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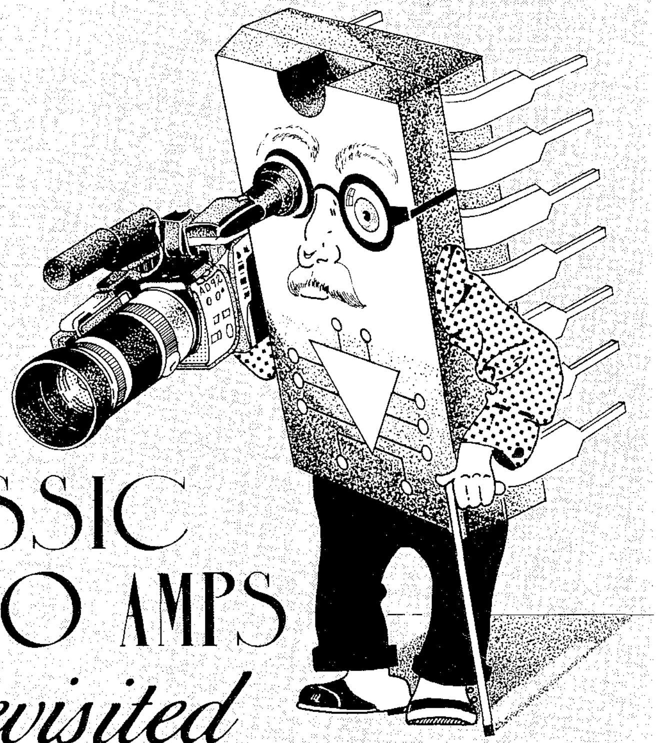
CLASSIC VIDEO AMPS *Revisited*



Learn to put mature high performance video amplifiers to work in your latest video and RF circuits.

BANDWIDTHS OF THE LATEST MONOlithic video amplifiers have now reached 600 megahertz. That performance has been achieved in differential two-stage video amplifier IC's because of recently introduced vertically integrated PNP structures. These new products have pre-empted earlier, more mature video amplifiers, including the 592 and 733, from many new designs.

Nevertheless, the 592 and 733, introduced in the early 1970's for such applications as tape- or disk-memory read amplifiers remain versatile devices. Leading-edge video amps in their day, they offered typical differential voltage gains of 400 and adjustable pass bands. Moreover, neither required frequency compensation. The typical bandwidth of the 592 is 90 megahertz while that of the 733 is 120 megahertz. Risetime on the 733 is 2.5 nanoseconds, and typical propagation delay time is 3.6 nanoseconds.

Originally developed by Fairchild as the μA592 and μ733, the parts were second sourced by IC suppliers including Motorola, National Semiconductor, Signetics, Texas Instruments, and VTC Inc. They were redesignated by those manufacturers with their prefixes such as MC1733, LM592, SE592, TL592, and VA592.

After making them for many years Motorola and National Semiconductor recently bowed out, but Signetics, TI, and VTC have confirmed that they are still producing one or both of those video amps. Both devices are available in a variety of packages including plastic and ceramic DIP's, and metal cans.

Although their performance has been superseded by newer video amps, the characteristics of the 592 and 733 remain attractive. They might no longer be at the forefront of video amplifier IC technology but they are definitely not obsolete! What's more, maturity has brought about a steady decline in pricing. Bargain prices as low as 25 cents apiece have been reported, but you can expect to pay from 70 to 90 cents for a plastic-DIP version from your distributor.

There are slight differences in performance between the 592 which was introduced in about 1974, and the 733 which was introduced a few years later. For most of the circuits in this article the 592 and 733 are pin-for-pin interchangeable. Figure 1 is the schematic of the 592, with an inset showing the circuit differences in the 733. (The 592 has two transistors in its first-stage differential amplifier (Q11 and Q12) while the 733 has only one (Q11).

Designers use both of these video amps in the differential output mode for DC applications, or with AC coupling for single-ended output. In place of external feedback to control gain, the video amps have built-in internal local feedback for operation in the open-loop mode only. Because they include only NPN transistors (as shown in Fig. 1), the outputs are always 2.4 to 3.4 volts above ground when both inputs are grounded.

Construction guidelines

You can take advantage of the low prices for these devices in your next RF- or video-circuit design if you are willing to follow some basic rules for designing and building radio-frequency circuits. So before you start to build anything, let's take time to review those guidelines.

- Use only passive components that are stable at radio frequencies. For example, use only car-

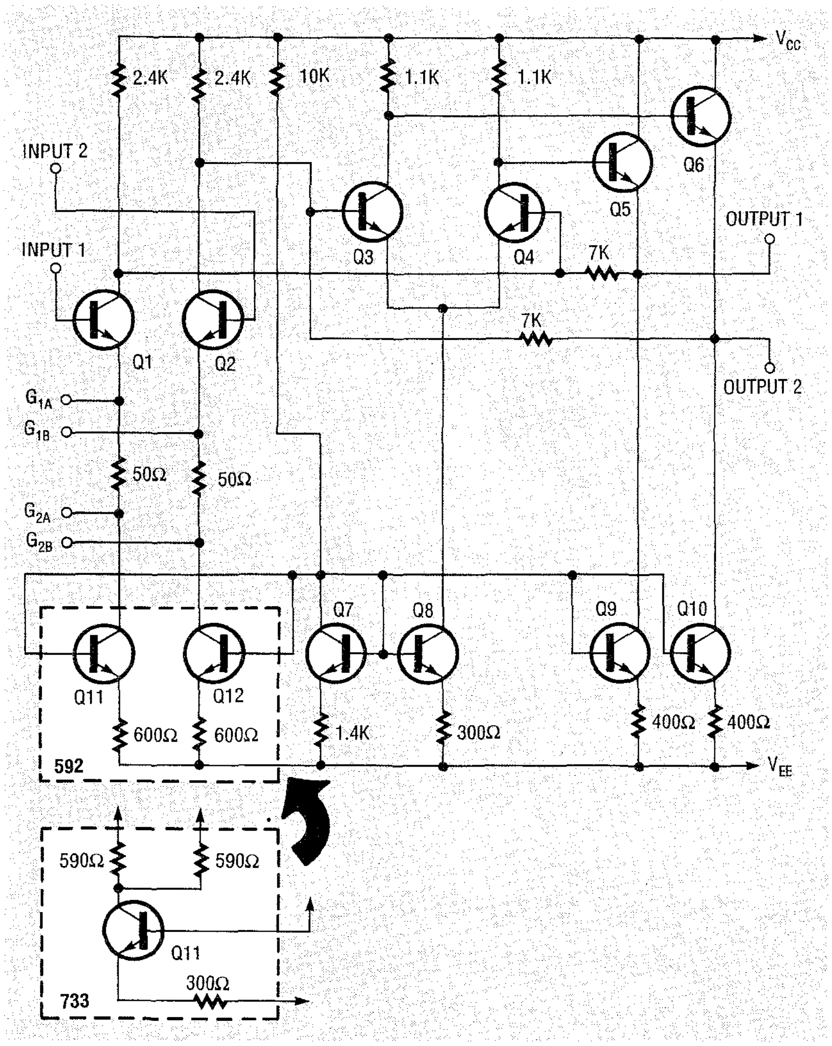


FIG. 1—SCHEMATIC FOR THE 592 with an inset showing the differences in the 733. Transistor Q11 and three related resistors replace transistors Q11 and Q12 and two emitter resistors.

bon-composition or non-inductive metal-film resistors. For small capacitance values, use only silvered-mica (rather than foil and mica), ceramic, and mylar-film capacitors. For large capacitance values, use solid or foil tantalum capacitors in place of aluminum electrolytics.

- Keep all traces on your PC boards short and wide to minimize both stray inductance and stray signal coupling from the input to the output. That precaution preserves the system bandwidth and eliminates possible circuit oscillation.
- Keep capacitance and resistor values as small as possible to minimize all unwanted time constants. High capacitance and resistance values could also cause oscillation or reduce bandwidth. This is especially true for feedback resistors. The use of resistors with values of less than 2 K is a good point of departure in resistor selection.
- Use a ground plane to keep return resistances as low as possible. Avoid point-to-point wiring but if you must use that construction technique, be sure to return all ground leads to one and *only* one point to reduce the possibility of ground loops. In circuits where large stray noise signals could show up, suitable input shielding is required.
- Each power supply lead of the video amplifier should be properly bypassed to ground with a capacitor located as close to the video-amp as possible. A 10-ohm resistor ahead of the capacitor will also help to decouple the power supply from the amplifier. In addition, if you have a problem decoupling the power supply from the video amp, try a radio-frequency choke (RFC) in place of the resistor, or slide a few ferrite beads on the resistor's leads.
- Keep the input resistance as low as possible to reduce the effects of input noise currents.

Communications applications

Both monolithic video amps will give you access to the emitters of their first differential amplifier stages (as shown in Fig. 1) via gain-select pins G_{1A}, G_{1B}, G_{2A}, and G_{2B}. By placing a variable potentiometer between the G_{1A} and G_{1B} pins (pins 4 and 11 on the DIP), you can adjust differential voltage gain over a range of 250 to 600.

With the addition of frequency-dependent components, these IC's can function as video-band active filters or RF amplifiers. Figure 3 illustrates five possible filter configurations. The components are placed across the G_{1A} and G_{1B} pins (4 and 11 on the DIP) for the out-

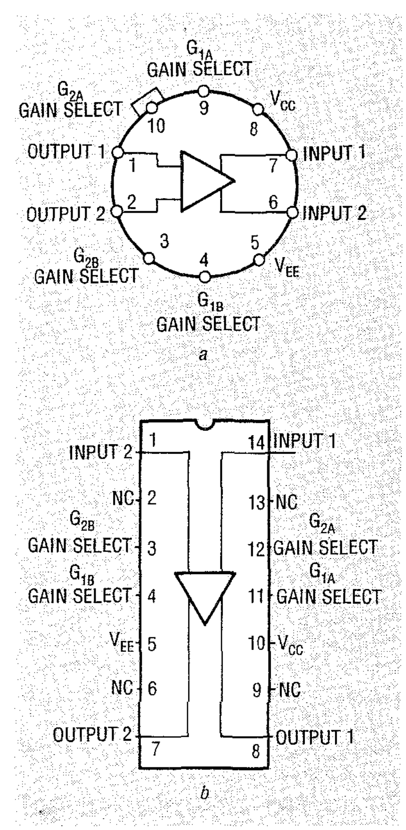


FIG. 2—TOP VIEWS OF 592 and 733 packages: (*a*) metal can and (*b*) ceramic and plastic DIP.

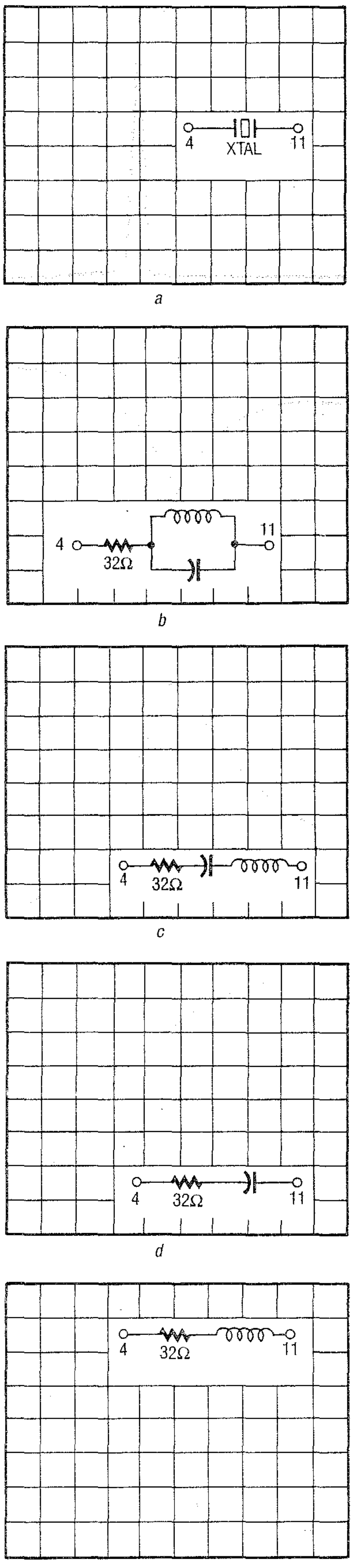


FIG. 3—ACTIVE FILTER using the 733 and 592: (*a*) crystal, (*b*) notch, (*c*) band-pass, (*d*) high-pass and, (*e*) low-pass.

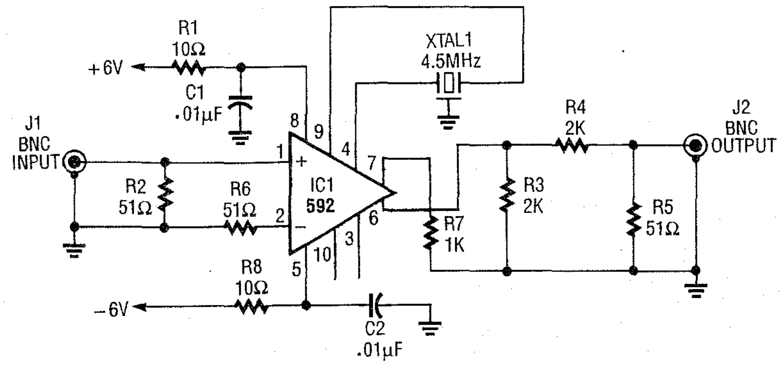


FIG. 4—A 4.5-MHz AMPLIFIER based on the 592 video amp.

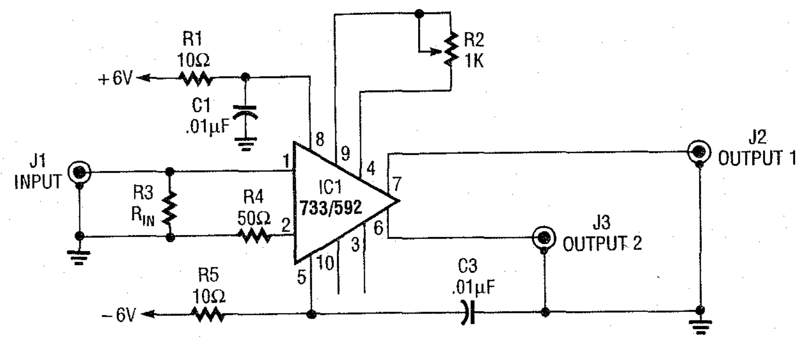


FIG. 5—A GENERAL PURPOSE PREAMPLIFIER based on either the 592 or 733 video amps.

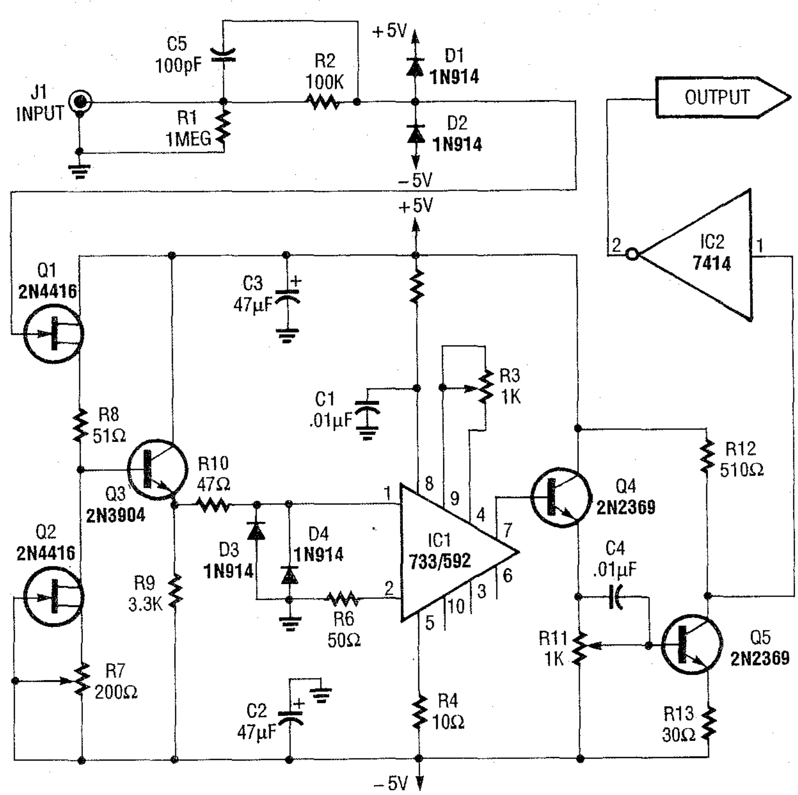


FIG. 6—FREQUENCY COUNTER based on either the 592 or 733 video amps.

put responses.

In Fig. 4, the addition of a 4.5-MHz ceramic filter between pins 4 and 9 of the 592 converts the circuit into an audio intermediate-frequency amplifier that is

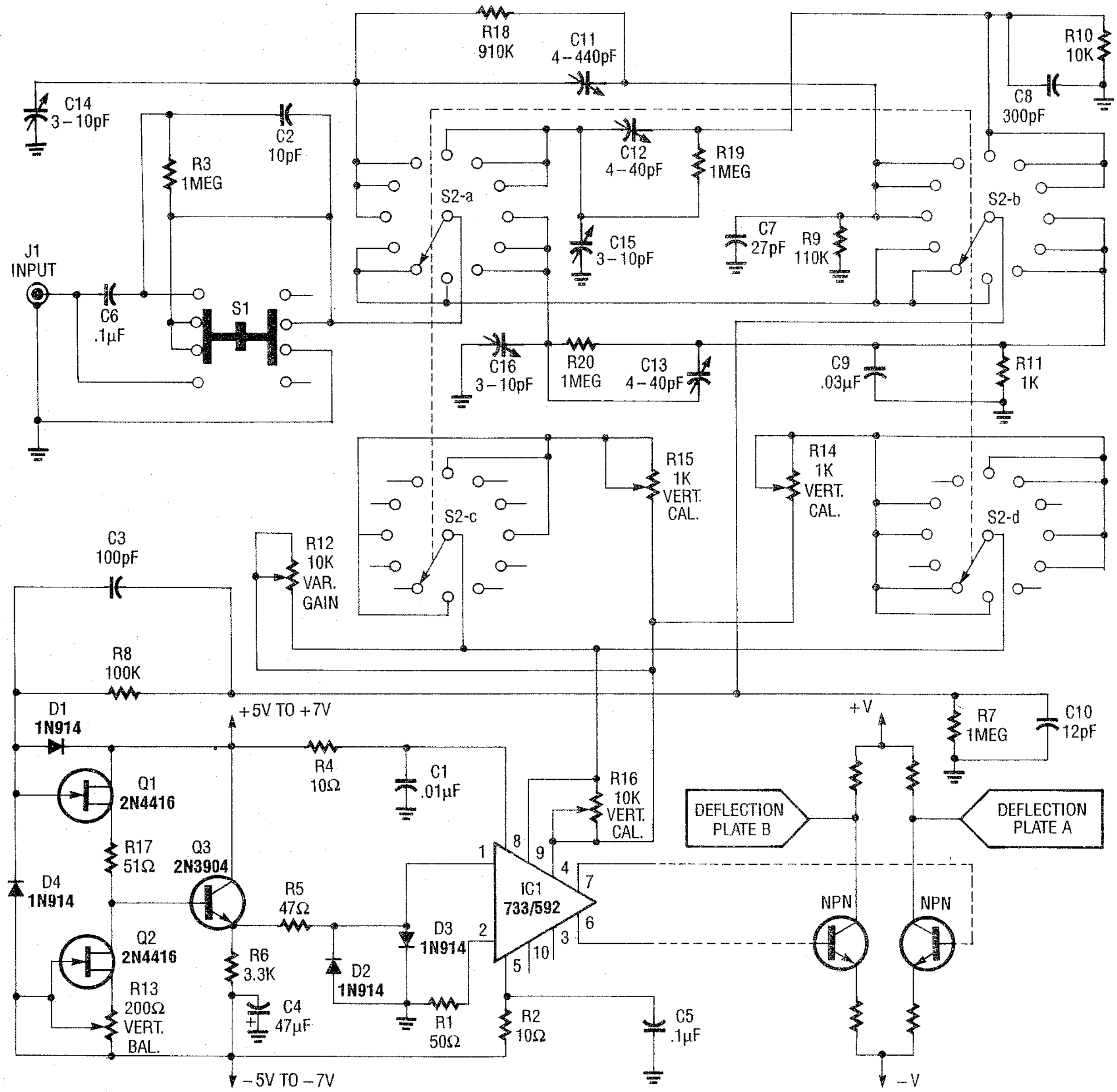


FIG. 7—OSCILLOSCOPE PREAMPLIFIER with input conditioning based on the 592 or 733 video amps.

suitable for use with TV signals. Many variations are possible. You could also place passive filters on the input, output, and gain-control pins for even better signal rejection and separation.

The 592, like the 733, permits you to control gain with an external impedance value. However, the 733's differential voltage gain (A_{vd}) can be as low as 8 with all gain- select pins open, an option not available on the 592. Thus, in a filter application, the unwanted signal will have a theoretical voltage gain of 20 dB minimum, making the 592 unsuitable for that application. However, the video amps can usually be interchanged with minimal or no modifications to your basic design.

Instrumentation applications

Because these amplifiers are wide-band devices, they are suitable for use as preamplifiers in meter and oscilloscope circuits. Figure 5 shows a basic general-purpose instrumentation preamplifier that will operate at frequencies down to DC. The preamplifier in Fig. 5 will work with either the 592 or 733. You can set resistor R3 (R_{IN}) to meet your requirements up to a maximum of a few hundred ohms. This design is limited, however, by its inherent low input impedance and high output impedance.

Figure 6 shows an improvement on the circuit in Fig. 5 making it suitable as a preamplifier for a frequency counter preamplifier. An FET buffer Q1 has been placed on the input of the 592 or 733, and the input impedance has been increased to 1 Megohm with R1. Input protection is provided by forward-biased diodes D1 to D4 which prevent input signals from overdriving the amplifier. Diodes D3 and D4 also keep the video-amp's outputs from saturating with increased switching fre-

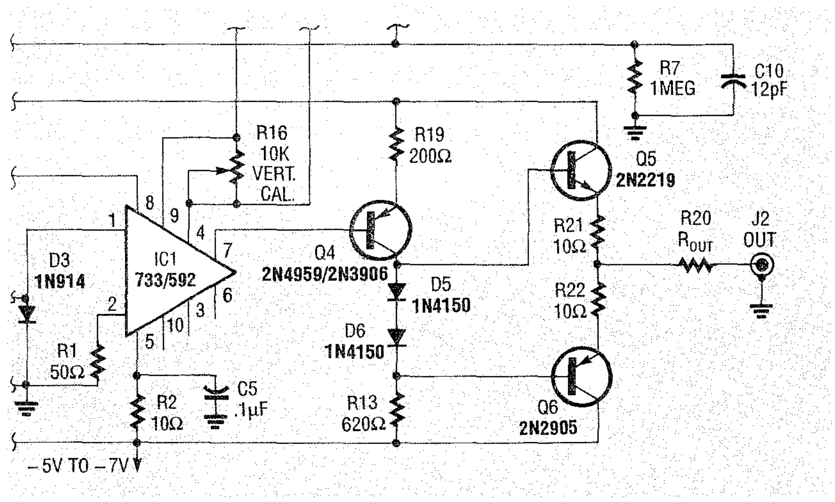


FIG. 8—SECTION OF PREAMPLIFIER circuit of Fig. 7 showing additional output compensation.

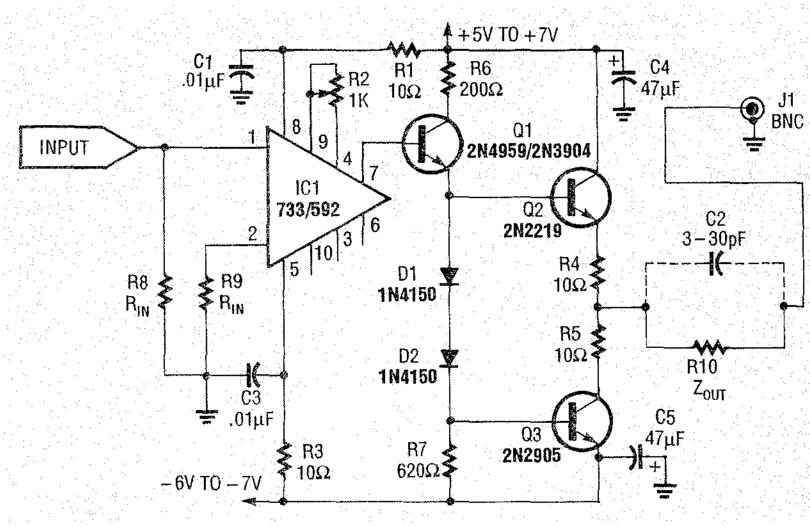


FIG. 9—GENERAL PURPOSE OUTPUT amplifier based on either the 592 or 733 video amps.

quency. The FET buffer has a bandwidth of 100 MHz so it will not restrict the bandwidth of the video amp.

For interfacing the preamplifier to TTL devices such as those found in a TTL frequency counter, the circuit in Fig. 6 also has an output buffer and TTL translator made up of Q4, Q5, and a 7414 inverter. Those will operate to 45 MHz with the gain of the 592 or 733 set to 10. (The gain pins of the 733 are left open.) To obtain measurable gain from the 592, an emitter resistor of the proper value must be placed across the gain-select inputs G_{1A} and G_{1B} (pins 4 and 11 of the DIP). Alternatively, a 1K potentiometer can be adjusted for the desired gain.

If you want to design your own oscilloscope, modify the circuit in Fig. 6 to those shown in Figs. 7 or 8. Both are oscilloscope preamplifier circuits that will operate at frequencies up to 10 MHz. In those preamplifiers more elaborate input circuits and gain- switching arrangements can produce the standard 1-2-5 calibrated oscilloscope steps with a range from 10 millivolts per division to 5 volts per division.

Figure 7 shows a method for coupling the preamplifier to an oscilloscope's vertical deflection amplifier for DC measurement without concern for the DC offset which occurs at the outputs. In that way, the equal offset at both outputs of the video amp are nulled by the common-mode rejection ratio (CMRR) inherent in the vertical-deflection differential amplifier. Capacitors C3 to C5 are input- compensation capacitors that can be adjusted with a square-wave input after the preamplifier has been completed and tested. Trimmer capacitors C14 through C16 compensate a ten-power magnification probe so that it will respond the same way to all input attenuators.

The circuit in Fig. 8 shows a modification of Fig. 7. It permits the video amp to be used in a single-output mode by eliminating the DC offset. A voltage-shifter arrangement around Q4 performs that function. With the related components shown, the output of Q4's collector is zero volts. To maintain the bandwidth of the video amp, a buffer configuration made up of Q5 and Q6 isolates the load from the high impedance of Q4's collector. The buffer will drive a 50-ohm load to 20 MHz at about 3 volts peak-to-peak. This characteristic makes it possible to couple the preamplifier to the front end of an oscilloscope near the attenuators so that the vertical amplifier can be driven through a coaxial cable.

Before placing either video-amp IC in the circuits of Fig. 6, 7 or 8, adjust the 200-ohm offset potentiometer (R7, R13, or R17, respectively) so that the voltage at the emitter of Q3 (a 2N3904) is zero. That moves the video-amplifier's output into a "ballpark" operating region.

In the frequency-counter preamplifier circuit Fig. 6, the offset potentiometer R7 and the 1K trimmer R11 at Q4's emitter will vary the threshold point of Q5, so both must be adjusted to obtain the best switching speed and bandwidth.

For communications purposes, the circuit shown in Fig. 8 can be modified once again to that shown in Fig. 9, a DC-to-20-MHz line driver. That type of general-purpose amplifier can be a variable-gain video distribution amplifier or even a broad-band local-area network (LAN) line driver.