off the excess stored charge on C_1.

Notes:

1. This device can be used to measure the ampere-hour capacity of batteries.
2. By adding series resistors to the current-sensing coil the output pulse rate will be directly proportional to the voltage being sensed, thus making the circuit a voltage-to-frequency converter.
3. Addition of an accumulator to the voltage-to-frequency converter makes the circuit a volt-time integrator.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B65-10308

Patent status: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

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(GSFC-203)