TM-875
6001.000

A FAIL-SAFE SOLID-STATE WATER LEVEL DETECTION SYSTEM

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April 11, 1979

Abstract

The propensity for flooding during heavy rain storms of several miles of tunnel that contain expensive experimental apparatus, approximately twenty feet below grade, led to the invention of a water detector system. The system described in this paper is solid state in nature and is designed to alarm in the event of component failure. In addition to water sensing, power failures are also sensed, and the device is equipped with a standby nickel cadmium battery pack to allow continued operation during power outages.

Introduction

Figure 1 shows a block diagram of the water detection system. Water detection is based on the conductivity of water. The signal generator consists of a 1000Hz square wave. This signal is directed toward the detector through a resistance of 50kΩ. The signal is routed through the water sensing probe. The probe consists of two stainless steel bars, one bar carrying the signal while the other bar is system ground. The signal that goes to

the detector is the output of the probe, the detector is looking for a signal greater than the reference input. Since the detector draws very little current the input signal to the detector is:

$$E_{GENERATOR} \frac{R_{PROBE}}{R_{PROBE}+R_{GENERATOR}}$$

The resistance across the two bars of the probe when dry is very high, and equal to approximately the resistance of 1/4" of air shunted by 1/4" of G10. Hence, the received signal is approximately equal to $E_{GENERATOR}$ for a dry probe. When water enters and touches both bars of the probe the resistance of the probe drops to about 10kΩ per cm^3 for clean water. Therefore, the received signal is reduced to $1/6^{th}$ the signal for a dry probe. This difference is signal is detected and causes the output signal to turn off.

Fail-Safeness

This particular system is considered fail-safe because if any component should fail, in any mode (shorted, open) the device will alarm. This is true because all components are required alternately to turn on and then off, with the same frequency of the oscillator. This 1000Hz signal must be passed through to the output transformer where it is rectified and becomes the output signal. If a component fails and becomes static, i.e. outputs some dc value, the transformer will block the dc. The frequency of

the output LC can be tuned to accept only 1000Hz and thereby reject other frequencies. The difference between power ground ($\perp$) and system ground ($\oplus$) is important. The operating circuitry, i.e. oscillator and detector, receives the system ground from or through one bar of the probe. If the probe is left disconnected or if the ground connection is poor the circuit will cease and cause an alarm. Failure of the signal-carrying bar to conduct the signal will also result in an alarm since that is the same as water in the probe. This feature eliminates failures caused by damage to the probe (i.e. opening or shorting of either bar) and by failure to have the probe connected.

Power Failure

The detector is equipped with a nickel cadmium battery pack rated at 12Vdc, 2AH. This is enough energy to operate the detector for 48 hours, without input power. In the event of a power outage the output signal is turned on and off periodically to indicate a power failure, as opposed to a continuous alarm to indicate presence of water.

Sensitivity

The sensitivity of the detector is adjustable by virtue of the reference input to the detector. Changes in sensitivity are accomplished by adjusting one resistor. Hysteresis is employed to eliminate false triggering from noise. The probe is wall mounted and is adjustable to either sit directly on the floor of the area

to be monitored or can be raised to any height. In some areas of the Proton Lab the probes are in the drain gutters to provide very early warning.

FIRUS

When any alarm is received a signal is sent to the FIRUS monitoring system as well as being sent to a master alarm chassis in the Proton Control Room. This is especially useful during periods when there is a shutdown or we are off shift for any reasons.

Conclusion

Operating experience has demonstrated high reliability operation of the water detection system. In the first month of operation, one unit out of 15 had to have a sensitivity adjustment. The remaining 14 units have been trouble free. The fail-safe feature has proved valuable in identifying infant mortalities during initial operation. An interesting feature of this detection system is that the probes can be daisy-chained in a serial link to monitor several areas slaved to one controller. The probe is ruggedly built and can sustain unusual abuse.

Acknowledgements

I acknowledge with thanks the help of Terry Kiper for the prototype work and Marty Solis for building the probes.

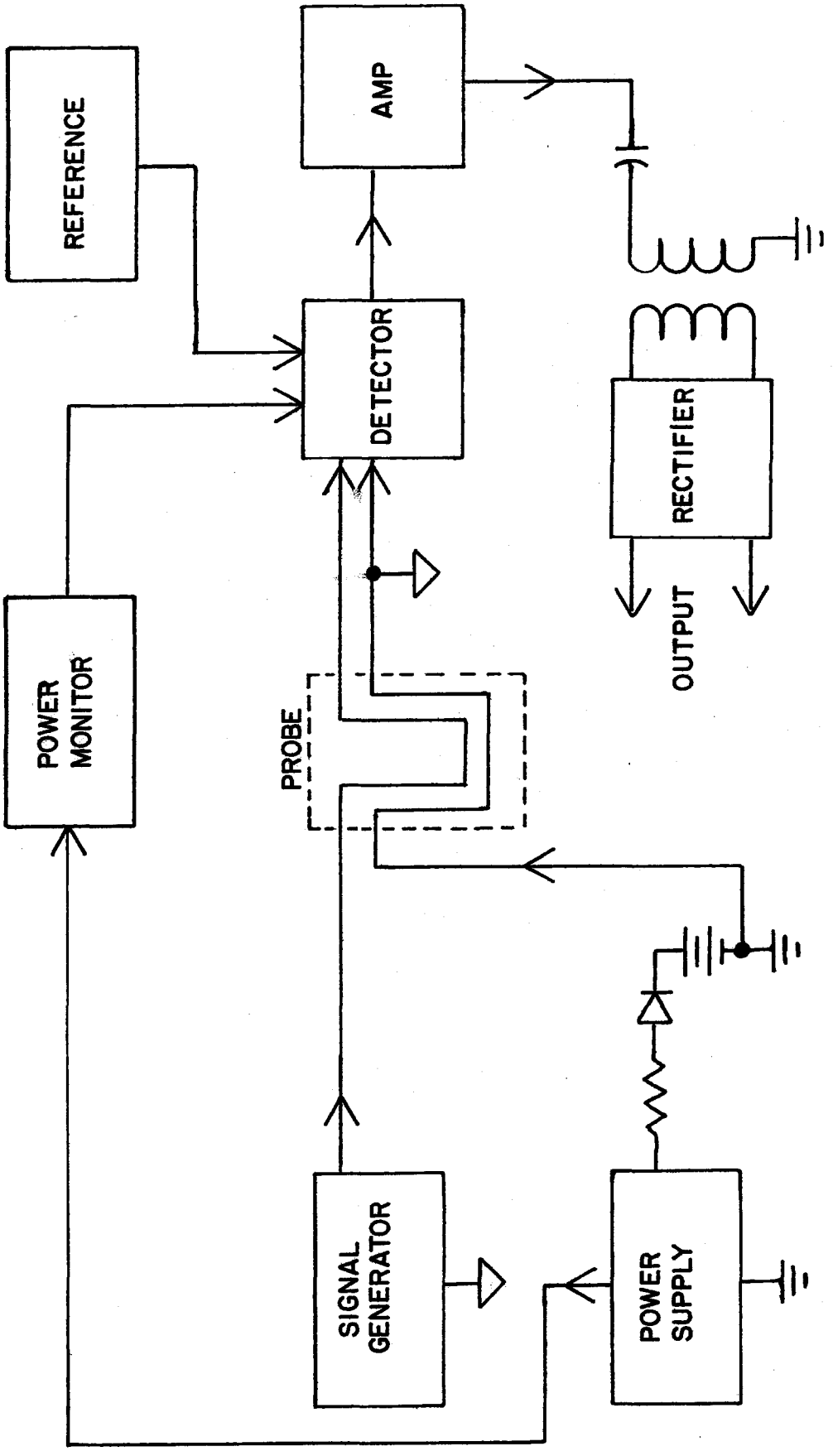
REFERENCE
AMP
DETECTOR
RECTIFIER
OUTPUT
POWER MONITOR
PROBE
SIGNAL GENERATOR
POWER SUPPLY

FIGURE 1