BIOTELEMETRY AND RADIOTRACKING OF WILD BIRDS: PORTABLE DEVICE USING SOLAR CELLS POWER SUPPLY

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A thick film hybrid transmitter for the radio tracking of wild animals is described. Weight considerations are of prime importance for such transmitters and the system discussed uses thick film hybrid technology, together with a solar cell power supply charging Cd–Ni batteries.

To reduce power consumption a pulsed system is used; the transmitter operating frequency is in the 72 MHz band.

1. INTRODUCTION

With the aim of minimizing the disturbance of the behaviour of wild animals, biologists limit the weight of biotelemetry portable devices to two percent of the weight of the animal. The battery accounts for a large part of this weight. For a given electrical energy, it limits the autonomy of the system. For small animals and particularly for birds this ratio cannot be met with conventional devices. The total weight of the portable device can reach ten per cent of that of the animal although the autonomy is limited.

In order to obtain a total autonomy while reducing the weight, the suggested system uses a solar cell power supply and hybrid microelectronic integration. The radio tracking receivers of the C.E.B.A.S. operate in an experimental field of about 30 square kilometres and need a radiating power of 10 mW in the 72 MHz range. With an efficiency of 20 per cent, the power consumption of the transmitter is 50 mW; a pulse modulator allows the average power consumption to be reduced to 1 mW.

2. EQUIPMENT

2.1 Transmitter

Taking into account the small size required and the low energy consumption, a simple design was chosen, although two stages were still necessary to avoid frequency shift induced by output load variations (Figure 1).
The first stage consists of a crystal oscillator, HC-45/U case, using overtone five (71.605 Hz). The collector circuit of the oscillator transistor is tuned on the transmitting frequency. A capacitative divider decreases the load added by the next stage.

The second stage is a C class amplifier using a common base transistor. The output is a 25 cm aerial loop, tuned to the transmitting frequency.

2.2 Modulator

The modulator controls the cyclic operation of the transmitter. The duration of the transmission is 20 ms ± 5% and the off-time is 930 ms ± 3%. These values must be held:

- in the temperature range from 10°C to 40°C.
- for a power supply voltage range from 4.7 V to 5.4 V.

The consumption of the modulator must be negligible compared to the average consumption of the transmitter.

The modulator is a multivibrator using two cross-coupled transistors \( T_1 \) and \( T_2 \) (Figure 2). The transistor \( T_3 \) acts as an active load. Blocking the diode produces a fast rise time of the output signal. The conducting diode balances temperature variations of the base-emitter junction of transistor \( T_1 \). For \( C_2 \) is a null temperature coefficient (NPO) capacitor and \( C_1 \) is a positive temperature coefficient tantalum capacitor in order to balance the effect of the base-emitter junction of \( T_2 \) on the off-time. Transistor \( T_4 \) acts as a switch in the power supply circuit of the transmitter.

2.3 Hybrid Integration

The 2 in. by 1 in. alumina substrate receives the modulator, the transmitter and the four Cd–Ni
batteries. The diameter of each cell is 15.5 mm; thus the area usable for the transmitter and the modulator is 1 in. by 0.75 in.

Gold conductor pastes were chosen in order to make the thermocompression wire bonding of transistors chips easier, and to obtain a high resolution. The tuning inductance of the oscillator was printed but it was necessary to make an extra serigraphic thickness to increase the Q factor of the circuit. All resistors were printed, the two resistors of the modulator which determine the pulses durations were designed for functional trimming. An overglaze was applied for the protection of conductors and resistors.

The six turn magnetic core choke, the crystal oscillator and capacitors were set with epoxy. Air abrasive dynamic trimming of the resistors was the last operation before soldering the batteries and connecting back to back the substrate of the solar cells and that of the electronic circuits. The system was coated with silicone.

2.4 Performance

The durations of pulse t and period T versus temperature are shown in Figure 3. In the considered temperature range the variations of t and T are less than 0.25% and 1% respectively. Spectral analysis of the transmitting signal (Figure 4) shows that rejection of harmonic 2 is 15 dB and that of harmonic 3 is about 30 dB.

2.5 Power Supply

The solar cell capacity has been designed for a system with a nominal voltage of 4.8 V and an average current consumption of 0.5 mA. The average continuous power to be provided is then 2.4 mW and it needs an energy of 21 Wh/year.

Taking into account the mean insolation in the region between 45° and 50° latitude north and a solar cell efficiency of 10%, the usable energy one can
count on, is 100 Wh/cm²/year. For the considered application this leads to a solar cell surface of 2.1 cm².

These values are valid for a stationary system; this is certainly not the case here. This fact and several practical considerations justified the choice of a solar cell surface of 3.2 cm².

The voltage requirement is met by putting several cells in series. The voltage at peak power of one solar cell is 450 mV. Twelve cells in series result in a voltage at peak power of 5.4 V, a slightly higher value than necessary and results in a good compensation for temperature variations (−2 mV/°C/cell) (Figure 5).

A good practical rule for the storage requirements in the considered region, is a capacity of 400 to 500 times the average energy consumption in one hour. Four Cd–Ni batteries of 50 mAH should meet this requirement.

The solar battery is built on a 2 in. by 1 in. alumina substrate. The interconnection pattern is screen printed with a Au–Pt paste; individual cells are epoxy die-bonded and interconnected by thermo-compression bonding. The total system is encapsulated in a transparent gel, to prevent mechanical and/or environmental damage.

The battery was built up from two independent sets of cells, connected in parallel (Figure 6). This prevents excessive current limiting by shadowing by the bird's wings.

A blocking diode prevents Cd–Ni battery discharge through the solar cells in periods of darkness.

3. SUMMARY OF SPECIFICATIONS

| Specification                        | Value               |
|--------------------------------------|---------------------|
| Solar cell surface                   | 6 cm²               |
| Short circuit current illum.         | 100 mW/cm² at 25°C  |
|                                      | 14.9 mA (two systems)|
| Open circuit voltage                 | 6.52 V              |
| Peak power                           | 64.8 mW             |
| Current at 4.8 V                     | 13.5 mA             |
| Weight                               | 5 g                 |

The weight of the system is 25 g and a total autonomy was observed during last months of the winter (Figure 7).

4. CONCLUSION

The proposed system was tested and gave satisfactory results. In the near future, it will be optimised for different animals. It gives biologists the possibility to collect results from radio-tracking during long periods of time. This realisation shows how the flexibility of hybrid microelectronic integration solves a specific problem in a multi-disciplinary research field.

REFERENCE

1. M. Marques, Télémesures radioélectriques appliquées à la biologie animale. Radiotracking et paramètres physiologiques. Thèse de Doctorat ès-Sciences, Université de Bordeaux II, janvier 1976.
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