WHOI-85-6

Woods Hole Oceanographic Institution

An Inexpensive Radar-Responding Relocation Device for Drifting Oceanographic Instruments

by

F. R. Hess

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Technical Report

Prepared for the National Science Foundation under grant OCE-82-15708
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Approved for Distribution: ____________________
Robert C. Spindel, Chairman
Department of Ocean Engineering

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ABSTRACT

The instrument described was designed to provide sufficient data to relocate a floating object at sea. It provides a line of bearing to the object from the tracking ship. Cost and power consumption were the major driving concerns. There is a minimum of microwave circuitry. The package is reproducible for under $2000.

AN INEXPENSIVE RADAR-RESPONDING RELOCATION DEVICE FOR DRIFTING OCEANOGRAPHIC INSTRUMENTS

BACKGROUND

The need for devices to assist in the rapid relocation of drifting buoys as well as free instruments returning to the surface has long existed. The increasing use of autonomous instrument systems, which descend to the bottom or to midwater and return, has increased the utility of a moderate range system. In this context, moderate range means five to ten miles.

The type of instrument system referred to above does not generally have very much reserve buoyancy and therefore does not stand very high out of the water. VHF radio beacons are frequently used as recovery aids. Their principal drawbacks are difficulty in obtaining an accurate, non-ambiguous bearing and their relatively short life.

Rather early on this problem was attacked, (Walden, 1964) and the advantages of using a radar triggered responder of some sort, recognized. The high bearing accuracy of a ships 3 cm radar would be hard to duplicate in any other system. Utilizing a radar-actuated device allowed the location device to remain in a standby or listening mode at reduced power consumption until brought to full operational status by receipt of a ships radar signal.

Unfortunately, the obvious answer to the problem, a radar transponder, is very expensive and very power hungry. Up until very recently, magnetrons were the only RF power source available. While they have been used at sea for some short-duration experiments, they have not been generally adopted as the cost is in the $6 to $10K range and large battery packs were required for even short usage. In addition, these units are not pressure protected and do not lend themselves to such protection for deep submergence.

APPROACH

The approach used in this latest attack on the problem is similar to one used as far back as World War II to track sonobuoys from aircraft. Basically the radar transmission is received, detected and used to key a VHF transmitter. In the aircraft, this VHF signal was received and injected into the video system of the radar to give a "pip" on the radar screen corresponding to the buoy location.

Our system, which requires no special, wideband receivers, is similar in that it "answers" the radar with a VHF signal. This signal is received on the ships VHF radiotelephone and correlated to the target bearing by the observer. A short (one-quarter second) tone is heard whenever the rotating radar search beam sweeps over the drifting buoy. The observer, while watching the PPI scope display of the ships radar, observes the bearing cursor at the moment that he hears the tone. Bearings to +/-2 or 3 degrees are readily obtainable.

OPERATION

The operation of the system may be described using the circuit diagram. (Figure 1)

The most critical part of the system, as well as the most expensive (almost $300) is the X-Band antenna system. This component is used on Motorola's own radar transponders. It is an array of slot dipoles tuned to the 3 cm marine radar band. The assembly is weatherproof and used as is in the surface unit. It provides the function of antenna and tuned "front end" for the responder. A low-noise detector diode is mounted directly to the antenna assembly and connected by coax to the 2N5031 preamplifier stage. A forward bias is applied to the detector diode by means of a 7660 voltage inverter and 10K potentiometer. This places the diode in it's most non-linear condition, making it capable of detecting microvolt level signals.

The detected video (pulse) of a few tens of microvolts is applied to the preamp which has a gain of about 25 dB. The pulse is further amplified by the low-power, wideband amplifier (CA3022) and used to drive the MPS-H81 switch. The pulse, 0.1 to 0.5 microseconds long, is now of sufficient amplitude to trigger the 4098 one-shot multivibrator.

The dual one-shot provides two output pulses for each pass of the radar beam across its antenna. A long (ten second) pulse, used to turn on the crystal oscillator in the VHF transmitter upon detection of the first pass of the radar beam. This multivibrator is retriggerable, that is, it will continue in the triggered state so long as trigger pulses come closer than ten seconds apart. This keeps the VHF transmitter oscillator on and allows it to stabilize.

The second half of the 4098, when triggered, provides a 0.25 second pulse which keys the transmitter's multiplier and power amplifier stages, causing a VHF transmission which is received aboard the search vessel.

Actual power switching is accomplished identically for both oscillator and power amplifier. Each one-shot turns on a power switch (IRF-9120) which switches the twelve-volt power to the appropriate stages.

The transmitter is a small, printed circuit FM unit designed to provide one to two watts out at VHF. It is modified to separate the power line to the oscillator from the line to the multiplier and power amplifier stages. A capacitor is inserted in the FM modulator section to provide feedback and cause a continuous tone to modulate the transmitter. (Without the tone modulation nothing would be heard on the vessel except the squelch breaking.)

A five-eights wavelength VHF whip is provided for the VHF transmitter. As with any VHF system, the operation of the antenna depends to some extent on the surrounding ground plane. The case of the responder provides a minimal counterpoise and the system radiates effectively when mounted on an insulated (non-metallic) structure. When mounted on a metallic structure, the responder should be the highest part of that structure. (A flag on a fibreglass pole above will not adversely effect operation.)

The system uses a minimum of power. The receiver draws six milliamperes from the six volt tap on the battery. There is no power consumed by the transmitter unless keyed. Two, six volt, lantern batteries provide power for thirty days or more usage, depending on the number of times the responder is interrogated. These batteries can provide sufficient power for over twenty hours of continuous transmission.

The accompanying photographs (Figure 2) show the responder and its housing. (shallow configuration)

Tests

The first tests on the finished unit were performed in Woods Hole. The test consisted of placing the responder in a window overlooking the harbor and listening on the VHF reply frequency. Numerous fishing boats were observed in the area and the replies were visually correlated to the various vessels by observing their rotating radar antennas. It was observed that vessels were able to actuate the responder as far as they could be seen. Unfortunately, this was only a bit over a mile due to a headland and some islands in the way. It did not determine the ability of the VHF transmitter to be heard and interpreted either.

The second test series involved sending the unit to sea with a group doing a buoy experiment to have them "piggyback" the responder on one of their buoys. The unit was deployed and was not heard at over a couple of hundred yards. There was no technician aboard familiar with the unit. As a result, the problem was not identified or rectified. Sometime during the work on it, the VHF transmitter quit cold and they were unable to get any output at all. The unit was returned to Woods Hole with something less than rave reviews.

Upon return the unit was examined and the transmitter crystal was found to be inoperative.(i.e. broken) As there was no spare for this, the unit could not have been repaired at sea anyway. A replacement crystal was obtained and the unit returned to life.

The latest test of the unit was also done in Woods Hole. This time the R/V KNORR was tied up at the pier and its radar was available for tests. The responder was secured to the towing bit on the deck of the R/V ASTERIAS,(Figure 3) about six feet above the water, and ASTERIAS sailed away towards Martha's Vineyard. The "beep" from the VHF radio-telephone was loud and clear on the bridge of the KNORR. There were several more beeps than could be accounted for by the sweeping of the KNORR's scanner however. It was observed that another vessel, tied up nearby, also had its radar in operation. It was readily verified that this was the cause of the extraneous replies. In fact, during the tests, several passing fishing vessels caused replies to be generated.

The ASTERIAS continued away from the KNORR for about four miles, being then forced to turn as Martha's Vineyard Island was in the way. ASTERIAS continued south along the shore of the Island until at about 6.5 N.M. the signal was lost. At that range the two ships were separated by an Island as high as the Radar antenna on the KNORR, behind which the ASTERIAS was steering. In addition, the KNORR's radar was pointing dead aft, into the mainmast. It is not clear whether the signal loss was due to excessive range, to the intercession of the land mass or to masking of the radar beam by the mast. We were unable to move KNORR to reestablish an over-water path. The author believes that the loss of radar line-of-sight was the cause of signal loss, rather than excessive range, if only because of the sudden cessation of replies. Reply signals were strong enough to easily break the receiver squelch right up to the dropout point.

Conclusions

We feel that this last test test fully justifies the design. The ease of making the correlation between the "beep" of the VHF radio and the position of the sweep on the radar was amply demonstrated. There were three ship's officers on the bridge during various parts of the last test and all were easily able to pick out the proper bearing after a short description of how the system was operating.

A "fringe benefit" may be claimed. The R/V ASTERIAS was tracked by the radar during the test. It was easy to determine which target "blip" was the ASTERIAS as it beeped as the sweep passed over it. This might be useful in multi-ship operations where there is no other way to identify a particular vessel.(IFF)

A version of the responder suitable for use on deep deployed instruments is presently under development.

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1. Walden, R. G. and Webb, D. C., Methods of Locating and Tracking Buoys. Transcript of 1964 Buoy Technology Symposium. Marine Technology Society, March 25, 1964.

Figure 1 VHF Radar responder and case. Shallow configuration.

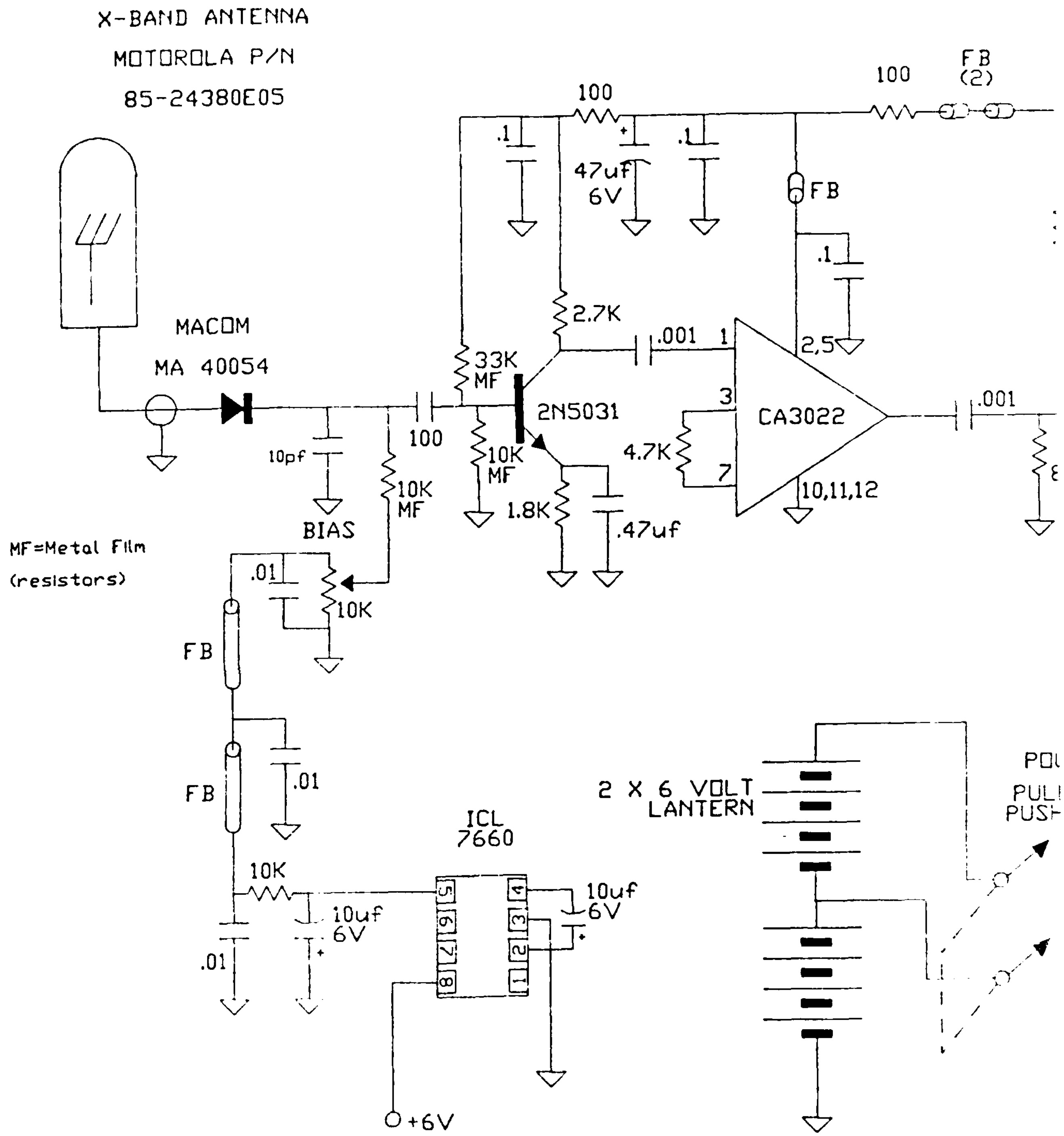
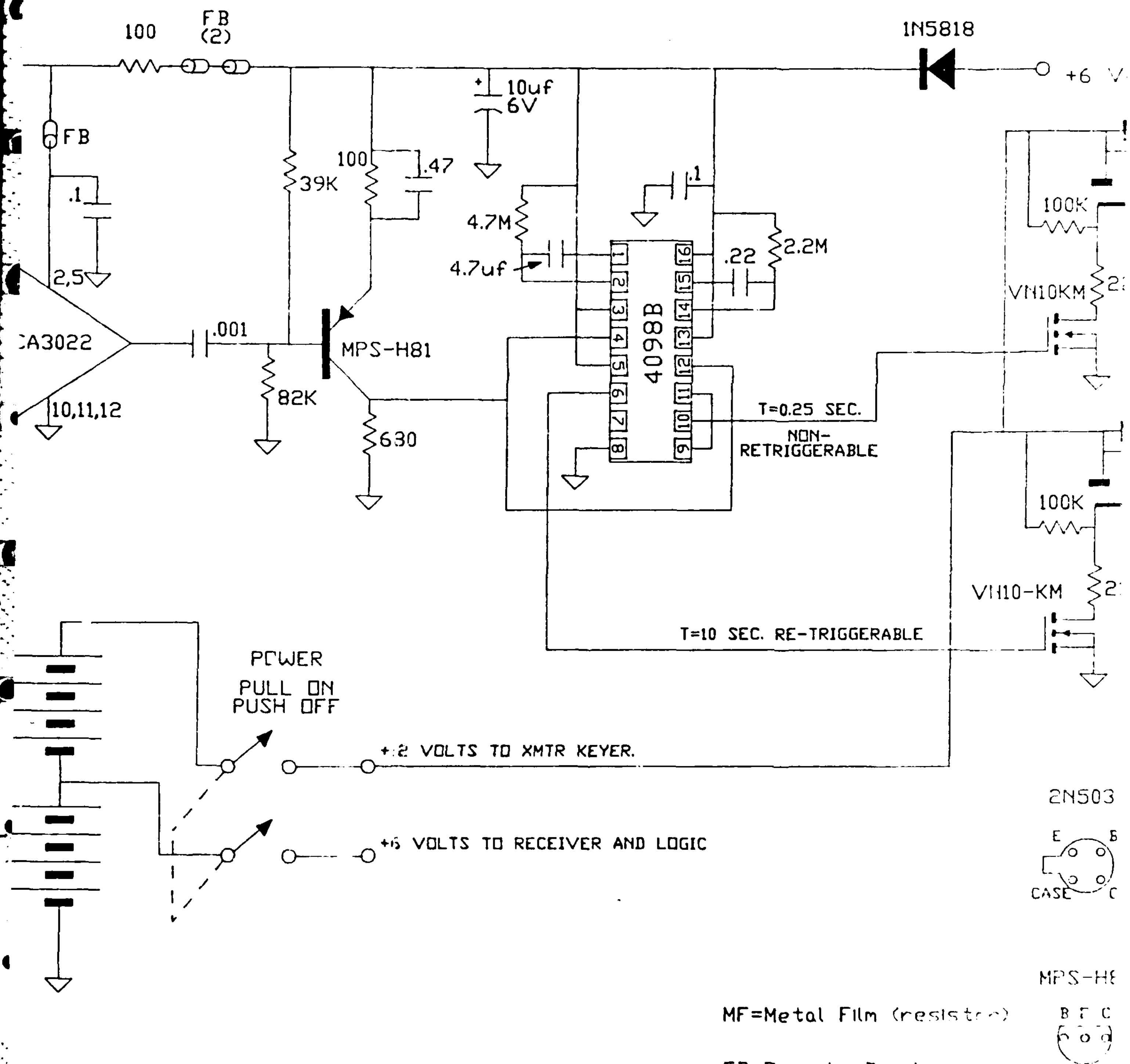


Figure ? ...hematic, video detector and power switching.



MF=Metal Film (resistor)

FB=Ferrite Bead

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Date: 18 OCT 81
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Revision: 0

switching.

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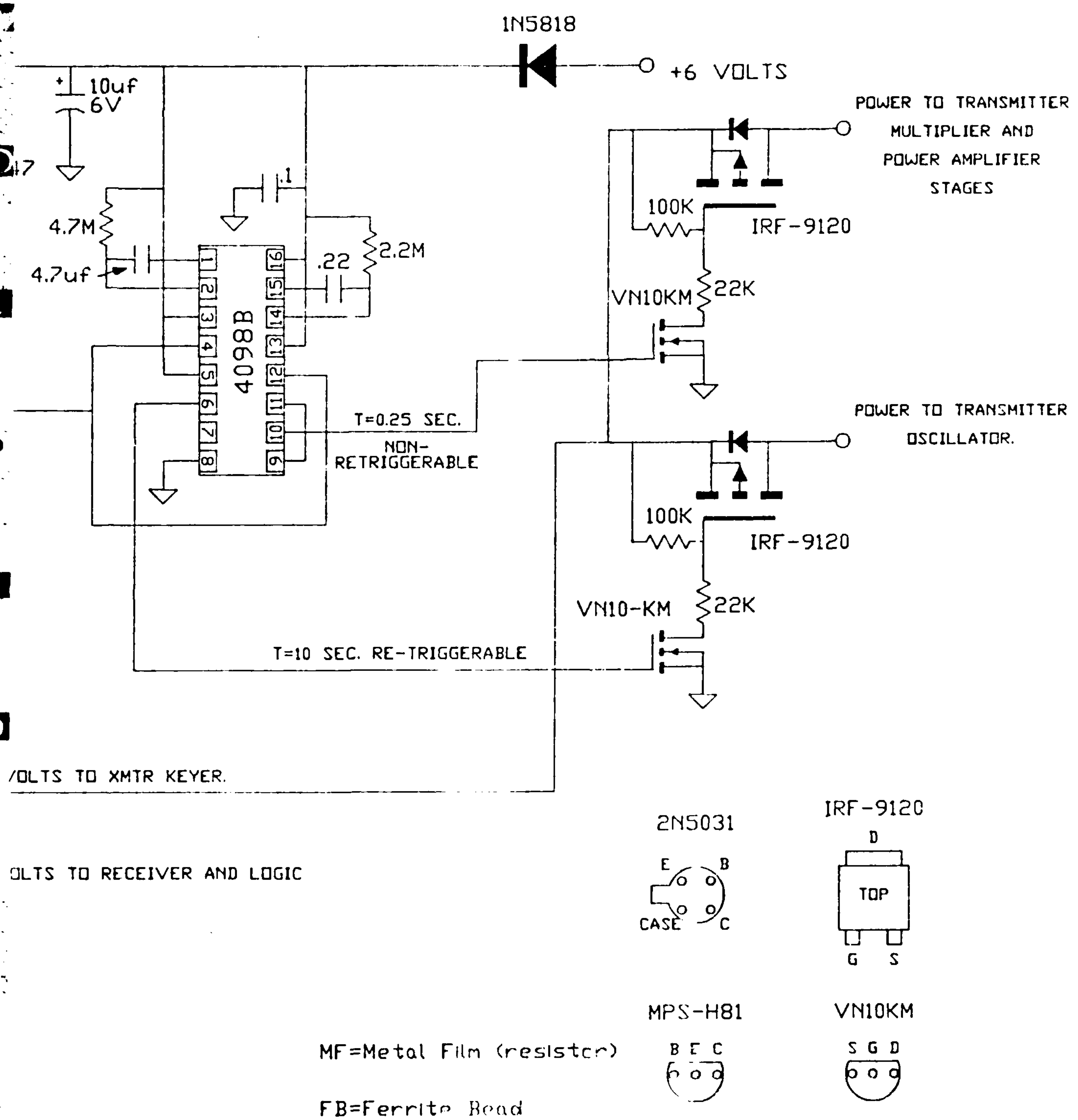

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Figure 3 Responder mounted aboard R/V ASTERIAS, December 1984.

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