New Arc Detector

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During this reporting period a new arc detector was constructed and tested both on the bench and at the Venus Deep Space Station. Test data show that the new arc detector meets or exceeds the performance of the existing arc detector and has the advantages of being simpler in construction and half the physical size.

I. Introduction

The arc detector is used to protect the 100/400 kW klystrons presently used in the DSIF. It optically senses arcs that can occur in either the klystron window or further down the waveguide. The arc detector also monitors voltage standing wave ratio (VSWR), and if the reflected power increases above a set level, the circuitry will automatically remove RF drive power in less than 10 μs and beam voltage in less than 1 ms, which is more than sufficient to prevent klystron damage. Figure 1 is a block diagram of the arc detector.

The present arc detectors now in use at DSS 14 have several problems. The arc detecting circuitry (light detector)is mounted in the waveguide where it is subjected to strong RF fields and high temperature variations. The RF fields have caused false trips in the existing light detector. The old arc detector assembly utilizes a large number of components and eight relays which would sometimes fail. It is housed in two large chassis.

II. Description

The new arc detector just developed will overcome the above problems by using fiber optics (light pipes). The use of light pipes allows the light detector to be mounted in the instrument cabinet away from the klystron and in a more constant temperature environment. The light pipe consists of quartz fibers arranged into a bundle that is split into two bundles at each end. One end is split so the pipe can view both directions in the waveguide. The opposite pipe end is split so that two identical light sensing amplifiers can be illuminated. The new arc detector occupies half the physical size of the old one.

The waveguide is viewed optically for arcs using fiber optics (light pipes). One light pipe is aimed at the klystron RF output waveguide window, and the other light pipe is directed down the waveguide away from the window. The opposite ends of the light pipes are coupled to a sensitive fast-operating solid-state light detector. The light (arc) detector that is used in this unit is a silicon photodiode/operational amplifier. This device has several advantages over the photo pin diode or the photomultiplier tube (PMT). It is almost as sensitive as the PMT and much more sensitive than the pin diode used in the old arc detector. It requires a ± 15 V power supply rather than 1500 V for the PMT. Finally, it is small and easy to package and its reliability and life expectancy greatly exceed other devices. The light detector uses a pin-type silicon photodiode and a selected low-noise high-speed operational amplifier in a single hybrid package. Sensitivity is controlled by selecting the proper feedback resistor. The output voltage of this unit is linearly related to the input light power. To test this part of the arc detector a small calibrated light is activated in the waveguide near the fiber optics. For reliability there are two identical light detector channels.

Reflected power is monitored from a waveguide directional coupler. This RF power (less than 10 mW) is divided and drives two crystal detectors. The dc output from each crystal is applied to the input of a voltage comparator. This dc voltage represents the VSWR (reflected power). When the VSWR is 1.2, the reflected power is approximately 4 kW in the waveguide. The reference voltage to the comparator is set to the value corresponding to 4 kW of reflected power. When the reference and monitor voltages are equal, the protective logic circuit is activated. There are two identical reflected power channels for reliability.

The arc detector logic which the above amplifiers drive, with the exception of three transistors, utilizes all digital integrated circuits. The output from both light detectors and both reflected power amplifiers is fed to two edge-triggered flip-flops (Fig. 1). The output from the flip-flops is fed through buffer amplifiers to two pin diode drivers. They are used to control the crystal switches that turn on and off the drive to the klystrons. The crystal switches are mounted in a stripline circuit and "turn-on" is when they are conducting (forward biased). For maximum switching speed they are reverse biased (negative voltage) for turn off instead of just being allowed to decay. When both crystal switches are turned off they will provide 40 dB of attenuation. If only one is turned off, it provides 25 dB of attenuation which is more than enough to reduce the RF output from the klystron; therefore extinguishing the arc or reducing the reflected power in the waveguide. If a fault occurs in one or all channels, one or both crystal switches will be turned off, removing the drive power and, at the same time, indicating both locally and remotely which channel fired. The crystal switches are reactivated by a system interlock reset command, and can be reactivated only if the faults have been corrected. When the unit is reset, it will automatically test itself. The light detectors are test fired by turning on a small light aimed into the waveguide, and reflected power amplifiers are tested by a ramp voltage from the logic circuit. If all the channels do not test fire, the arc detector cannot be reset.

III. Conclusion

The present arc detector which this is going to replace is packaged in two chassis each 7 in. high. One chassis contains the power supply; one chassis contains the logic; and a third waveguide mounted module contains the light detector. It has several critical adjustments, several of which are on the front panel where they can be accidentally disturbed. It uses all discrete components and eight relays.

The new arc detector will be housed in one chassis approximately 7 in. high, completely self-contained, including power supplies and light detector. It uses no relays and has only three adjustments which are not panel mounted. It will be cheaper to produce and more reliable.

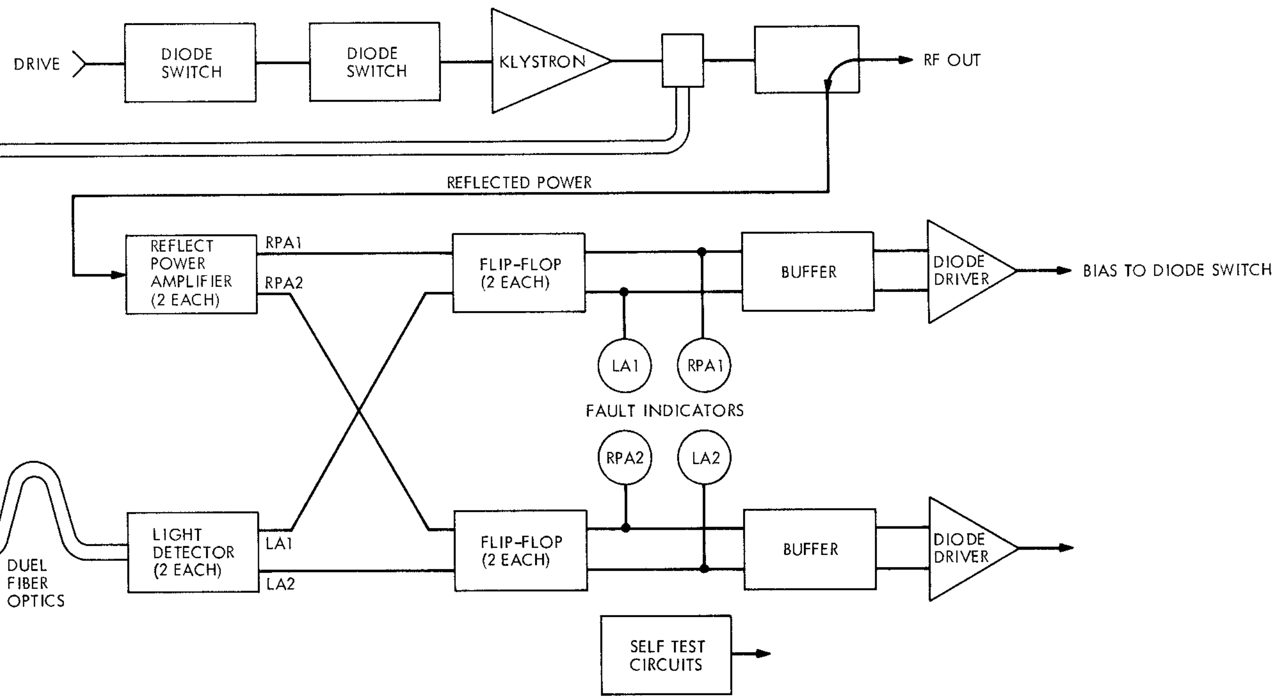

Fig. 1. Arc detector