Technical Notes

by George Caporaso

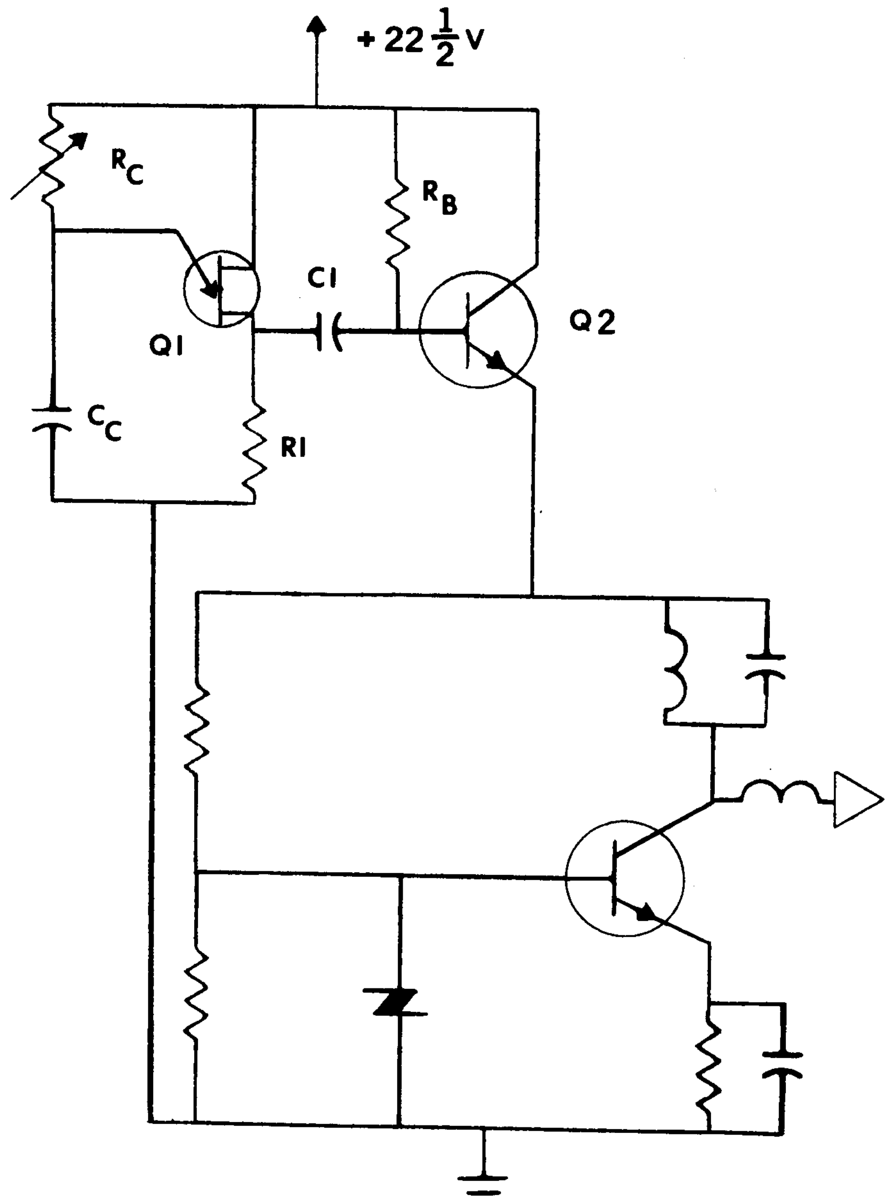
This month we will discuss some points about model rocket transmitters and sensors. The series of articles by Richard Fox on transmitters and sensors has provided model rocketeers with the first comprehensive set of plans for a reliable transmitter that is both inexpensive and reasonably small. Fox's design was the foundation, the first step, the breakthrough. It is now up to the rest of the modelers interested in this problem to further refine his designs and invent new and more useful sensors.

The present transmitter (of Fox) has 5 transistors, one citizen's band crystal, 2 r.f. chokes and a handful of small capacitors and resistors plus a sensor and a 22½ volt battery. Most of the resistors in the circuit can be of the ¼ watt type and the capacitors used can be very tiny tantalum components. The chokes used in the circuit can either be purchased or wound to a very small size.

A major problem in reducing the size of the present Foxmitter is that of reducing the number of transistors. As mentioned in Fox's May article in **Model Rocketry**, the unijunction transistor acts in conjunction with the sensor and a capacitor as a relaxation oscillator. The output of that oscillator is fed into a three stage Darlington amplifier which controls the flow of current to the transmitter stage.

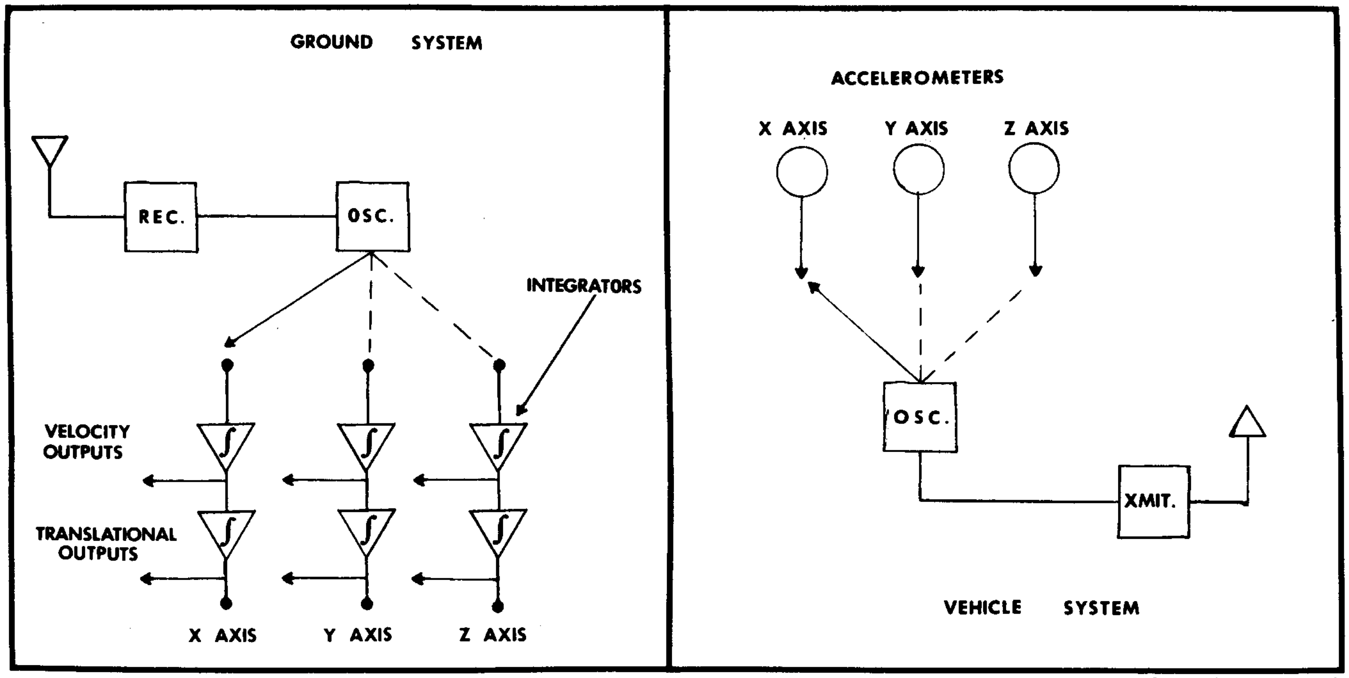
In this circuit, only about 12 volts appears the transmitting stage, the other 10½ being dropped across the collector-emitter junctions of the Darlington transistors and across the base 2-emitter junction of the unijunction transistor. This voltage is pure waste! Something should be done either to utilize that wasted voltage (and power) in the collector-emitter junctions or sythesize a network that can operate at 12 volts.

As mentioned previously Fox's transmitter uses a three-stage Darlington as a current amplifier. The author has found, however, that since the current requirement of the transmitting stage is so low (on the order of 12 ma.), the Darlington stage can be replaced by a single 2N697 emitter follower stage as is shown in the accompanying diagram. The unijunction transistor relaxation oscillator was also modified to a somewhat more simple circuit as shown in the schematic. With the 2.2 microfarad charging capacitor a charging resistor R_c of at least 2.5 kohms must be used to insure oscillation. The larger the beta of the 2N697, the better because of the lower loading of the base 1 resistor that will result.



PARTS LIST FOR MODIFIED TRANSMITTER

R_c – Sensor resistor, at least 2.5k
R_1 – 100 ohm, ½ watt
R_b – 100k, ¼ watt
C_c – 2.2 ufd., electrolytic (negative terminal to ground)
C_1 – 1.0 ufd., electrolytic tantalum
Q_1 – 2N490 Ge unijunction transistor
Q_2 – 2N697 NPN transistor
NOTE: All unmarked components are identical to the transmitting section of the Foxmitter.



Typical betas for the 2N697 range from 20-60 presenting an input impedance (to the emitter follower) of from 20 kohms to about 33 kohms. The sensor oscillator will still function, however, at a beta of 10 with a loading impedance of about 10 kohms.

Once the above mentioned modifications have been made, the Foxmitter will have two less resistors and one less capacitor. It's not a "great leap for mankind" type of miniaturization, but it's a start.

Once the hoped-for improvements in the transmitter have been forthcoming all sorts of hairy things will come creeping out of people's minds for innovations and more sophisticated sensors.

For instance, an absolutely lovely but complicated creature would be a transponder module. Essentially, the transponder must have a receiver to accept pulses from the ground and a trigger mechanism that performs two functions: it must temporarily shut down the receiver and simultaneously send a pulse to the transmitter. The transmitted pulse will reach the ground where the time-delay between the original ground-originated trigger pulse and the returned pulse can be measured by either a time-gate circuit or a triggered-sweep oscilloscope. The transponder's receiver is temporarily shut down so that it won't pick up its own transmitted signal, a situation that might result in catastrophic oscillation of the transponder. The transponder will require a 27Mc. receiver stage as well as some micrologic circuits to perform the triggering and receiver shutdown and turn-on. With today's microcircuit stockpile such a device would not be too large to be impractical.

Another, even more intriguing possibility, is a multiple-axis accelerometer telemetry system. Professional, manned spacecraft use a three-axis accelerometer system which is capable of measuring the acceleration along the x, y, or z axis very accurately. The acceleration signals are then integrated by the spacecraft's computers to give the velocity of the vehicle along the same three axes. The velocities can again be integrated to yield the distances travelled along the three axes.

An accelerometer module that could produce acceleration information (voltages) for two or three axes would be highly useful. The signals could be rather easily integrated on the ground by simple operational amplifier circuits to provide instantaneous data on all three components of acceleration, velocity, and distance (translation). In this manner, the precise location of the vehicle with respect to the launch area could be determined. The sophistication of the equipment required on the ground will be somewhat greater than the also complicated and sophisticated accelerometer module.

Dick Fox has already presented plans for an accelerometer. These must be further refined to the point where the accelerometer circuits *have outputs proportional to the accelerations.* The accuracy must be greatly improved. An additional feature for the successful operation of the module is also needed; that of sending three channels of data. As has been proposed by a recent correspondent of Gordon Mandell's, an oscillator can be constructed that will alternately switch rapidly back and forth from the transmitter to each of the three channel inputs. The three channels can similarly be re-separated on the ground by an identical switching oscillator and then fed to three circuits with two ganged integrators. The concept of the system is perhaps made a bit more transparent by the block diagram accompanying the text.

Today, no area of technology is advancing more rapidly than the field of electronics. The Foxmitter has now provided an opening for model rocketeers. We will now be able to utilize the advances in electronics to build highly sophisticated payloads, telemetering and control systems, and range determination systems. Start designing . . . or the transmitter may very well be known as the Foxmitter for evermore!