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401 MHz transistorised radiosonde transmitter

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सार — यह शोध-पत्र एक ट्रांजिस्टरी रेडियो सोंन्दे ट्रांसमीटर की चर्चा करता है जो कि, उपरितन वायु आंकड़ा अर्जन के लिए राष्ट्रीय उपरितन वायु संजाल में पहले प्रयोग किए गए वाल्व युक्त संयंत्र के स्थान पर लगाने के लिए अभिकल्पित किया गया था। 22.5 वोल्ट जल से सक्रिय बैटरी का प्रयोग करते हुए 500 मिलीवाट पॉवर आउटपुट के साथ 400.6- 406 मैगाहर्टज बारम्बारता बैंड (ट्यूनेबल) में यह ट्रांसमीटर काम करता है। उपयुक्त आंकड़ा रूपान्तरण और प्रसारण के लिए ईष्टतम अभिकल्पना को प्राप्त करने के लिए स्ट्रिपलाइन तकनीक उपयोग में लाई गई और परिशुद्ध आवश्यकताओं को पूरा करने के लिए ट्रांसमीटर लगाए गए राष्ट्रीय उपरितन वायु संजाल में यह प्रणाली दैनिक प्रयोग में है और इसका कार्य संतोषजनक है।

ABSTRACT. This paper describes a transistorised radiosonde transmitter which was designed to replace valve version earlier used in national upper air network for upper air data acquisition. The transmitter operates in 400.6-406 MHz frequency band (tunable) with 500 milliwatt power output utilising a 22.5V water activated battery. Stripline technique has been deployed to obtain the optimum design and transmitter meets all the stringent requirements laid down for accurate data conversion and transmission. The system is in routine use in the national upper air network and the performance is satisfactory.

Key words — Stripline technique, Audiomodulated radiosonde, Transmitter, Observational network, Radiowind, Carrier frequency, Pulse width, Radiation element.

1. Introduction

Before 1975, audiomodulated radiosonde was using a valve type transmitter-cum-modulator operating at 400 MHz frequency band for acquisition of upper air data in the national observational network. High operating voltage (112 V plate supply and 7.5 V filament supply) of valves required a battery weighing 1200-1500 gm, thus increasing the total payload to 2.2 kg. This high payload considerably limited the bursting height of the balloons, thereby limiting the overall data acquisition capability. In addition, poor conversion efficiency, high power drain and obsolecence of valve technology were posing serious operational problems. The availability of UHF power transistors prompted the development of transistorized system to overcome all the above mentioned problems.

The transistorised transmitter thus developed uses all indigenous cheaper, sturdier components and utilizes 22.5 V water activated battery weighing 450 gm. The reduction in overall payload has considerably improved the performance of radiosonde/radiowind soundings.

2. General specifications

(1) Carrier frequency	: 403 $\pm$ 3MHz tunable
(2) Carrier frequency stability	: $\pm$ 100 KHz
(3) Pulse repetition frequency	: 0-200 Hz
(4) Pulse width	: 200 microseconds
(5) UHF power output	: 500 mW
(6) Type of modulation	: Pulsed FM
(7) Frequency deviation	: 500 KHz
(8) Radiation element	: $\lambda/4$ dipole

3. Design and circuit description

The schematic diagram of the transmitter consisting of a UHF power oscillator and modulator is given in Fig. 1. Use of indigenous components, simple design, easy to mass manufacture and stringent accuracy, requirements, have been kept as guidelines for designing the system circuitry.

3.1. *UHF power oscillator*

Emitter ballasted overlay UHF power transistor 2N 3866 has been used as clapp oscillator as per circuit

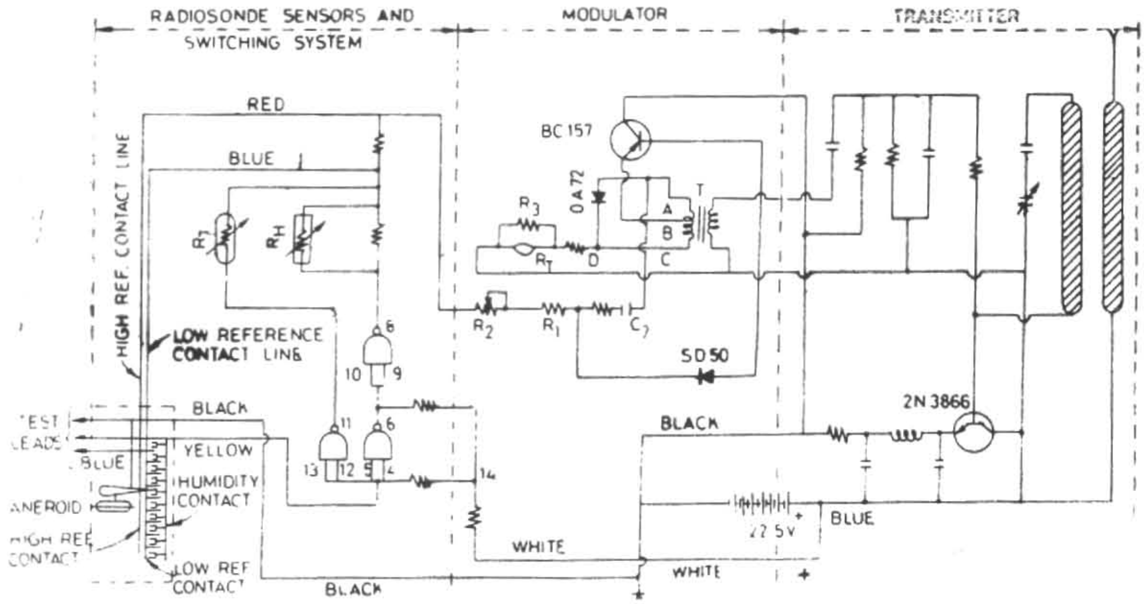


Fig. 1. Circuit diagram of 400 MHz transmitter with modulator

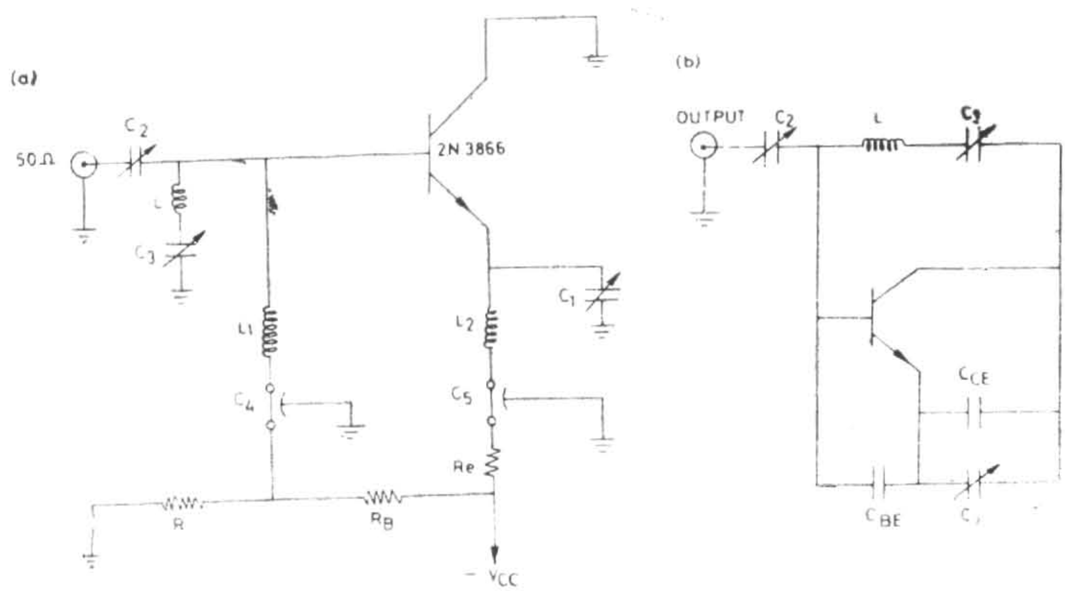
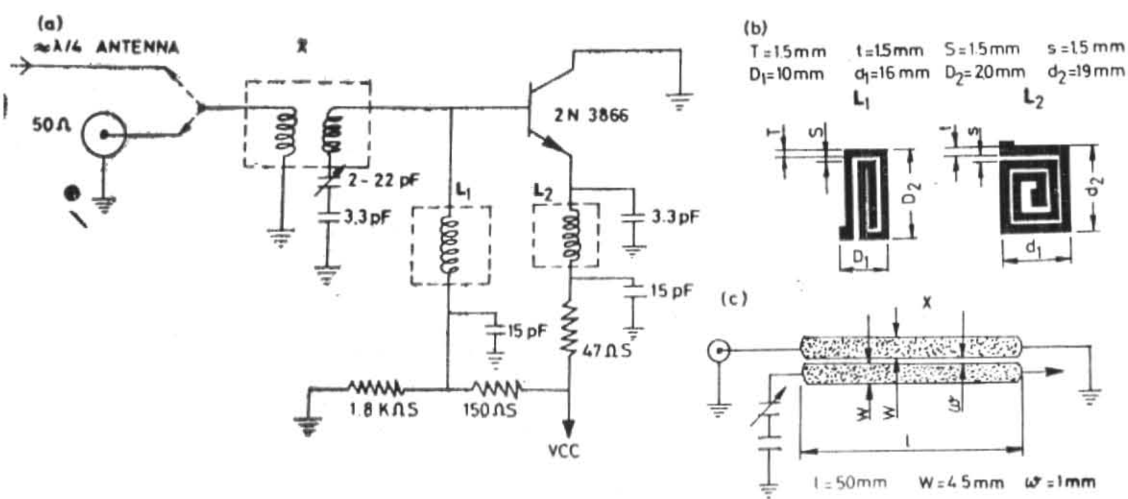


Fig. 2(a & b). (a) 400 MHz, 500 milliwatt power oscillator and (b) Clapp's equivalent of the circuit



Figs. 3(a-c). (a) Printed circuit version of Clapp's oscillator, (b) Stripline chokes and (c) Strip transmission line transmitter for power outlet

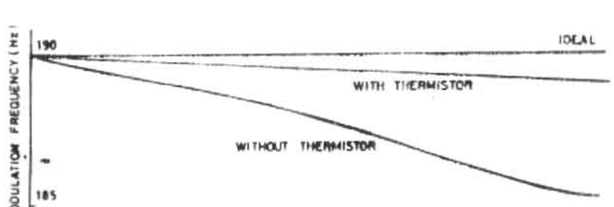


Fig. 4. Effect of ambient temperature on modulator

diagram shown in Fig. 2 with its equivalent circuit. Base emitter capacitance (C_{BE}) alongwith a variable capacitance C_i forms the feed back network as shown in Fig. 2(b). While working at UHF band stray capacitances and inductances pose a critical problem in the standardization of the circuit for repeatability in mass manufacture. Thus stripline approach has been successfully used in converting various inductances including that of the tank circuit, on a standard printed circuit board (as shown in Fig. 3) after theoretical and experimental considerations. The dimensions of a stripline emitter/base chokes and a transmission line transformer for impedance matching and transferring the power to a $\lambda/4$ dipole antenna, which forms the down link from balloon borne radiosonde to ground reception system, is also shown in Fig. 3.

3.2. *Modulator*

The basic purpose of modulator is to convert the resistances of the temperature and humidity sensors whose resistance values depend upon the temperature and humidity of the ambient atmosphere into electrical pulses. The pulse repetition frequency of modulator follows a stringent pre-determined resistance *vs* frequency curve for converting the resistance of thermistor which is temperature dependent and the resistance of lithium chloride hygristor which is humidity dependent into pulses of proportionate repetition frequency. The repetition frequency varies in 0-200 Hz range depending upon the resistance of the sensors with a fixed pulse width of 200 microseconds.

A self pulsing relaxation oscillator utilising a silicon BC 157 transistor is shown in Fig. 1. When the circuit is initially switched on, the supply voltage is distributed on the resistance network consisting of R_3, R_T, R_4, R_1, R_2 of meteorological sensor. At this instant the transistor BC 157 becomes forward biased. Since part of the primary winding, *i.e.*, AB of the pulse transformer is in emitter circuit of BC 157, the sudden increase in current causes fall of voltage at point B and due to auto-transformer action, double voltage fall will appear at the other end 'C' of the primary winding of transformer. The capacitor C_7 has a large series resistance consisting of R_1, R_2 and meteorological sensor. Therefore, the fall of voltage across the primary of transformer will appear at point D. Thus the forward bias of the transistor suddenly increases causing more emitter current to flow and more voltage drop at point D. After some time, a stage is reached when the emitter current ceases to increase further. As soon as this happens the voltage drop across primary winding becomes zero and voltage at point D increases suddenly, causing the emitter current to reduce. Because of inductive effect the reduction in emitter current, voltage of reverse polarity develops across primary winding, making point D more positive. This process brings the transistor to cut off suddenly. At this instant, the voltage at point D goes even higher then power supply voltage by approx. 8 V. At this stage, the capacitor starts discharging through R_1 R_2 and the sensor, thus slowly reducing voltage at point D where as the voltage at emitter remains almost constant at 22.5V. When the voltage at point D becomes less than that at emitter, the transistor again start conducting and the process is repeated. A low leakage back-to-back diode SD50 has been used in the base circuit to produce high emitter to base impedence during the discharge period of the capacitor C_7 to produce standard resistance *vs* frequency curve. Variable resistance R_2 is used for initial adjustment of the reference frequency.

The radiosonde encounters temperature variation from + 50°C to — 50°C inside the housing capsule during an ascent. At low temperature the common emitter gain β of the transistor reduces. Hence it takes longer time to come into full conduction and then back to the cut off stage causing frequency to reduce. To compensate for this drift combination of one thermister R_T and resistance R_3 has been used. At low temperature R_T increases which in turn reduces the max. current at full conduction of BC 157. Since the charging voltage across the capacitor C_7 depends on the rate of change in current at cut off, this voltage, reduces due to increase in resistance of R_T at low temperature. Hence it takes less time during discharge to make BC 157 forward biased, thus increasing frequency which compensates for the drift due to change in voltage at B with temperature. Fig. 4 shows the response of the modulator with and without thermistor in the temperature range of +50 to —50°C. The variation without thermistor is of the order of 5 Hz from the references value whereas when it is compensated with thermistor, the variation reduces to about 1 Hz in the entire operating temperature range. However the slow and small variation of reference frequency due to temperature effect is adjusted by the ground reception system whenever low reference is repeated and hence it does not introduce any error in the measurements. The modulator pulses are fed through a transformer to the base of UHF transistor 2N3866 for achieving a frequency modulated carrier which forms the down link for data transmission.

4. Conclusion

The transmitter was thoroughly tested in the laboratory and field to evaluate its performance and specifications under varied environmental conditions before introducing in a phased manner in the national upper air network. In Feb-March 1985, Indian radiosonde comprising of transistorized transmitter was compared with radiosondes of other countries during the International Intercomparison of Radiosondes held at Wallops Island, U.S.A., and its performance was found satisfactory and at par with other radiosondes.

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