

P. B. HELSDON, A.M.I.E.E, A.M.I.E.R.E

TWO NEW AMPLIFIERS FOR VIDEO AND PULSE DISTRIBUTION

INTRODUCTION

THE COMPANY HAS introduced two new transistorized distribution amplifier designs, one for video and the other for pulses. The V.D.A, which is designed to meet the exacting performance specification necessary for colour television, provides five outputs at 1 V p-p for video or 2 V p-p for sub-carrier sine waves. Six outputs of 4 V p-p pulses are available from the P.D.A, which is designed to handle this level without introducing waveform errors.

Both are built, each with an integral power supply, in a modular plug-in form. Any combination of seven can be accommodated in a $5\frac{1}{4}$ in. (13.3 cm) high frame.

CONSTRUCTION

The amplifier portion in each design is laid out on a main printed board, with an auxiliary board containing the power regulator. These boards, together with a small mains transformer are assembled on a metal chassis, which acts as an inter-amplifier screen and as a heat sink for the power regulator transistor. The integral front panel carries a pre-set gain control and test jacks connected to the input and output points of the amplifier (Fig. 1).

Seven of these module assemblies can be plugged into a frame (Fig. 2). At the rear of the frame there are seven connector panels containing: a gold-plated 16-way printed circuit connector; a protected mains connector; a mechanical interlock to prevent the accidental interchange of video and pulse modules; co-axial sockets for amplifier bridging inputs and multiple outputs; and a "coiling out" network for the video amplifier input circuit. These rear connector panels are detachable so that any combination of V.D.As and P.D.As can be assembled in one frame.

VIDEO AMPLIFIER (FIG. 3)

The video amplifier basically comprises a three-stage d.c coupled feedback amplifier with a single ended

push-pull output stage, preceded by a compound emitter follower which is capacitor coupled to the input. The use of only a single a.c coupling overall gives a monotonic response and ensures freedom from low frequency bounce troubles. Amplifiers which have capacitor coupling at both input and output often suffer from objectional l.f bounce effects when the average picture content is suddenly changed by normal mixer switching operations.

Direct current flow to the output is reduced to a very low level by the use of both positive and negative h.t supplies. Once the main amplifier bias control has been set for zero d.c at the output, this condition is maintained over a wide temperature range by the inherent d.c stability of the amplifier and regulator. Amplifiers which include output coupling capacitors to block the d.c can be inferior in this respect due to the heavy leakage current exhibited by the high capacity electrolytic capacitors necessary for a good l.f performance.

Another bias control, in the first stage, is preset so that negligible d.c flows in the gain control. This means that the gain control can be operated, "on the air" if necessary, without adding noisy flashes and bounces to the transmitted signal. The gain range is continuously variable from -1 to +6 dB.

The single a.c coupling also allows an excellent low-frequency square-wave performance to be achieved — better than 0.2% tilt per ms. This method of specifying l.f tilt is preferred to the older way where tilt was expressed as a simple percentage for say a 50 c/s or 60 c/s square wave. If the tilt is uniform, 0.2% per ms. is the same as 2% tilt for a 50 c/s square wave, but cases have been known where most of the 2% tilt took place in the first ms or so after the vertical blanking interval. This kind of tilt becomes irremovably "clamped in" after passage through subsequent line by line clamps.

A uniform high frequency response is maintained

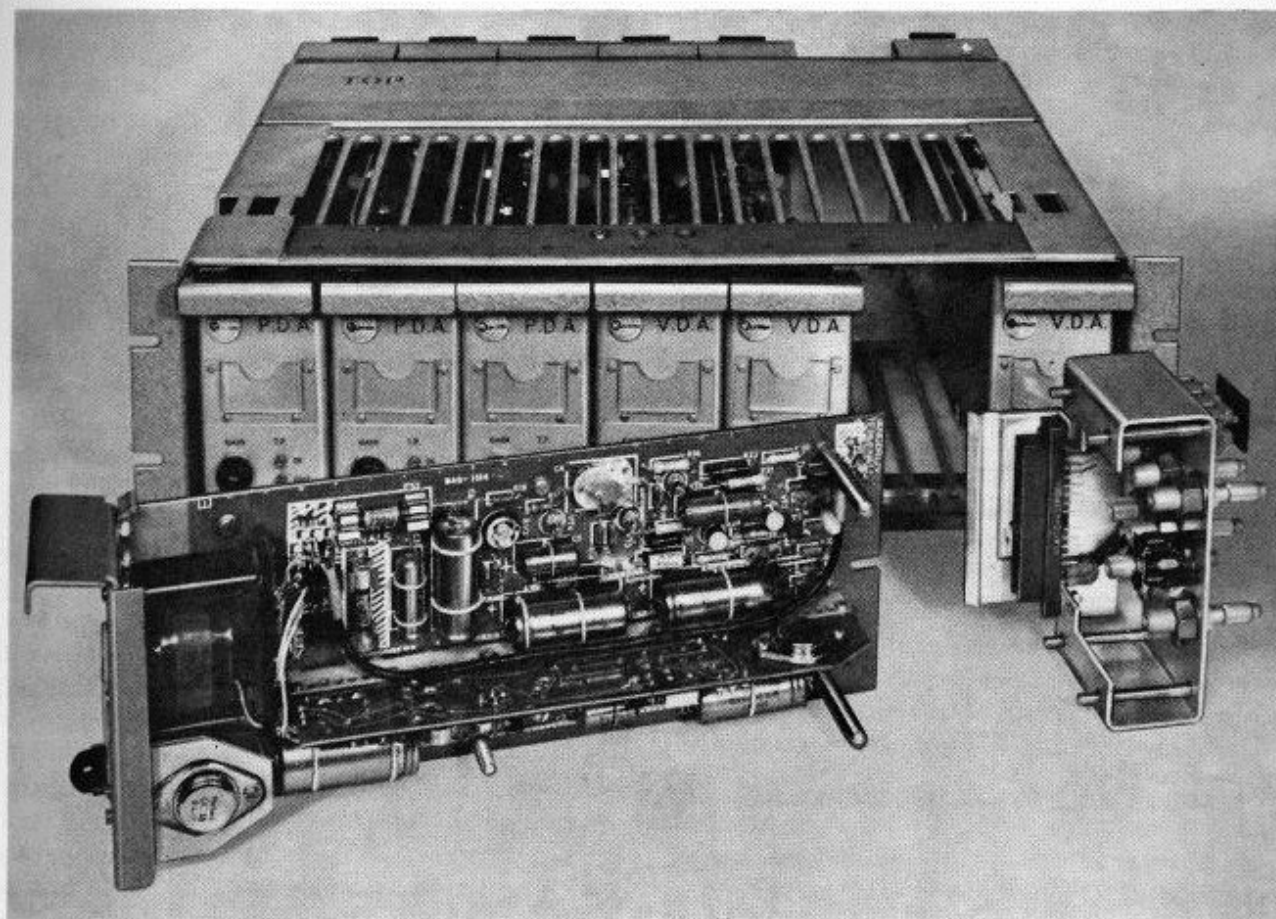


Fig. 1. Video distribution amplifier showing the modular construction.

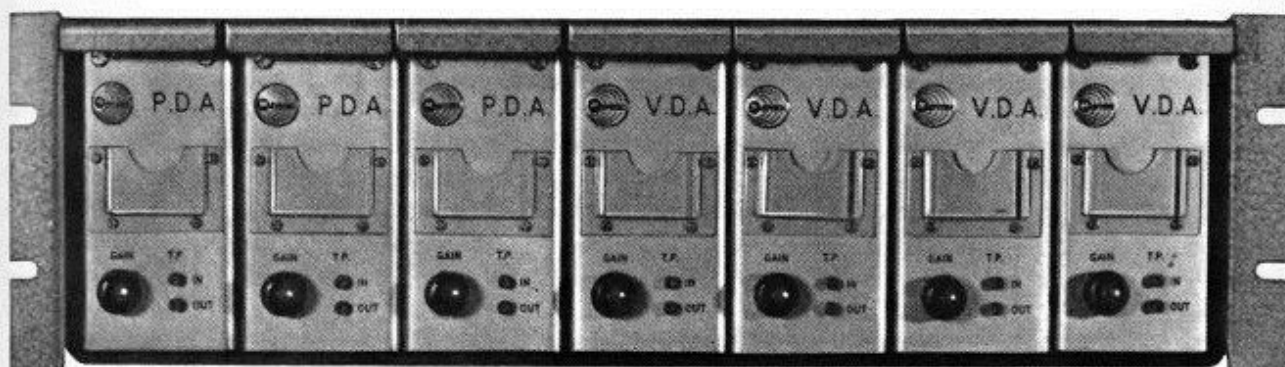


Fig. 2. Seven modules plugged into a standard frame.

overall well beyond the sub-carrier frequency; and a good high frequency transient response is ensured by the subsequent slow roll-off to beyond 10 Mc/s. Consequently the sine-squared pulse and bar K rating is too small to measure with any accuracy.

With any multiple-output V.D.A it is essential that all the outputs should be identical, so that if only one is monitored and proved to be satisfactory for level and

quality there can be full confidence that all the other outputs are the same. At the same time there must be maximum isolation between outputs, so that any accidental mis-termination on one does not noticeably affect the others. Both of these requirements are met by having a single amplifier, which has only a fraction of an ohm output impedance over the whole video spectrum, giving an isolation of better than 35 dB at

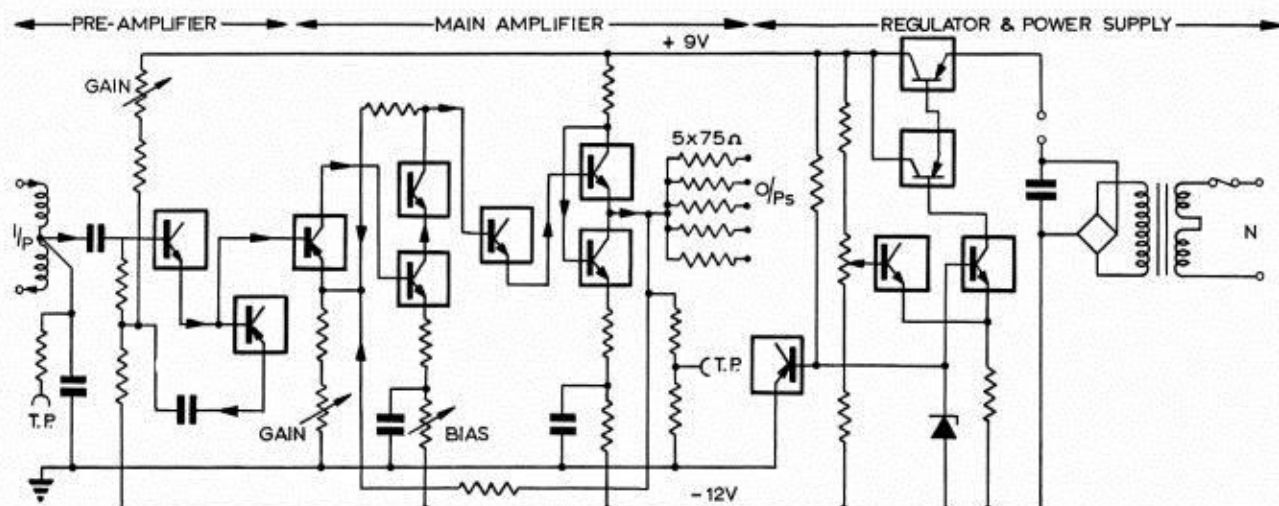


Fig. 3. Simplified circuit diagram of a video distribution amplifier.

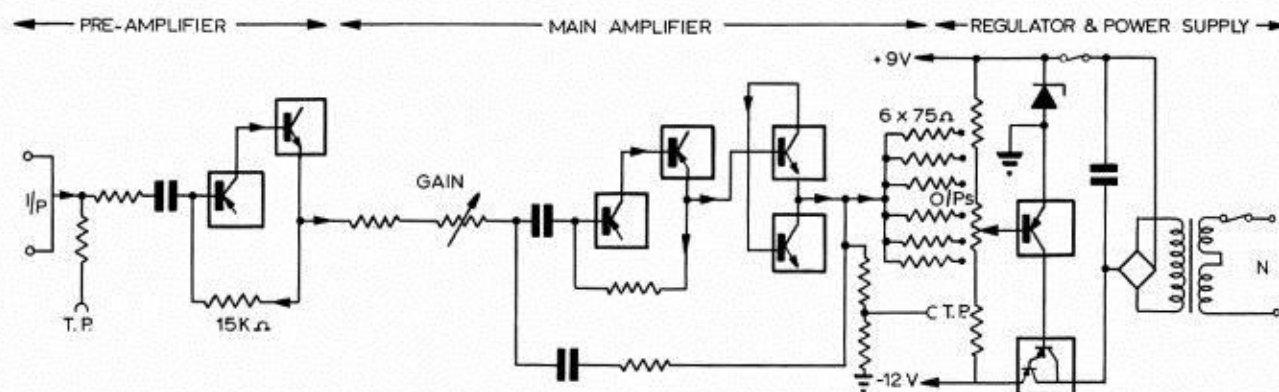


Fig. 4. Simplified circuit diagram of a pulse distribution amplifier.

5 Mc/s and 50 dB at 100 kc/s, and which feeds five precision metal-oxide 1% tolerance resistors, one to each output. The resultant sending impedances do not deviate from 75 ohms by more than $\pm 5\%$ to 8 Mc/s.

The very low output impedance of the main amplifier, together with the low distortion and closely defined gain, demand a large amount of negative feedback. Transistors of a given type exhibit a wide spread in all of their characteristics. This, together with the fact that their phase response at high frequencies can exceed 90° in one stage, makes the design of wide-band multi-stage negative-feedback amplifiers difficult.

The technique used to solve these problems has been first to define individual stage gains by local feedback, then to define the overall loop gain by a minor feedback path before applying overall feedback. This, together with the usual phase-advance capacitors and Bode networks, has resulted in an amplifier stability such that several of the five outputs or the inputs may be

accidentally removed without danger of oscillation. (The best overall performance is of course obtained when all five outputs, even if some are not in use, are properly terminated.)

The input pre-amplifier uses a compound emitter follower arrangement. The first transistor is a conventional emitter follower, but the second is used solely as a driving source to "boot-strap" the input base bias network. This reduces the signal current swing in the first transistor so that differential gain distortion is minimized, as well as increasing the input impedance to greater than 20 K ohms. The capacitive component of the input impedance is "built-out" to a constant 75 ohm impedance by means of the filter section incorporated in the rear connector panel. An amplifier module may be temporarily removed without seriously disturbing a looped-through signal.

A number of protection diodes are included in the amplifier circuits so that the input will withstand a non-useful d.c or switching surge of ± 4 V.

DIFFERENTIAL GAIN AND PHASE DISTORTION

There are two separate sources of differential phase distortion in a transistor amplifier stage. One is basically due to the transistor's non-linear input impedance which produces a phase error that is a function of the emitter current signal swing, and the second is due to the non-linear collector capacitance and is a function of the voltage gain and the resulting collector signal voltage swing. The latter distortion is only severe when there is a significant amount of internal Miller effect present.

With a single-output amplifier as described in these pages recently¹ it is possible to balance the Miller effect distortion against the first type by off-setting the working currents of one or more stages in the right direction. This method is successful where current swings are small and low power transistors, having a very good gain-bandwidth product and hence inherently low differential phase distortion, can be used. With the higher power transistors required to handle the much larger current swings necessary for a five-output distribution amplifier, care must be taken to design each stage individually for minimum distortion. In the case of those stages which do not produce voltage gain and hence no Miller effect this is largely a matter of choosing suitable transistors and operating at the optimum mean d.c. conditions. In at least one stage, however, there must be some voltage gain. If a conventional grounded emitter configuration were used, the non-linear Miller effect would produce a large amount of differential phase distortion. If this were offset by moving the working point of another stage to give a critical partial cancellation, the overall distortion might be better, but obviously any slight drift in the d.c. working conditions would rapidly increase the distortion again. Also the offset which tends to cancel differential phase distortion will often be found to increase the overall differential gain distortion unacceptably.

The problem can be solved by choosing a voltage gain stage configuration which avoids the Miller effect. There are two ways — one is to use a long-tailed pair, the other is to use a cascode pair. In both of these the voltage gain is produced by a common-base stage and is free from the non-linear internal Miller effect. Any external Miller effect due to wiring capacities or phase advance trimmer capacitors is of course linear, and does not generally cause differential phase distortion. In the present case a cascode stage has been used, and as all the other stages in the amplifier are also working at their individual optimum conditions, the bias

controls can be used for zero setting, as previously described, without seriously affecting the distortion obtained.

The circuit positions and values of the phase advance and Bode networks also have a marked effect on differential gain and phase distortion. The combination chosen gives the best overall performance for h.f. stability and minimum distortion. Production amplifiers typically give distortion figures well below the $\frac{1}{4}^\circ$ and $\frac{1}{2}\%$ specified, with an ample factor of safety.

POWER SUPPLY

The usual mains transformer primary taps, covering 100 V to 125 V and 200 V to 250 V, have been reduced to two, to simplify installation, and the range covered by use of an improved voltage regulator. Two d.c. supplies are required, but these have been obtained from a single rectifier bridge and a single series regulator, by using the reference voltage as an earth point. In the case of the V.D.A. the regulator needs to have a better performance and hence is slightly more elaborate than in the case of the P.D.A. Fuses protect the transformer primary and the regulator circuit.

THE PULSE DISTRIBUTION AMPLIFIER (FIG. 4)

The pulse amplifier will provide six outputs of 4 V p-p pulses. The design of the single ended push-pull output stage takes advantage of the asymmetrical shape of the pulses, the negative excursion available being much greater than the positive one. This could be described as a kind of class AB working and is responsible for the high power efficiency obtained. This linear amplifier approach has been used, since the even more efficient switching mode can be subject to a serious drawback if the input pulses concerned have any low-frequency errors, such as hum and tilt, added. Simple switching mode amplifiers in these cases suffer from pulse stretching and hum or tilt modulated timing errors.

The P.D.A. comprises two virtual earth (see-saw) amplifiers in cascade. The pre-amplifier has a passive input impedance of 12 K ohms shunted by 20 pF, which is effective even if the mains should fail. The input will withstand a non-useful d.c. of ± 4 V or the accidental discharge of a 100 μ F capacitor previously charged to 50 V d.c. The first stage has a small auxiliary bias regulator so that it is thoroughly decoupled from the d.c. supply. A bias control is included in the first collector circuit so that the second collector voltage can be set (via test point T1) at the correct level. The pre-amplifier is coupled to the main amplifier via the series type gain control and a blocking capacitor. The gain control may be operated during

Table 1

Performance Characteristics

	V.D.A	P.D.A
H.F Response (at unity gain)	± 0.1 dB to 6 Mc/s, not more than -1 dB at 10 Mc/s	
H.F Transient Response	Increase in rise time not more than 15% with 0.1 μ s rise time input pulse: overshoot $< 3\%$	
Output Impedance	75 $\Omega \pm 5\%$ to 8 Mc/s	75 $\Omega \pm 5\%$ to 5 Mc/s
Bounce	Not greater than 2%	
Differential Phase	$< \frac{1}{2}\%$ at 4.43 Mc/s	
Differential Gain	$< \frac{1}{2}\%$ at 4.43 Mc/s	
L.F Tilt	$< 0.2\%$ per ms	$< 2\%$ for field blanking up to 2 ms
Output Isolation	Better than 35 dB at 5 Mc/s	Better than 30 dB at 3 Mc/s
Gain Range	-1 dB to $+6$ dB	-3 dB to $+6$ dB

programmes without causing surges or flashing and provides a continuous gain range of $+6$ dB to -3 dB.

The main amplifier uses negative feedback to provide an output isolation of 30 dB at 3 Mc/s and has six precision resistors defining the output impedance of 75 ohms $\pm 5\%$ to 5 Mc/s. The output stage includes a large capacitor which acts as a reservoir for the heavy pulse current which has to be supplied for the duration of field blanking.

The overall frequency response is such that an input pulse with a rise time of 0.1 μ s is reproduced as less than 0.115 μ s and with a delay of less than 0.1 μ s. Most of the outputs or the inputs may be accidentally removed without danger of oscillation but, if any outputs are not required, they should be terminated in 75 ohms for best overall performance.

Field blanking pulses of up to 2 ms duration are reproduced with less than 2% tilt. Hum and noise at the output for unity gain is less than 2 mV p-p even when the mains voltage is 7% below the nominal value shown on the mains tap.

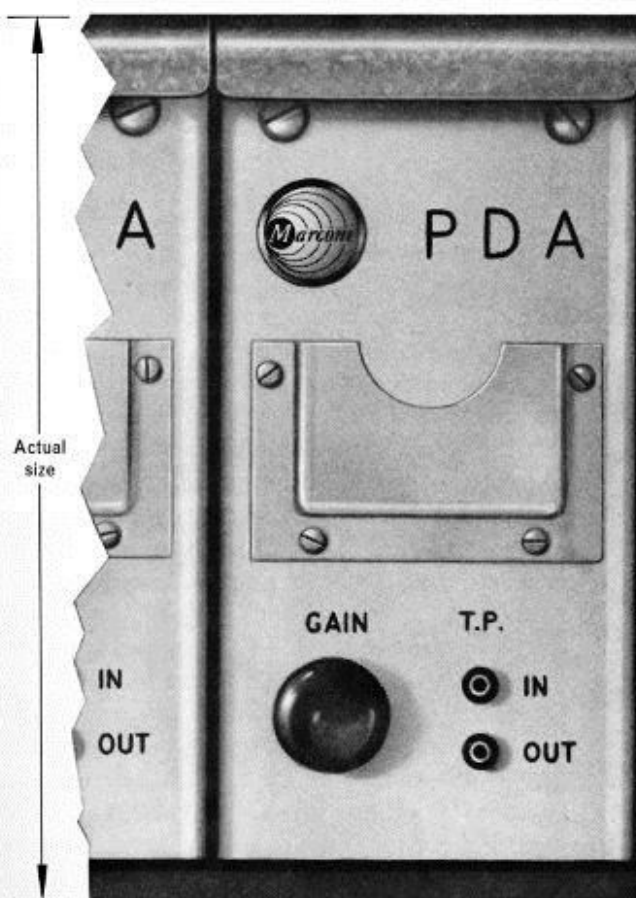
ENVIRONMENTAL PERFORMANCE

Both amplifiers have been conservatively designed with regard to transistor dissipations and give full performance for an inlet air temperature of 0°C to +45°C. A slightly reduced performance is obtained down to -15°C .

REFERENCES

- 1 R. M. GARBETT: Video amplifiers for N.T.S.C. Colour; *Sound & Vision broadcasting*, Vol. 4, No. 3, Winter 1963/4.

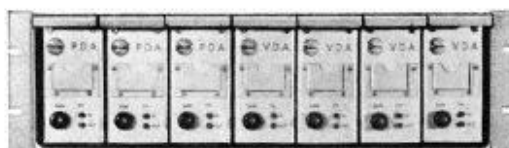
Marconi pulse and vision distribution equipment



B4002

This equipment occupies only $5\frac{1}{4}$ in. of rack height, and provides 35 Vision or 42 Pulse Output with high input isolation.

- Fully transistorized
- Integral regulated power supply in each amplifier
- Fully colour specification
- Seven amplifiers are mounted on a $5\frac{1}{4}$ in. rackframe. Vision and pulse amplifiers may be intermixed.



Complete rack

Marconi television systems

The Marconi Company Limited, Broadcasting Division, Chelmsford, Essex, England

LTD/865