DIFFERENCE AMPLIFIERS AM1/535 SERIES

Introduction

An amplifier in this series accepts two separate video or d.c. inputs, and its output is the difference between the two inputs resulting from disparity in their wave shape, amplitude or phase.

The AM1/535 is constructed on a CH1/12A chassis. The unit contains its own mains-fed power supply circuits. This version of the amplifier is intended to feed a high-impedance load such as an oscilloscope.

The AM1/535P is electrically identical with the AM1/535, but is constructed in a box suitable for attaching to an oscilloscope. Its weight is about 3 pounds. The front panel is reversible and the labelling on opposite sides serves for operating the unit in different planes.

The AM1/535A is externally identical with the AM1/535 but has additional amplifier stages to permit feeding a 75-ohm load.

The AM1/535AP is externally identical with the AM1/535P but is electrically the same as the AM1/535A.

General Specification

Max. Applied Signals

At each input	1 V p-p a.c. 2 V total d.c. and peak a.c.
Between inputs	3·5 V total d.c. and peak a.c.
Input Impedances	10 kilohms; but source impedances should not exceed 100 ohms.

Difference Gain

AM1/535, AM1/535P	−0·4 dB with high impedance load, at 10 kHz.
AM1/535A, AM1/535AP	−0·5 dB with 75-ohm load, at 10 kHz.

Common Mode Rejection

At d.c. and 10 kHz	Greater than 60 dB.
At 5 MHz	Greater than 40 dB.

Output Impedance

AM1/535, AM1/535P	About 75 ohms.
AM1/535A, AM1/535AP	75 ohms.

Hum and Noise Output	Less than 2 mV p-p.
Supply Input	200 to 250 V, 50 Hz.
Index-peg Positions	10 and 13.

Circuit Description

The amplifier circuits of the AM1/535 and AM1/535A are shown in Fig. 1, and their power supply circuit is shown in Fig. 2. The respective amplifier circuits and the power supply circuit of the AM1/535P and AM1/535AP are identical with those in Fig. 1 and Fig. 2 except for the connectors, which are detailed later.

TR3 with TR4, and TR6 with TR7, are in two emitter-coupled amplifier stages (long-tailed pairs) in cascade. Inputs to the unit are fed to the first emitter-coupled amplifier through emitter followers TR1 and TR2. The output from the collector of TR6 is proportional in amplitude and corresponds in polarity to any sensed difference in the input to TR3 relative to the input to TR4. The signal from the collector of TR6 is fed to emitter follower TR8. Negative feedback is taken from TR8 to the base of TR4, and complementary negative feedback is taken from emitter follower TR9 to TR3; this feedback reduces the overall gain to about unity, widens the bandwidth, and improves the common mode rejection (the ratio of the gain with respect to difference inputs to the gain with respect to push-push inputs). R10 and C3 modify the phase change round the feedback loop to preserve stability.

Because TR1 and TR2 are emitter followers, the impedances presented at the inputs to the unit are largely determined by R1 and R2, which are equal.

The preset controls RV1, C4, RV2 and C5 permit adjustment of the common mode balance throughout the frequency range of the unit. To enhance the common mode rejection of the first emitter-coupled amplifier, a transistor, TR5, is used to present a high dynamic impedance in the common emitter circuit. Further, a push-push signal at the first emitter-coupled amplifier is opposed by common mode negative feedback applied through

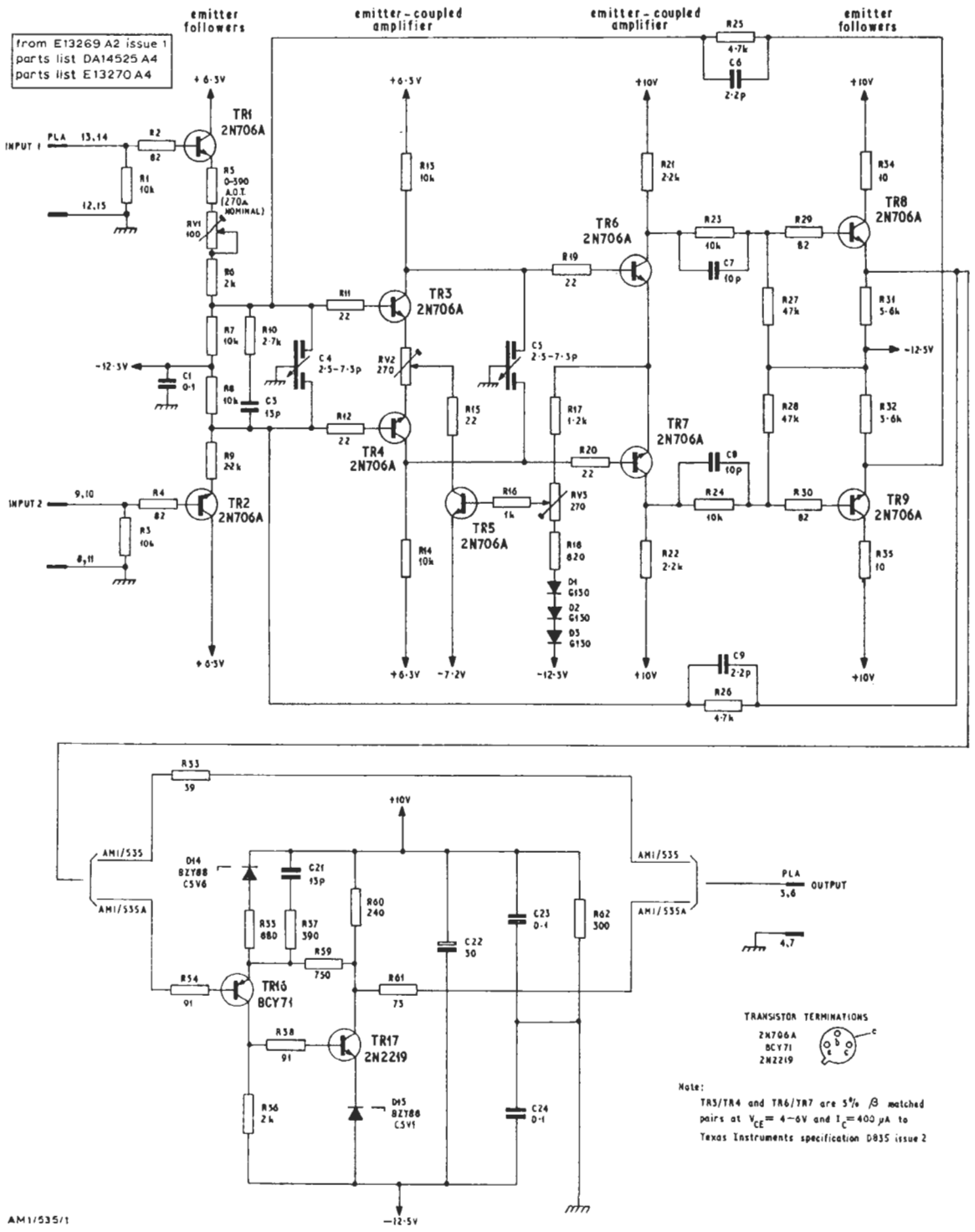

Fig. 1. Circuit of the AM1/535,A

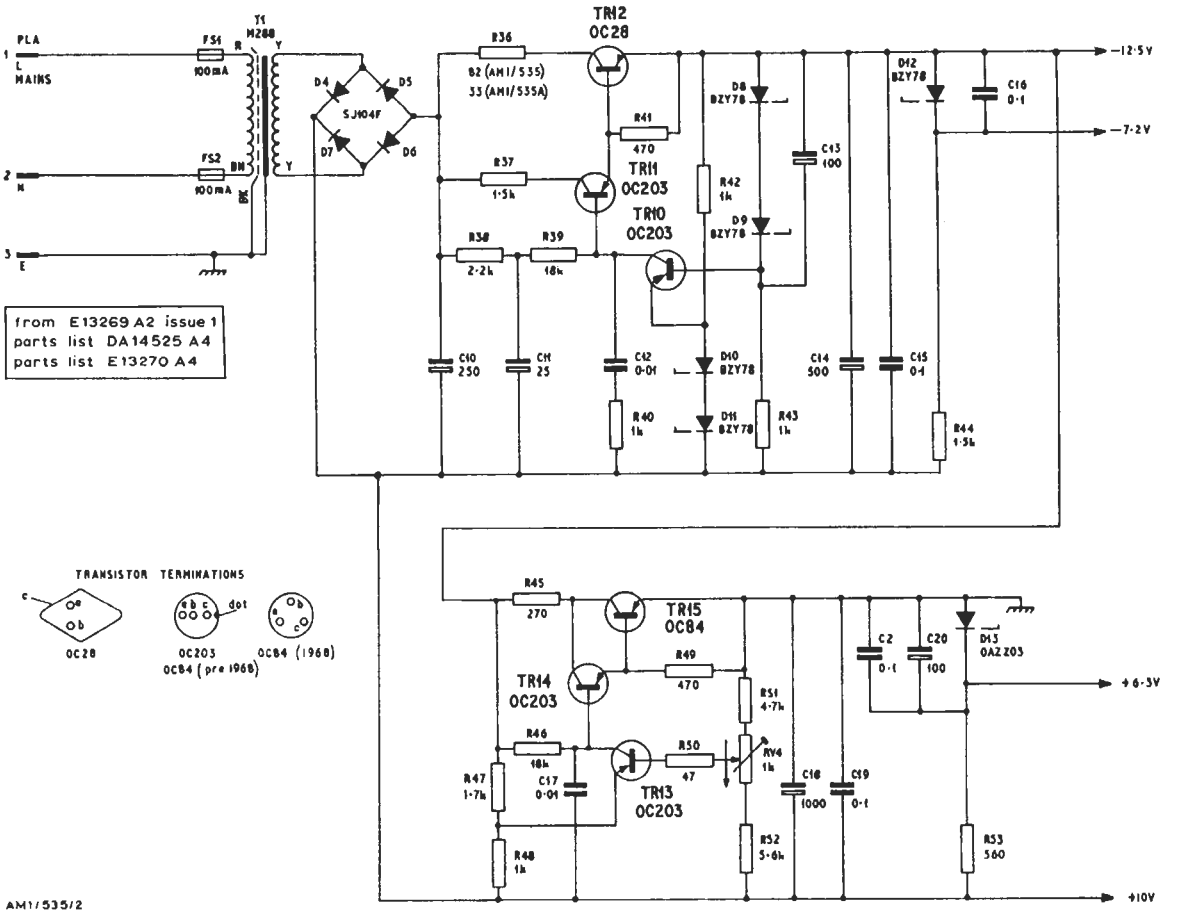

Fig. 2. Power Supply for the AM1/535

TR5 from the common emitter impedance of the second emitter-coupled amplifier; only a common mode component develops a signal across the common emitter impedance and gives rise to feedback. D1, D2 and D3 are temperature compensating diodes to preserve stability in the d.c. conditions, set by RV3.

In an AM1/535, the output of the unit is taken, through R33, from the emitter of TR8. In an AM1/535A, TR8 is coupled to amplifier stages containing TR16 and TR17 in cascade. Negative feedback from TR17 reduces the overall gain of these additional stages to unity (when the output load is 75 ohms), and also so lowers the source impedance at the collector of TR17 that the output impedance of the unit is substantially the value of R61 (75 ohms) connected between TR17 and the output connector.

In the power supply circuits, the series stabilising stage including TR10, TR11 and TR12 provides current at 22·5 volts. From this, a second series stabilising circuit, containing TR13, TR14 and TR15 provides a supply at nominally 10 volts. The arrangement and earthing of these circuits is such that sources at nominally +10 volts and —12·5 volts are formed. Adjustment of the positive voltage by RV4 produces an opposite change in the magnitude of the negative voltage.

In the first series stabilising circuit, any voltage variation on the negative rail is sensed by the base of TR10 in series with the fixed voltage drop across diodes D8 and D9.

Subsidiary supplies at —7·2 volts and +6·3 volts are fed from shunt regulator diodes D12 and D13.

In place of the single 15-pole Painton plug represented in Figs. 1 and 2, the AM1/535P and

AM1/535AP are provided with the following connectors:

Two P.O. No. 1 (Musa) coaxial plugs in parallel, for *Input 1*
Two P.O. No. 1 (Musa) coaxial plugs in parallel, for *Input 2*
One P.O. No. 1 (Musa) coaxial plug, for *Output*
One 4-pole plug, Cannon EP-4-14S, for *Mains In*
One 4-pole socket, Cannon EP-4-17S, for feeding an *Oscilloscope* with a mains supply via the difference amplifier.

The 4-pole plug and 4-pole socket are connected in parallel. When a mains lead is joined to either, the individual pin or socket numbered 1 should be used for line, 2 for neutral, and 3 and 4 for earth.

Maintenance

Power Supplies

To confirm that the power supplies are correct in voltage:

1. Power the unit from a 240-volt, 50-Hz source.
2. Connect a 75-ohm resistor across each signal input.
3. Allow 15 minutes for operating conditions to stabilise.
4. With an Avometer Model 8, or other d.c. voltmeter of similarly high resistance, check that the following potentials exist:
   +22 ±1·5 volts at the positive end of C14 relative to the negative end,
   +5·35 ±0·35 volts at TR5 emitter relative to the negative end of C14,
   +6·3 ±0·4 volts at the junction of R13 and R14 relative to chassis.

The actual voltage, relative to chassis, of the supply at nominally +10 volts depends on the setting of RV4. This control should give a range of at least ±0·5 volt, but it should be noted that disturbing its setting will necessitate readjustment to obtain zero d.c. voltage at the output of the unit when there is no input, as described later.

Transistor Replacement

TR3 with TR4, and TR6 with TR7, must be fitted as pairs, matched as specified in a note on the circuit diagram.

Checking Zero d.c. Output

When no inputs are applied, the output of the unit should be 0 ±50 mV d.c.

Check this periodically, and particularly before using the amplifier when a d.c. component in the difference output will be significant. To do this, connect a resistor of 75 ohms ±1 per cent across each signal input and test whether any d.c. voltage in excess of 50 mV exists at the output relative to chassis, after the unit has been switched on 15 minutes. If so, reduce the voltage to zero as nearly as possible by adjustment of RV4, the *D.C. Bal* control.

RV4 is on the front panel of an AM1/535 or AM1/535A, and is accessible when a bung is removed from one side of an AM1/535P or AM1/535AP.

Common Mode Rejection

In the event of replacement or disturbance of any component or wiring, check and adjust the common mode rejection as follows:

1. On an AM1/535 or AM1/535A, ensure that the cover which fits over the rear area of the unit is in position, having identified the holes through which RV1, C4, RV2, C5 and RV3 are accessible.
   On an AM1/535P or AM1/535AP, the lid must be off to allow adjustment of the preset controls.
2. Power the unit and allow time for its operating conditions to stabilise.
3. Apply a 625-line 1T pulse and bar signal to both inputs. Use a common cable from the generator as far as possible and fit a 75-ohm matching resistor in shunt where a junction is made to feed the two inputs of the unit. Make the two connections between the junction and the unit short and identical in length. A PN3A/2 or PN3A/17 cable termination block is recommended for making these connections to an AM1/535 or AM1/535A.
4. Apply the output of the unit to a wide-band high-gain oscilloscope. Set the oscilloscope to receive an a.c. input and provide a time base sweep at half or one-third line frequency.
5. Adjust RV1 to reduce the low-frequency component in the display to minimum.
6. Adjust C4, RV2 and C5 (in that order) to reduce high-frequency spikes in the display to minimum.
7. Repeat operations 5 and 6 until further reduction in low-frequency and high-frequency components cannot be obtained. C4, RV2 and C5 are interdependent in their effect, and adjustment of RV2 also modifies the setting of RV1 required. The displayed output remaining should consist of hum and noise not exceeding 2 mV p-p and some small high-frequency

spikes; the total amplitude of the hum, noise and spikes should not exceed 8 mV p-p.

8. Set the oscilloscope to receive a d.c. input. Position RV4 (*D.C. Bal*) and adjust RV3 so that zero d.c. output is obtained with RV4 near to the centre of its range.
9. Check that the common mode rejection established by operations 5, 6 and 7 is still satisfactory.

References

1. Designs Dept. Specification 8.177(65).
2. *Low-drift D.C. Amplifiers*, Semiconductor Application Reports, Vol. 1, No. 5, Texas Instruments Ltd. (Bedford, England).

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