About the Author:

Jerry Spanier is assigned to the Experimentation Division, ATC Branch, at NAFEC and usually is associated with display projects. He has done considerable work recently testing improvements and modifications to the RBDE-4 and 5 scan converter systems. This article is based upon experimentation by Jerry and others to improve the technical design and operation of the RBDE-4 and 5 equipment. This effort has resulted in a micropositioner for the RBDE-5 focus coils, the use of raysistors as remote control devices to replace the motor driven controls, and improvement of the RBDE-5 alignment procedure, all designed to improve equipment maintainability.

THE RAYSISTOR

BY
JERRY SPANIER

The need for increased accuracy of control for ATC bright display systems has resulted in the development of new and simple circuits for remote control of scan converter equipment.

Remote control capability in present equipment is provided by special motor controls. These motorized devices, found particularly in the RBDE-4 and RBDE-5 (Radar Bright Display Equipment) scan converter systems, are essentially low rpm motors, capable of being operated in either direction and attached to the shaft of a potentiometer. The pot acts as a termination, and the desired attenuation is achieved by turning the motor on in a particular direction for the time required to move the shaft and the wiper of the pot to correspond to the desired attenuation. A device of this type is shown in Figure 1.

This method of remote control is difficult to adjust to a precise video level and DC voltage level because of poor amplitude reset ability; little, if any, reference to relative or absolute amplitudes; lag, overshoot, and coast of the motor; and in general, because of poor human engineering relationships.

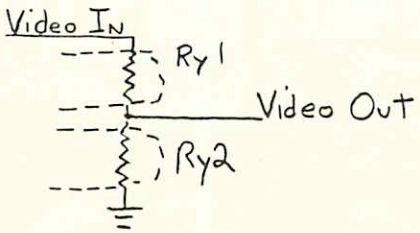
Several non-mechanical methods exist for remote gain control. Generally, they involve remote gain amplifiers, and require elaborate or complex circuits which include active devices such as vacuum tubes or transistors.

In the near future, a new type of control will be replacing many of the motorized controls in the RBDE-4 and RBDE-5 display systems, and undoubtedly will be considered for remote controls in other systems.

This control satisfactorily handles video up to 10mc, is passive, reliable, and very inexpensive compared to comparable devices. The following is a description of the application of this control to the RBDE-5.

Photosensitive resistors and sources of illumination (small light bulbs) are connected in a very simple circuit which closely approximates the attenuation circuit (Figure 2) previously used.

The key to the new circuit is a device built by Raytheon called a "Raysistor". This device is approximately the size of a IHF transmitter crystal, 3/4" by 3/4" by 3/8", and similar in appearance. It is enclosed in a metal can with four prongs on the base (Figure 3). The type used for this application contains a 100mw photosensitive resistor and a long life 25 volt 36 ma control lamp. With full bulb illumination, 25 vdc, the resistance of the photoresistor is approximately 20 to 40 ohms. With no illumination, Ovdc, the resistance is on the order of 100 million ohms (100 megohms). Herein lies the capability to provide an easily adjustable remote control. Two Raysistors are combined in the following:



The two photoresistors are placed in series.

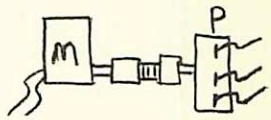


Figure 1

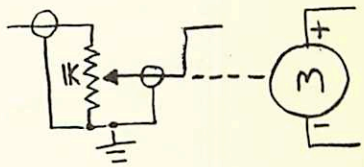
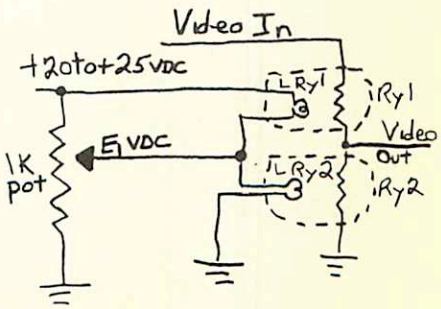


Figure 2

Power control to the Raysistors is then applied as follows:



The light sources are connected so that one has voltage E1 on it and the other has (20 - E1) on it. As the control pot is rotated, one light gets brighter as the other gets dimmer.

If the control is adjusted so that LRyl is fully off (pot maximum). then LRy2 is fully on. Under these conditions Ryl has a resistance of 100 tions Ryl has a resistance of 100 megohms and Ry2 has 20 to 40 ohms. This means that the output line is effectively at ground potential.

If we reverse the control so that LRyl is fully on and LRy2 is fully off, then Ryl has a resistance of about 20 to 40 ohms while Ry2 has 100 megohms. Thus the output line is effectively tied directly to the input line, across an impedance to ground of approximately 100 megohms.

By varying the control pot, the output line varies electrically between the ground and the input line. This, in fact, is identical to the way an ordinary pot works.

In the RBDE-5, termination for the video attenuation line is 1000 ohms. To maintain this termination, the following final circuit is used:

A one thousand ohm resistor is placed in parallel with Ryl and a 1000 ohm pot set at 1000 ohms is placed in parallel with Ry2. Now, when 1000 ohms are in parallel with 100 megohms, the resulting resistance is, for all practical purposes, 1000 ohms. When 1000 ohms are in parallel with 20 ohms, the resulting resistance is approximately 20 ohms.

Hence, the new Raysistor "synthesized" potentiometer circuit provides a variation (input to output) on a 1000 ohm range of from 20 ohms to 980 ohms. In this case the variation of input to output ranges from 2% to 98%. In most cases this variation is adequate for complete input control of a device by remote means.

In the event that a lower "off" resistance is desired, with a corresponding decrease in maximum output, the 1000 ohm pot can be decreased so that the effective parallel resistance is less than 20 ohms. In control circuits that are fed by emitter followers or cathode followers, the variation in load due to the changes in the 1000 ohm pot has negligible effect.

The photoresistor acts like a carbon resistor in its ability to pass high frequency signals without distortion. One of the most important benefits of this particular circuit is that it is surprisingly insensitive to temperature variations over the range of 10o C to 60° C. Solid state devices are notoriously affected by temperature. Temperature compensating networks by themselves can be complex. The particular configuration used with the Raysistors results in very small output voltage changes when temperature in

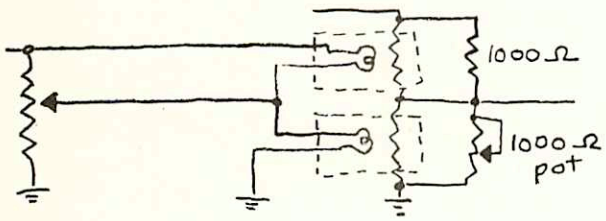
voltage changes when temperature increases. A rule of thumb is that the "On" resistance increases 20% for a temperature change from 10° C to 60° C. The "Off" resistance decreases by a factor of 10 from 10° to 60° C.

Analysis of the circuit shows that changes in the "Off" resistance have no effect on the signal voltage, and a 20% change in 20 ohms (4 ohms) means a 4/1000 or .4% change in the signal output voltage.

Tests and numerous installations bear out the circuitry, and the operation is exactly as described.

Test installations on RBDE-5's and RBDE-4's have shown that control is very accurate, resettable, provides a usable and realistic range of attenuation, and is very reliable.

Because of these advantages, the low cost of the circuit, and its acceptability and desirability by air traffic controllers, this circuit has been recommended to the Agency for use in traffic control equipment. Existing equipment is being modified, and future systems, where remote control of video and other key parameters is required, will contain similar circuits. This will further increase confidence of controllers and facility personnel in the use of bright display equipment.



The NASA has published a new group of 11 Technical Briefs on developments in the field of electronics

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