Op amp converts DVM to fluxmeter

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The flux and flux density in a magnet usually are measured with a search coil and either a ballistic galvanometer or a galvanometer especially designed for use as a fluxmeter. Such fluxmeters are delicate, require special provisions for mounting and leveling, and must be calibrated from a mutual-inductance standard or a standard magnet.

A direct-reading fluxmeter that does not use a galvanometer and does not require calibration can be made with two operational amplifiers and a digital voltmeter, as shown in the circuit diagram. When the search coil moves through the magnetic field, a voltage is induced across its terminals. This voltage is amplified in the first op amp, and integrated in the second op amp. The integrated output voltage is displayed on the digital voltmeter; the gain of the amplifier stage is adjusted so that the reading of the voltmeter directly represents the flux density in the magnetic field.

The voltage induced in an N-turn search coil cutting flux lines ϕ is given by Faraday's law:

$$e = N(d\phi/dt) \times 10^{-8} \text{ volts}$$

Therefore the number of flux lines cut in T seconds is

$$\phi = (10^8/N)\int_0^T e\,dt \text{ lines}$$

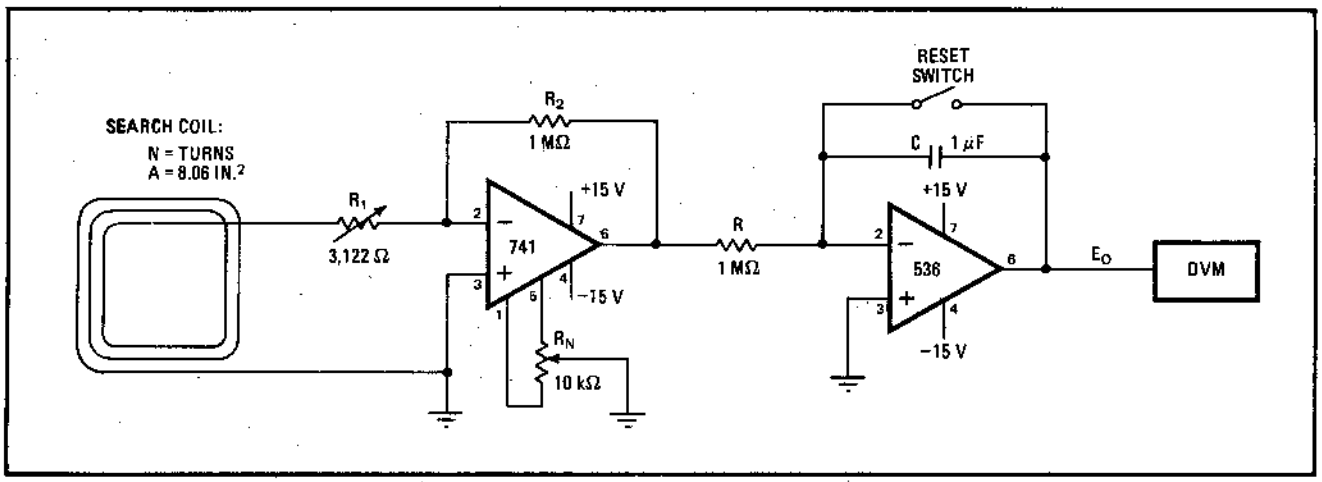
If the area of the loop is A square inches, the flux density B is ϕ/A lines per square inch. Flux density is commonly expressed in units of gauss (1 gauss = 6.44 lines/in.^{2}), so

$$B = (1.55 \times 10^7/NA)\int_0^T e\,dt \text{ gauss}$$

In the fluxmeter circuit, which has a voltage gain of (R_2/R_1) in the amplifier stage, the output from the integrator is

$$E_O = (R_2/R_1)(1/RC)\int_0^T e\,dt \text{ volts}$$

Therefore, the flux density is given by



Fluxmeter. When search coil is flipped out of magnetic field, induced voltage pulse is amplified and integrated to produce output voltage that is displayed on digital voltmeter. Component values in circuit are chosen so that magnetic flux density in gauss is 100 times the DVM reading. This simple fluxmeter is more rugged than the galvanometers often used for magnetic field measurements, and it does not require calibration.

$$B = (1.55 \times 10^7/NA)(R_1RCE_O/R_2) \text{ gauss}$$

The value of R_1 is set at 3122 ohms to make the DVM read directly; therefore, for the circuit as shown,

$$B = 100\,E_O \text{ gauss}$$

In the measuring circuit, the offset-null potentiometer R_N is adjusted to give a zero drift reading on the DVM. The search coil is then placed with its plane perpendicular to the flux in the magnetic field that is to be measured, and the reset switch is closed momentarily to ensure zero initial charge on capacitor C. Then the search coil is either rotated 90° or removed to a flux-free region. The resulting voltage pulse is amplified and integrated by the circuit to produce output voltage E_O that is displayed on the digital voltmeter. If the flux density is 1,000 gauss, the DVM reads 10 volts.

An unselected 741 op amp was used in this circuit, but if lower fields are to be measured and greater sensitivity is required, a low-drift op amp should be used. □