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Administrative Committee 1974-1976.....	i
Standing Committees: Chairmen and Members.....	ii
Call for Nominations.....	ii
Group Constitution and Bylaws.....	iii
Minutes of June 11, 1974 AdCom Meeting.....	xv
Honors and Awards.....	xvi
Call for Papers.....	xvii
Editor's Message.....	xviii
Luncheon Address..... <i>W. M. Harrold</i>	xx
How Computer Aided TV Remote Transmitter Design Was Accomplished..... <i>S. Choi</i>	169
One Knob Picture Control..... <i>G. Cecchin</i>	179
Horizontal Output Transistor Base Circuit Design..... <i>R. J. Walker and R. Yu</i>	185
25-V Inch 114-Degree Trinitron Color Picture Tube and Associated New Developments..... <i>S. Yoshida, A. Ohkoshi, and S. Miyaoka</i>	193
The Power Mean Frequency Estimator: Another Approach to the FM Detector..... <i>J. N. Denenberg</i>	201
A 25-Watt Monolithic TV Sound System with Refined DC Volume Control..... <i>B. Cocke</i>	206
Signal Processing for a Video Disc System (VLP)..... <i>G. C. Kenney and A. H. Hooendijk</i>	217
An Optical Video Disc Player for NTSC Receivers..... <i>R. Adler</i>	230
Integrated Circuit System for Channel Selection of Varactor Tuned Television Receivers..... <i>R. W. England, J. Puskas, and J. Collins</i>	235

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ONE KNOB PICTURE CONTROL

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INTRODUCTION:

Since the beginning of color television, a main concern has been over the complexity of customer controls. It is difficult for the average layman and even for most engineers to properly set the contrast, brightness and chroma controls for optimum picture quality. Attempts have been made to solve this problem but costs were high and the solution left much to be desired. With the advent of integrated circuits, the solution is in hand. This paper describes a monolithic integrated circuit wherein a single adjustment controls the contrast, chroma amplitude, and brightness level of the TV receiver. This control adjusts both luminance and chrominance amplitude simultaneously. DC restoration of the video signal to black level eliminates need to readjust the brightness control. The unique DC restoration function is performed in the I.C.

Alternative Approaches:

A study of the color television receiver reveals several options available for simultaneously controlling the luminance and chrominance signals. Figure 1 shows the three most applicable areas of control.

The first and most obvious approach is the controlling of the luminance and chrominance at the output of the video detector before separation of the signals. Here we would have the ideal control point since the two signals are one. The problem encountered at this point is that the burst signal cannot be varied with the chroma. This would result in critical color oscillator stability and ACC problems. Various circuits can be implemented to avoid these problems. One such circuit could be the gating of the burst to full amplitude, effectively bypassing the attenuators. This results in the gating pulse appearing in the luminance channel making it difficult to DC restore to the desired black level. Another solution would be the addition of a separate burst channel and supply ACC control to both burst and chroma channel. This would require much additional circuitry to achieve satisfactory results.

A second method of implementing a single control could be by varying the gain after demodulation, that is, controlling the red, blue, and green color signals individually. This would require the use of three closely matched attenuators, one in each of the red, blue and green channels. This approach would place a rigid requirement on the IC attenuators matching tolerances. A poor match would result in CRT tracking problems. Three separate DC restorers would also be required to control the brightness level. This would present a severe cost burden.

A third method of control would be to vary the luminance and chrominance signal independently before demodulation, but after the chroma has been processed in the chroma channel. Here, using two matched attenuators to vary the signals would have no adverse effect on the burst channel or on the ACC loop. The matched electronic attenuators required can easily be produced on a IC chip. The required component matching tolerances are well within present IC technology. A single DC voltage could control both attenuators. DC unbalance can easily and economically be restored with a single DC clamping circuit. Because of these advantages this approach was chosen in the design of the "One Knob Picture IC".

One Knob Picture IC:

The One Knob Picture IC incorporates a system where a single adjustment controls the contrast, chroma amplitude, and brightness level of the color receivers. The contrast (picture) control adjusts both luminance and chrominance amplitude simultaneously. DC restoration of the video to black level eliminates need to readjust the brightness control whenever contrast is adjusted. The DC restoration function is performed in the IC. The objective here is to greatly simplify control adjustment by eliminating interacting controls. This will produce more consistently desirable picture.

Circuit Operation:

A block diagram of the basic functions is shown in Figure 2. The single control circuit basically consists of two different amplifiers, video and chroma, whose outputs are controlled by current steering attenuators. The attenuators are electrically matched and controlled from a single source DC bias voltage. By adjusting this DC voltage via the Picture Control, the contrast and chrominance components are varied simultaneously.

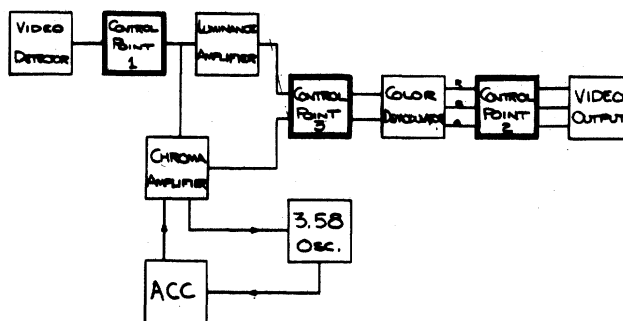


Figure 1 Control Options Available

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Cecchin: One-Knob Picture Control

179

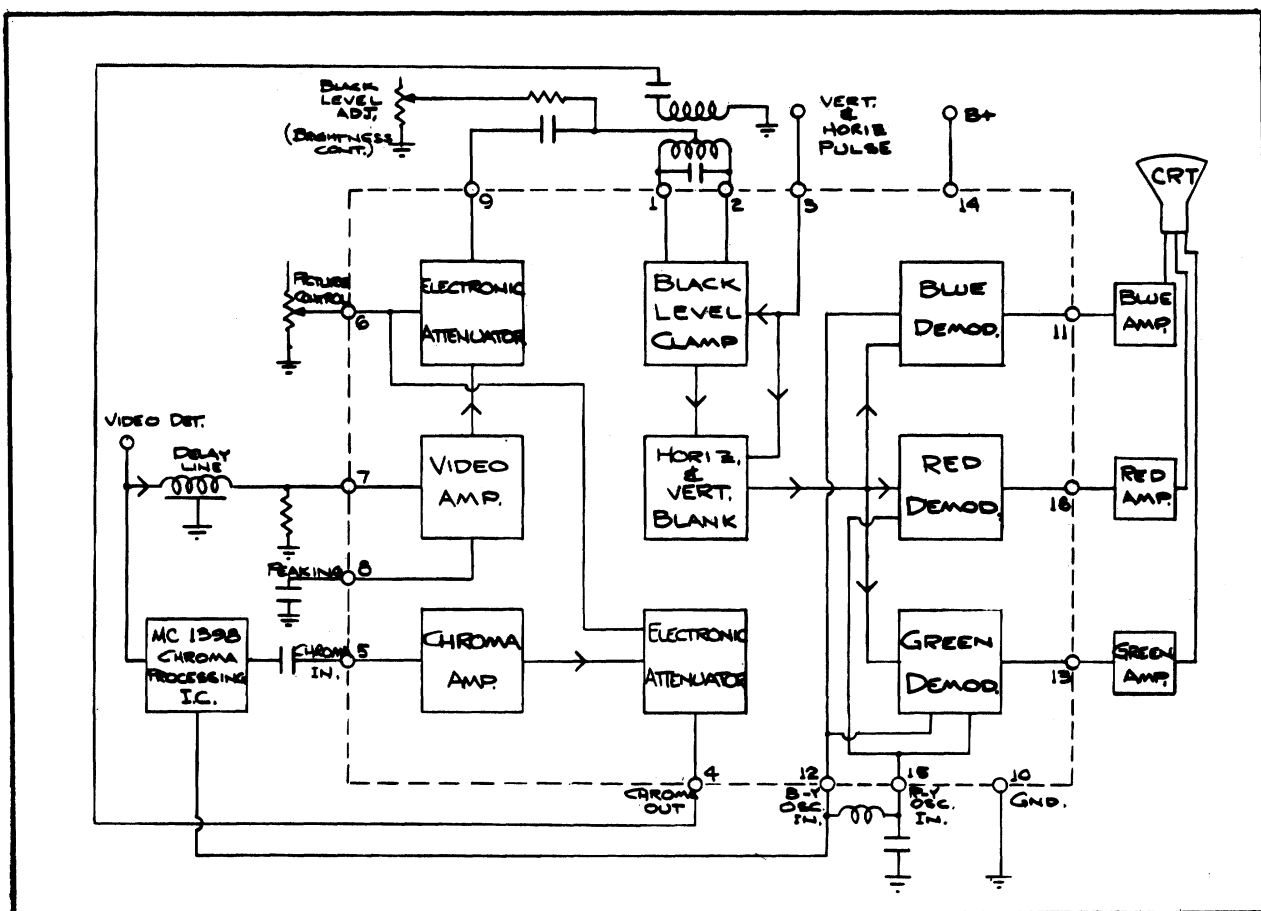


Figure 2 Block Diagram Signal Control Color IC

The adjustment of the picture control upsets the DC component of the video resulting in a change in the brightness level of the picture. By the insertion of a blocking capacitor (CB) and the addition of a DC clamping circuit, the black level is properly restored, thus eliminating need for adjustment of a brightness control. The DC restoration function is performed in the IC. Two diodes are added to the clamping circuit to bias the demodulator amplifiers into conduction. Three separate demodulators are used to reproduce the desired red, green and blue video signals. The demodulation is performed in the video output stage. The demodulators are essentially current sources feeding the video output power transistors in a cascode mode. This effectively places the video output characteristics in the IC resulting in excellent electrical and thermal matching of the three video output stages.

Luminance and Chrominance Attenuators:

A simplified diagram of the luminance and chrominance attenuators is shown in Figure 3. Transistor Q1 is the luminance amplifier and transistor Q3 is the chrominance amplifier. The modulated luminance and chrominance currents are fed to pairs of matched differential current steerers (Q4, Q5 and Q8, Q9) which are controlled from a single DC voltage source. By varying this DC voltage with

the Picture Control, the viewer adjusts the contrast, chroma and the brightness simultaneously. The Picture Control in reality varies the white level (red, blue, green) of the video while the black level remains fixed due to the action of the DC clamping circuit.

Transistors Q2, Q6, Q7 are added to reduce the DC voltage variation at the output of the luminance stage (see retrace blanking section).

The gain of the chroma amplifier is designed to be 2.8 times. Input impedance of the amplifier is a minimum of 1800 ohms. The output is driven from an emitter follower stage and is intended to drive a series tuned circuit for maximum power gain. The voltage gain of the luminance amplifier is fixed at three times. The input impedance of this amplifier is a minimum of 25,000 ohms. The output impedance is approximately 30 ohms via a darlington emitter follower circuit. The emitter of the luminance amplifier is externally accessible for use in video peaking if desired.

Automatic Picture Control:

It is a known fact that daylight viewing of a color television receiver requires higher video drive to produce pleasing pictures. Conversely, viewing in a dimly lighted room requires a reduction in video drive for optimum performance.

An important feature of this IC is that the Picture

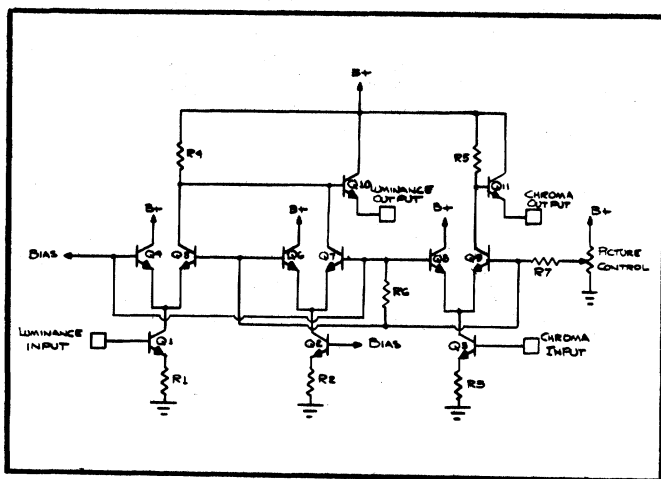


Figure 3 Luminance and Chrominance Attenuators

Control can be replaced by a light sensitive device. This will allow automatic adjustment of the video drive to correspond to change in the ambient room lighting. Figure 4 shows the circuit for controlling with a light dependent resistor (LDR). The input impedance at the Picture Control is designed to be very high (300K ohms minimum). Thus, a minimum of external components will be needed for automatic operation (one LDR and one setup pot).

Red, Green & Blue Demodulators — Outputs:

A challenge to any IC designer working in television has been to place the video output transistors into the IC chip. Due to the power and voltage requirements this task seems insurmountable. One interesting approach was used in this IC design which essentially has placed the video output stages in the IC. This was accomplished by placing the video output amplifiers in the IC as current sources and feed the high power discrete transistors in a cascode mode, that is drive the emitters of the output transistors. The bases of these discrete transistors are returned to a IC B+ (6V) supply. This approach requires a peak output current of 60 milliamp to be drawn in the IC. Power dissipation with this current with a 5.3V collector voltage is 320 milliwatts; well within the reach of most packaging requirements. Figure 5 shows the basic circuits of one of the doubly-balanced synchronous detectors. Transistors, Q5, Q6 are common emitter amplifiers modulated with the luminance and chrominance currents. These currents are supplied to transistor gates Q1, Q2, Q3, Q4 and feed into a cascode driven transistor Q7. Transistor Q7 serves to handle the high voltage (200V) and power requirement of the video output stage. With this arrangement, the gain and temperature characteristics of red, green and blue video output transistors are essentially incorporated as part of the IC. This has the advantages of the excellent matching characteristics associated with IC technology.

With the addition of transistor Q5 and resistors R4, R5, an effective control of gain (for CRT tracking) can be had. Varying resistor R5 steers current from the output load resistor R6. The main advantage of this circuit is that the gain is controlled without effecting video peaking.

Cecchin: One-Knob Picture Control

The color demodulation¹ is performed by the gate transistors Q1, Q2, Q3, and Q4. They may be considered to be two pairs of emitter coupled transistors that are utilized as synchronous switching gates. These gates serve to "steer" matched dc current sources which are modulated by appropriate luminance and chrominance signals. The collectors of these gates are cross-coupled to deliver demodulated chroma into load resistors R6 via cascode trans Q7. Gating amplitudes of 500 mv (p-p) or greater are applied to the bases of transistors Q1 and Q4. Bases of Q2 and Q3 are returned to bias. One phase of chrominance signal, plus luminance signal is applied to the base of Q5. Equal, but inverted chrominance phase, plus in-phase luminance is applied to Q6. The demodulator outputs result in full wave recovery of chrominance information (R-Y, B-Y, or G-Y) plus the addition of undistorted luminance signal. The chrominance signal gain can be controlled by adjusting the value of the emitter coupling resistor R3. This resistor controls differential gain (to oppositely phased chrominance inputs) without affecting "same phase" gain (luminance).

The gating signal phase relation is externally fixed for R-Y and B-Y oscillator injection. The green demodulator gating signal is internally matrixed by combining the R-Y and .36 (B-Y) reference voltages. The IC has been designed to operate in receivers employing illuminant "D" (6500°K) color temperature. Parker's computer program² on decoder gain and angles has been updated to include the latest CRT phosphors. This resulted in adapting the following color matrix data:

R-Y gain = 2.10, angle 82.2 degrees
B-Y gain = 2.17, angle 0.2 degrees
G-Y gain = .76, angle 245.8 degrees

The voltage gain of the R-Y and B-Y chroma signals is internally fixed at 263 times. The gain of the G-Y amplifier is set at 94 times. The voltage gain to luminance signal is designed at 94 times.

The original design had intended to use video output load resistors of 10,000 ohms. This required operation of the IC close to maximum power rating (400 MW) and anticipated use of a power IC package. The present design has been modified to reduce the video output current by one-fourth thus operating at

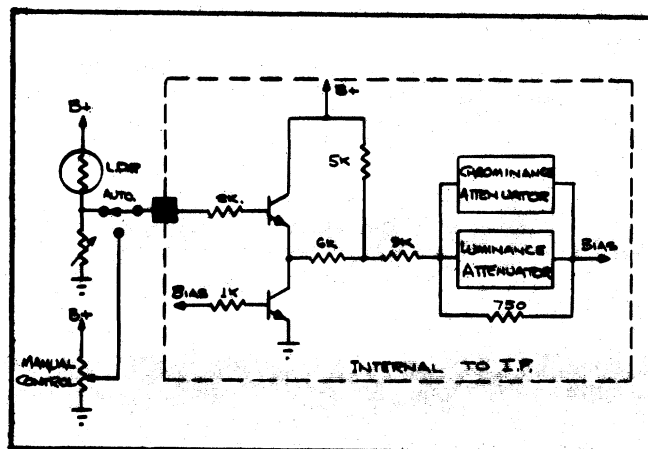


Figure 4 Automatic Picture Adjust
For Ambient Light Conditions

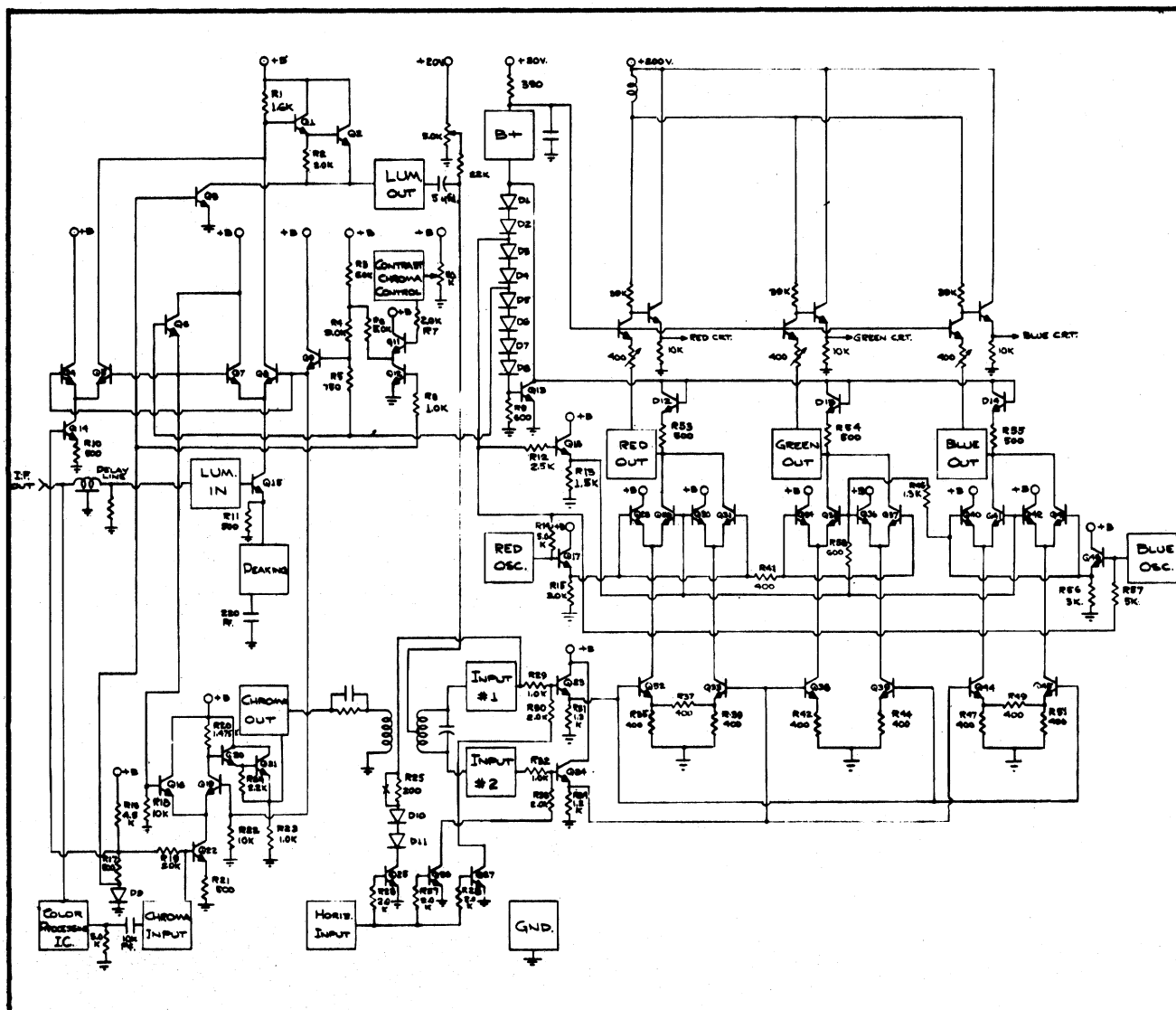


Figure 7 Circuit Diagram of Single Control Color IC

3.58 MC Oscillator Rejection:

Close matching of the demodulator's collector currents (I1 and I2 of Figure 5) is essential to prevent 3.58 MHz oscillator unbalance from appearing in the output. The most critical components in this regard are the emitter resistors R1 and R2. To assure a high degree of 3.58 rejection, these resistors have been designed to ratio within 1% of each other. This is achieved by using two mil wide resistor geometry to minimize mask variations, alignment errors and etching differences. The match of current source transistors (Q5 and Q6) are not critical if the driving impedance is kept relatively low. Gate transistor match (Q1, Q2, Q3, Q4) is no problem if sufficient gate drive is made available (500 millivolts peak-to-peak).

Calculation for the worst case rejection of oscillator indicates that we should expect no more than .5 RMS of 3.58 MHz components at the collectors of each video output. Visual observations indicate that up to 1.2V RMS of 3.58 MHz can be tolerated at the cathodes of the CRT.

Miscellaneous:

This IC makes use of 46 transistors, 14 diodes, and 58 resistors. Total chip size is 62 x 63 mils. Total current drawn by the circuit via the B plus pad is 22 MA. The regulator may draw an additional 10 MA depending on the luminance level of the video. The demodulator stages will require 2-8 MA each. Total dissipation in the IC will be about 260 milliwatts.

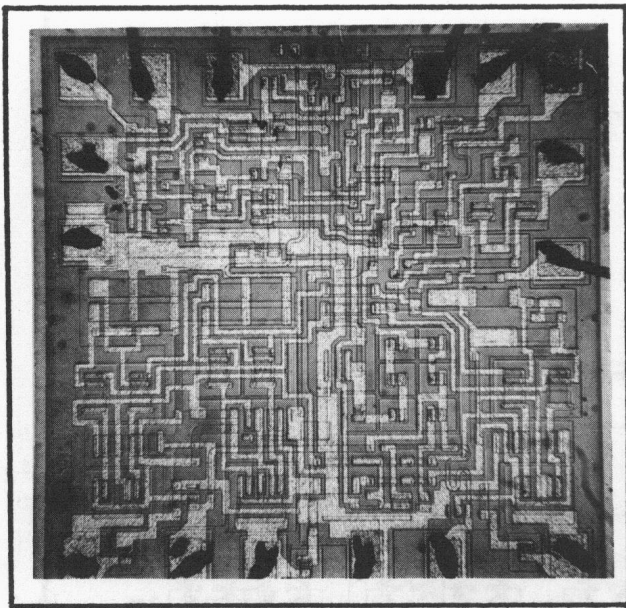
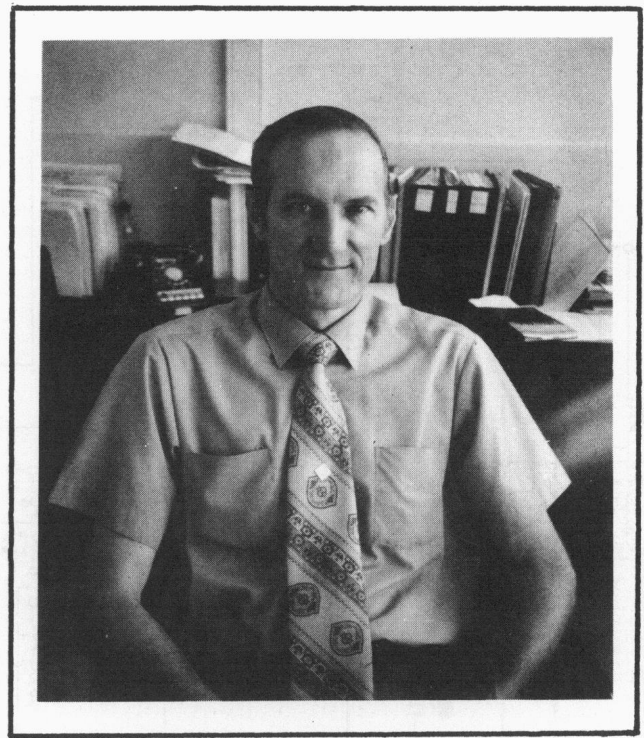


Figure 8 Photo of IC Die

Conclusion:

The use of the One Knob Picture IC definitely will improve average picture quality by eliminating critical adjustments. This circuit with the use of a light sensing device (LDR) makes it possible to design a receiver with no chroma, contrast or brightness control accessible to the user. The use of the DC clamping circuit internal to the IC results in an effective and low cost method of controlling the black level of the video. Furthermore, the integration of the video output stages into the IC relaxes the discrete power video output transistor's specifications and at the same time upgrades the electrical and thermal characteristic of the video output stages.



BIOGRAPHY Gildo Cecchin

Gildo Cecchin has been with the Motorola Consumer Products Division (Now Quasar Electronics Corp.) since 1948. He is presently a project leader in the New Technology Engineering Department and is currently engaged in IC development. He has developed several custom IC's in the color processing, color demodulation and video processing areas. He holds 10 patents and has several more pending in the television video recording and stereo-multiplex field. Mr. Cecchin is a member of IEEE and BTR, and has previously co-authored a prize winning BTR paper.

¹ For a complete treatise on color demodulation sampling theory, see "A method of Directly Demodulating Color Signals" October, 67 G-BTR Transactions N.W. Parker and F.H. Hilbert.

² An analysis of the necessary decoder correction for color receiver operations with non-standard receiver primaries, N.W. Parker, G-BTR July '66 Transactions.