A SIMPLE PASSIVE SYSTEM FOR TELEMETRY OF PHYSIOLOGICAL DATA

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Abstract

The system described uses a passive implant circuit powered from a low power 1 mHz external transmitter. Data are returned by frequency changes in an audio tone. The use of audio frequencies precludes frequency shift problems in the presence of conductive body fluids. It was designed particularly for intracranial pressure monitoring, but has other uses.

The circuit used for implanting is of very simple design and depends on changes in resistance. It may therefore respond to pressure, temperature, light, humidity, or any physical action which can be converted to a resistance change. It does not contain tuned circuits, and is accurate in the presence of wide changes in input power.

The external circuits also are very elementary — a one-transistor transmitter, a low pass filter system, and a high-gain audio amplifier. Readout may be either a frequency counter or a simple demodulator/meter circuit. Total equipment cost is low, and the transducer may be made very small. However, when the transmitting and receiving antennae aresmall, the range is limited to about 2 cm. This is adequate for intracranial pressures.

A need was expressed for a device for long-term monitoring of intracranial pressure in patients with hydrocephalic tendencies. Properties demanded of such equipment are inertness, impermeability, small size, and absence of batteries. The first two requirements in this case have been met by utilizing a ceramic case described at the 2nd Conference[1]. Small size is readily achievable by keeping the circuit simple. Power can be supplied from an external oscillator by radio frequency induction.

Two particular problems were encountered in developing a circuit to use broadcast power. The most important is the very wide range of voltages that are induced in a remote circuit when the spacing is variable. Since the spacing cannot be predetermined, and may not remain constant after implantation, a very large difference in voltage between the calibration value and the in vivo value may occur. With any circuits we have tried, this resulted in unacceptably large frequency variations, independent of those caused by the variable under study. Attempts at regulation of the voltage by additional implant circuitry were not helpful, because the voltage and current were too small to bring regulators into their working range.

The other problem, encountered whenever radio frequency circuits are used in vivo, was frequency shift caused by the conductive medium (body fluids). This shift was cited by Douglas[2] and caused him to develop a circuit operating at audio frequencies, which was not affected by the conductive medium. The N.R.C. circuit, for the same reason, also works at audio frequencies. The penalty for the increased accuracy so achieved is a substantial reduction in range. Power is supplied to the implant at radio frequency, for increased efficiency and ease of separation from the return signal. Frequency shift is of no importance here because the pickup circuit in the implant is not tuned.

The solution to the problem of voltage fluctuations caused by distance variations was found in a unijunction transistor circuit which stops oscillating if the voltage is too high or too low. The frequency just before cutting out as voltage is raised is precisely reproducible. In use, the output of the power oscillator is increased until the returned signal reaches its highest frequency (and the meter its highest reading) just before stopping. Although it is thus necessary to make an adjustment before taking a reading, this is the only control on the instrument, and the accuracy of the readings plus the simplicity of the circuits are considered adequate compensation for making a simple setting.

The implant circuit is a basic relaxation oscillator working at audio frequencies (2000–3000 Hz). The frequency is varied by changing the value of a resistance in the timing circuit. Thus, any variable which can be detected by resistance change can be transduced. Pressure is measured by using a semiconductor strain gauge on a diaphragm. Other possibilities are temperature (using a thermistor), light (with a light-dependent resistor), and humidity (a lithium chloride unit).

Apart from the implant circuit, the system includes a 1 mHz transmitter (consuming about 0.9 watts of DC power), a pickup coil wound concentrically with the transmitter coil, a passive low pass filter to remove the radio frequency from the audio signal, a high gain (10,000) audio amplifier, an output filter to remove noise, and finally a readout. This can be a frequency counter, if available, or a simple demodulator/meter circuit calibrated in the units which are being measured (pressure, temperature, etc.). There is, of course, a power supply, in this case with a fixed output for the amplifier and a variable output for the oscillator.

Acknowledgment

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References

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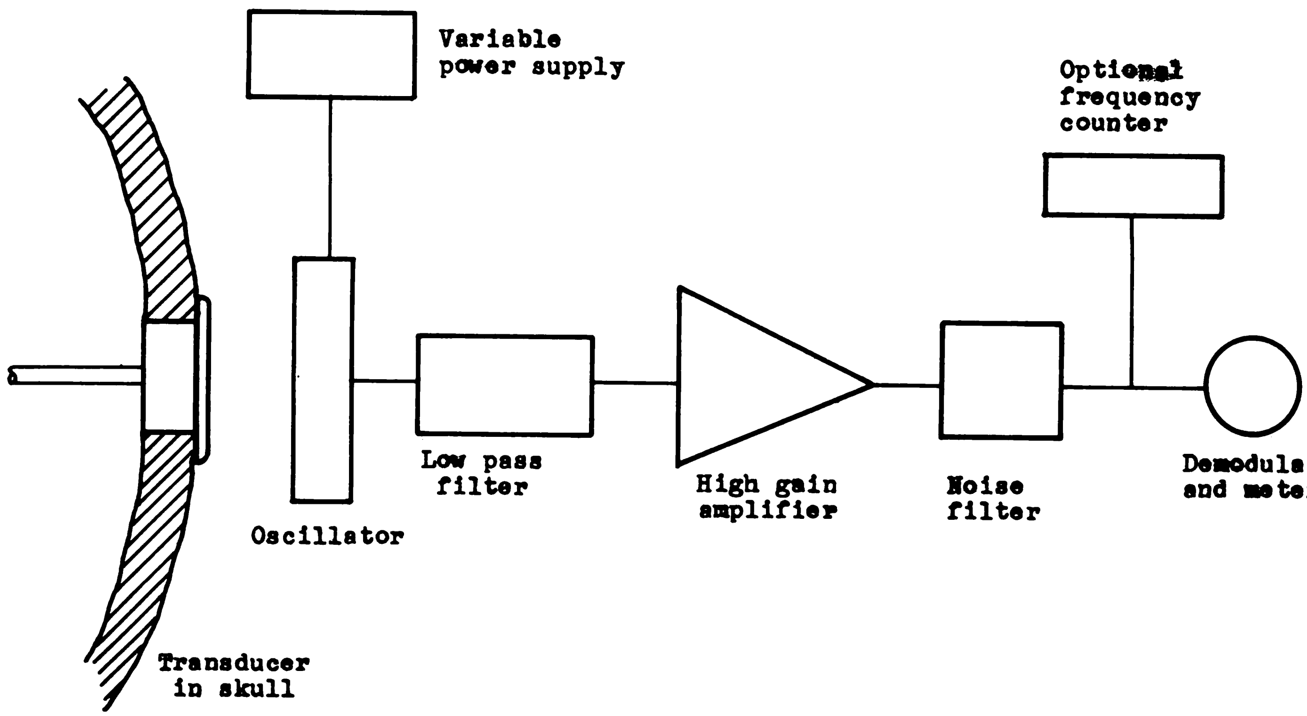

BLOCK DIAGRAM OF THE SYSTEM AS USED FOR INTRACRANIAL PRESSURE MEASUREMENT