HIROSHIMA INSTITUTE OF TECHNOLOGY

AN IMPLANTABLE BATTERYLESS TELEMETRY SYSTEM FOR CARDIAC SYMPATHETIC NERVE ACTIVITY AND ECG MEASUREMENT

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INTRODUCTION

A miniature implantable batteryless telemetry system has been developed for cardiovascular neural control research in conscious animal preparations. Most implantable telemetry systems are powered by a rechargeable nickel cadmium battery to eliminate the power limitations of primary batteries such as lithium or silver oxide cells. However, the rechargeable battery requires charging for a few hours at least. The described implantable system has been designed with a high value, light weight and small size capacitor instead of the rechargeable battery with heavy and large. The capacitor can be rapidly charged and can drive the system for long time.

CIRCUIT DESCRIPTION

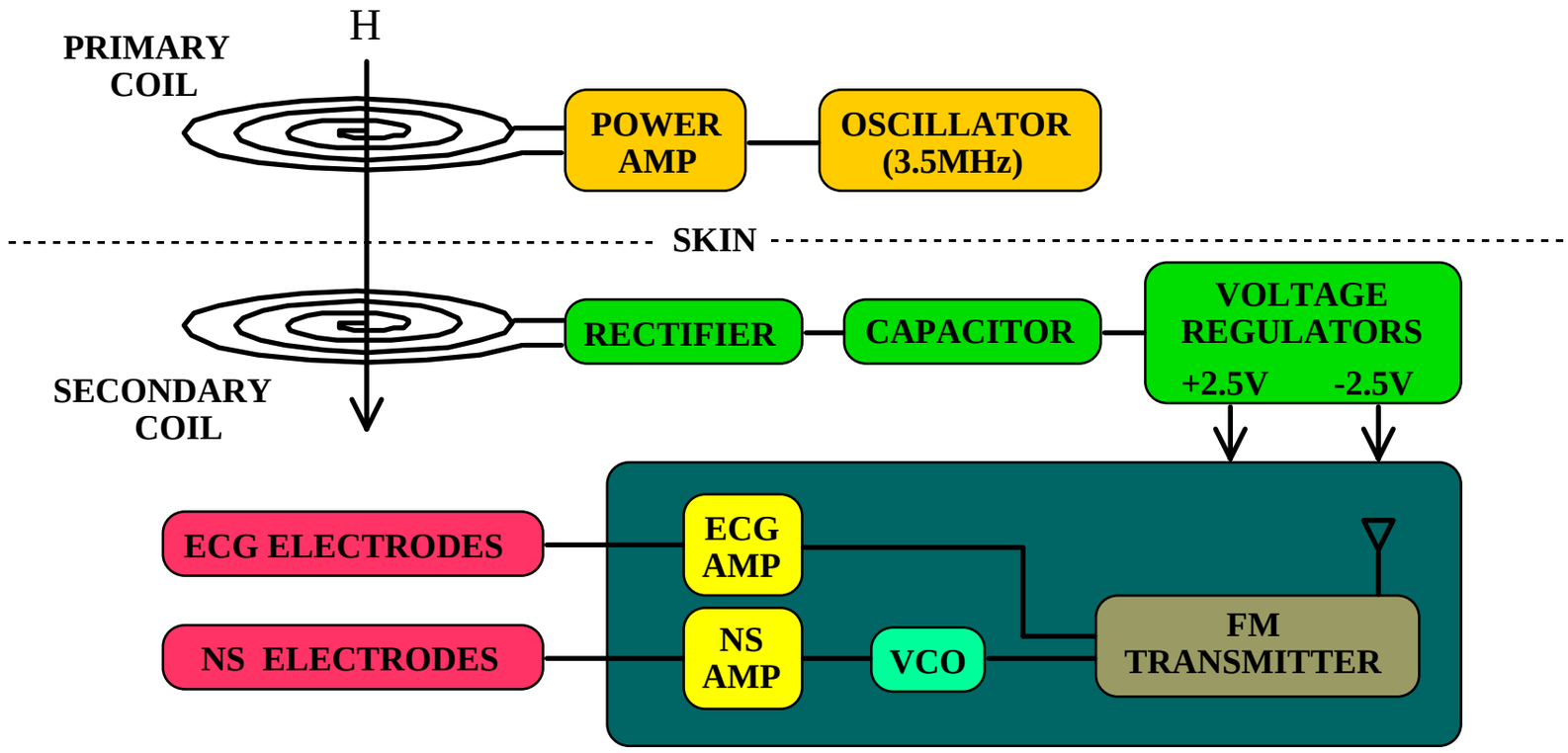

Figure 1. Telemeter block diagram.

The power for the system is inductively coupled and transmitted to a capacitor. The voltage regulators supplies plus and minus powers to the transmitter. A voltage-controlled oscillator(VCO) converts the amplified neural signal(NS) to a proportional subcarrier frequency. The VCO output and amplified ECG signal are then combined and used to frequency modulate a FM transmitter.

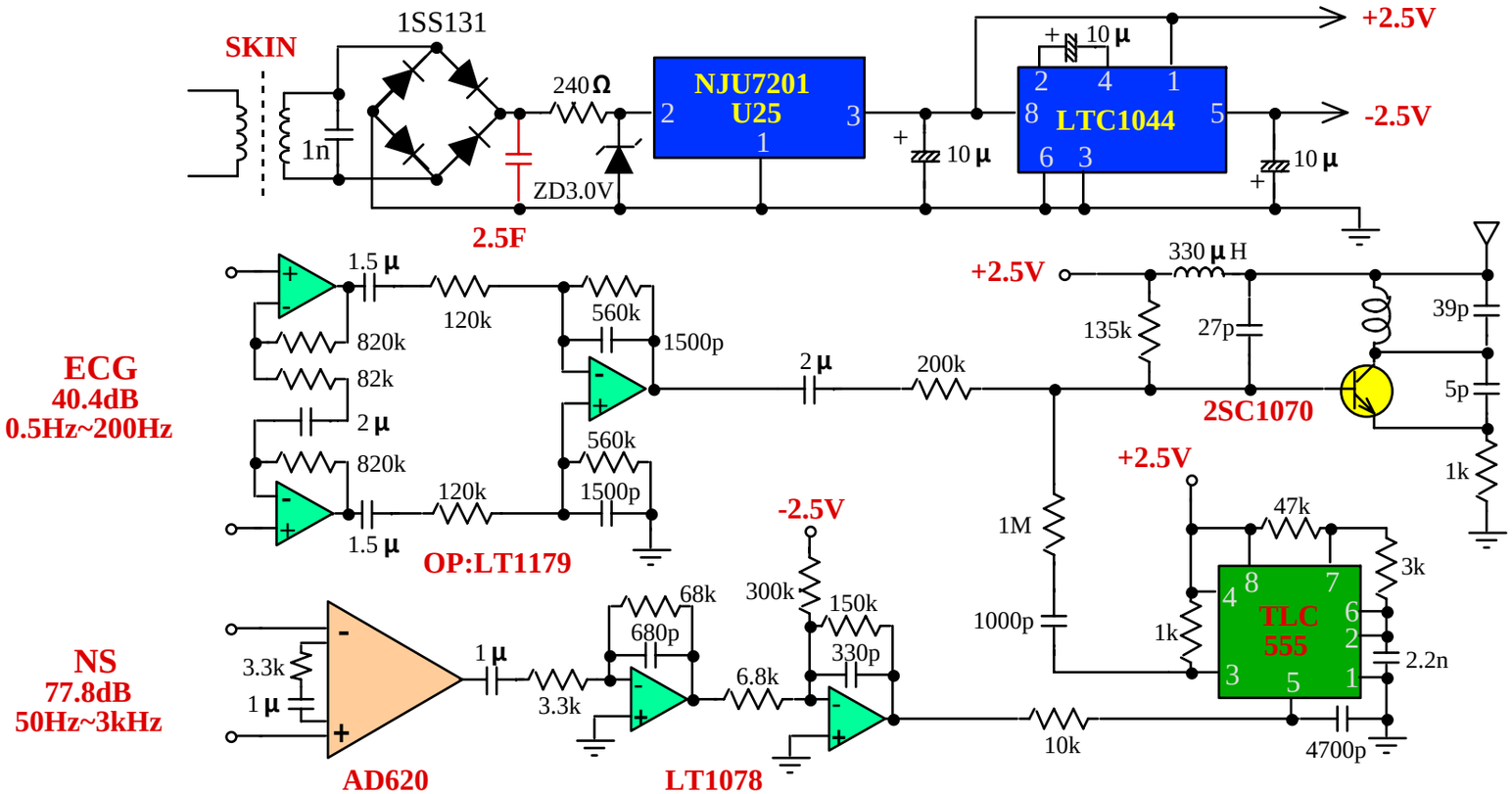

Figure 2. Implantable batteryless telemeter schematic.

The capacitor is recharged through the intact skin by induction at 3.5 MHz to an implantable spiral pickup coil. A NJU7201U25 voltage regulator and a LTC1044 DC-DC converter supply plus and minus 2.5 volts powers to the transmitter, respectively. The instrumentation amplifiers for ECG and NS are designed with low-power IC chips. A TLC555 C-MOS timer IC is used as a voltage-controlled oscillator. The timer IC output and amplified ECG signal are combined and used to frequency modulate a single-transistor radio transmitter. The telemeter is constructed on a 4 x 4 cm printed circuit board and encapsulated in epoxy and silicone rubber, yielding a total volume of 16 cc. The weight is 50 g.

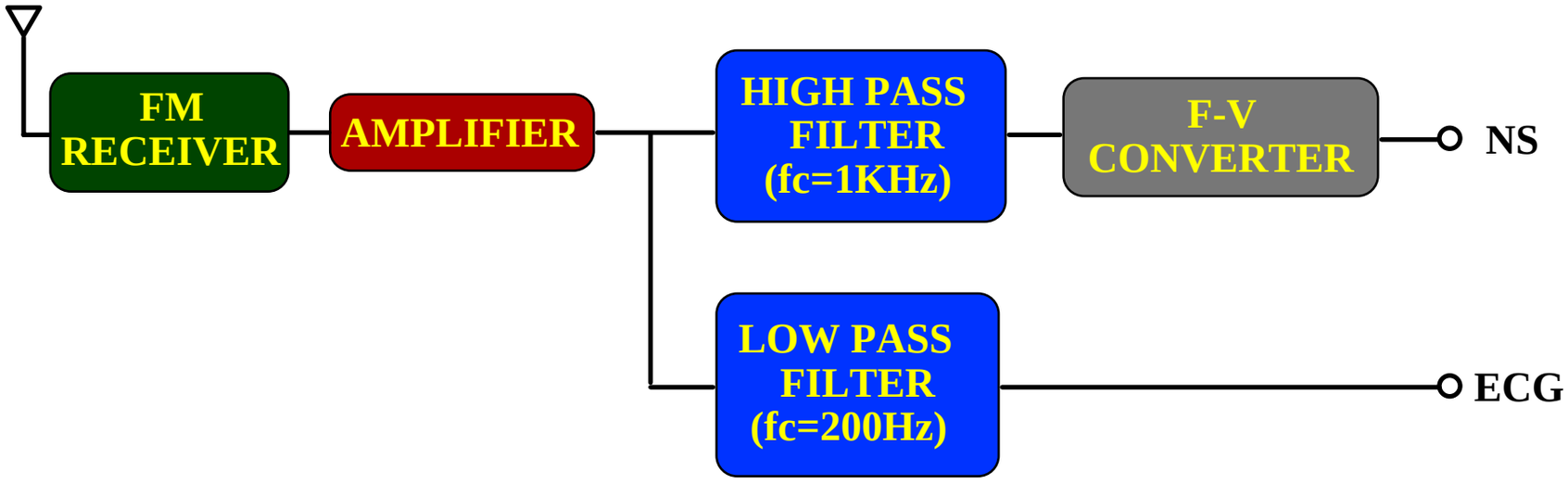

Figure 3. The receiver and demodulator circuit.

The transmitted signals are received by a modified consumer FM receiver, which has a wideband signal output. The summed VCO and ECG signals are obtained from this output. The VCO and ECG signals are separated by a high-pass filter and low-pass filter, respectively. The separated VCO signal is demodulated to a voltage level proportional to the neural signal by a frequency to voltage converter (F-V converter).

RESULTS

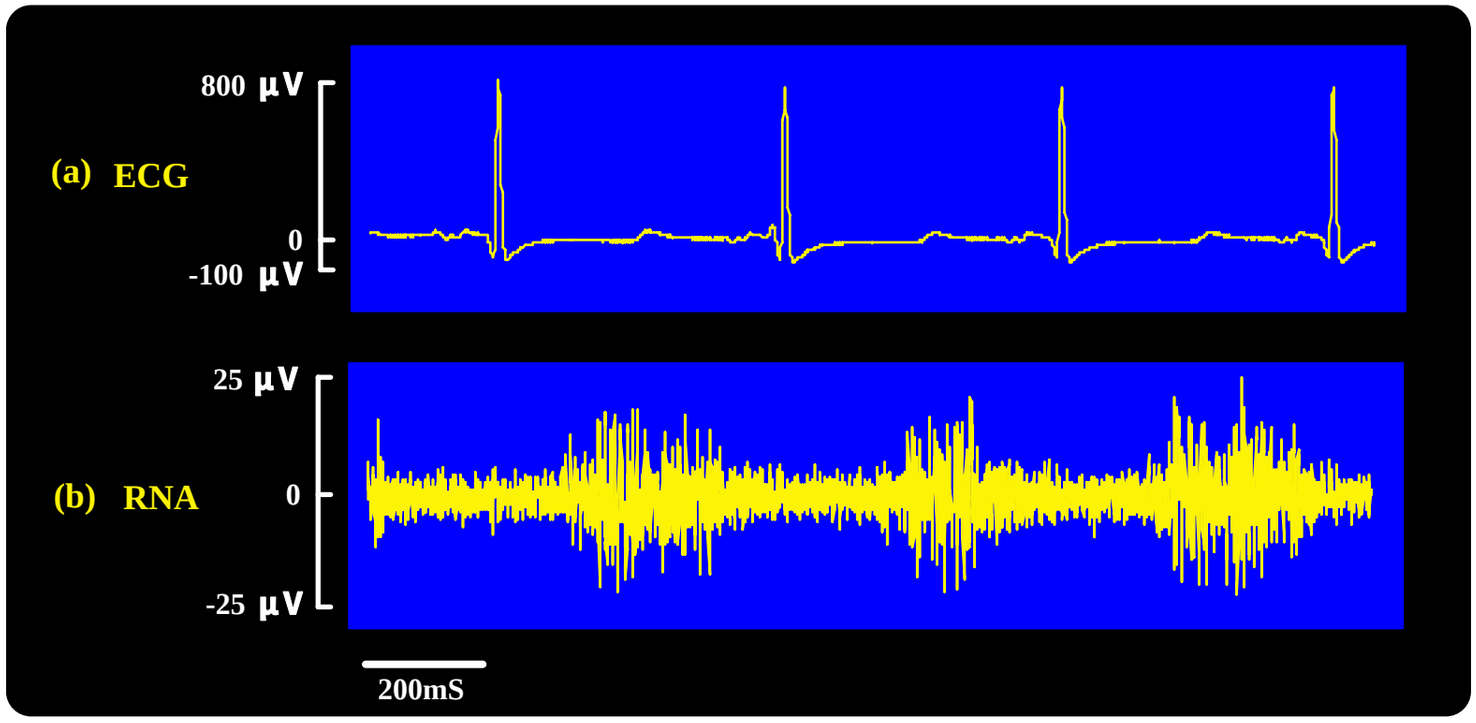

Figure 4. The RNA and ECG recorded from the swine under battery charging.

The experiments were carried out on swine(6-8 kg body wt). Under sodium pentobarbital anesthesia, a bundle of nerve fibers from the left renal nerve (RNA) was separated from the renal plexus located near the renal artery and vein, and then the recording electrode was attached to the nerve bundle. For recording ECG, a pair of wires was implanted in both sides of the chest wall. The electrode lead cables are passed the subcutaneous tissue and soldered directly to the telemeter. The telemeter package was placed and implanted into the subcutaneous tissue under the back. The recorded signals were independent of the 3.5MHz. Discharge patterns of RNA were regular and showed a grouped activity synchronous with cardiac cycle.

CONCLUSION

The implantable batteryless telemetry system, using four standard low power integrated circuits, two voltage regulators and one transistor, has been designed for chronic unanesthetized animal studies. This system can simultaneously record the cardiac sympathetic nerve activity and ECG from awake animals. The power for the system is inductively coupled and transmitted to a small size, light weight and high value 2.5 Farad capacitor. In case that the capacitor is charged in 5 minutes, the system can be driven for 25 minutes. The system has a transmission range up to 5m, depending on intervening tissue depth and FM receiver characteristics.