TEKNIQUE

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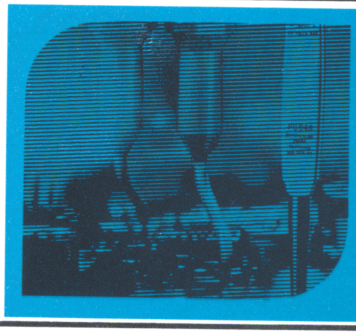

A PRACTICAL APPROACH TO

DIFFERENTIAL AMPLIFIERS AND MEASUREMENTS

In Part I of this series we examined the basic concepts of the differential amplifier and the common-mode rejection ratio (CMRR). Part II dealt with making the differential measurement. The relative merits of the ADDED mode technique and the true differential amplifier were discussed. The use of the differential comparator and DC offset were also covered. In this final article of the series we will discuss the problem of overdriving the amplifier inputs and some seldom used techniques such as the "guarded" input.

PART III

INPUT LIMITATIONS AND GUARDED MEASUREMENTS

Maximum Common-Mode Voltage

The question often arises, "what is the maximum common-mode voltage that can be applied to a differential input?" There is no set answer to this question. This will vary from instrument to instrument. However, we can get a better understanding of this question if we understand the problems involved.

There are two major problems caused by large common-mode signals:

(1) The amplifier stages may be caused to operate in the nonlinear region resulting in degradation of CMR capability.

(2) Component failure may occur in the input circuitry.

You will recall in Part I of this series there were two methods by which CMR was achieved in a differential amplifier—by the use of an active longtail, or by using a floating power supply for the input amplifier. The longtail method assumed that both the desired signal and the common-mode signal generated separate currents which were operating within the linear design limits of the active device. It stands to reason that large common-mode voltages will drive the input amplifiers into saturation invalidating the CMRR specifications. The same argument can be applied to amplifiers using the floating power supply technique. The mechanism is different but the results are the same.

Most differential comparators and amplifiers provide the operator with some indication of this condition with an overdrive lamp located on the front panel. The lamp indicates an overdrive condition from either signal and/or common-mode voltage.

Common-mode voltage normally takes two forms—a DC voltage common to both inputs, and an induced voltage, either through ground loops or EMI.

It is plain to see that this combination may damage input components, especially in those amplifiers such as the Type 7A22 that do not use attenuators in the most sensitive positions. With this fact in mind, the inputs are normally protected with the use of diode clamps and fuses (NOTE: resistor limiting is not used since component tolerance may upset symmetry). An example of this type of protection is shown in Fig. 1.

It is wise to check that the DC voltages at the point of measurement do not exceed those specified in the manual for common-mode signal conditions. If you must use probes, and invariably you will have to, use only the recommended probes for the instrument and make sure the probes are properly compensated.

The passive probes are easy to disassemble for changing the probe cable. The instructions and exploded view of the probe in the manual are helpful in describing how the probe comes apart. You may have a little difficulty in removing the probe contact pin and insulator bushing from the BNC connector end of the probe cable, especially on some of the P6006's. The usual procedure in assembly is to solder a short piece (about 5/16″) of #20 wire to the copper stud on the end of the probe cable. The insulating bushing is slipped in place over the wire, and the probe contact pin is then soldered to the wire extending from the bushing. On some probes the contact pin is crimped on rather than soldered. It is not feasible to salvage these. When you order the replacement probe cable it would be well to order some spare probe contact pins and insulating bushings.

The Needed Items

The first item you'll need for each type of probe to be repaired is a manual. This contains a complete breakdown of the probe assembly, part numbers, schematic, maintenance and calibration details and probe characteristics. Some parts are also made available as part of a subassembly as it is sometimes easier to replace the subassembly than the individual part. The manual usually lists the part number for the subassembly. If you don't have the necessary manuals, contact your nearest Tektronix Field Office.

The only special tools you will need in addition to those normally found on the workbench are a few thin open end wrenches. If not available locally, these can be manufactured by grinding down standard thickness wrenches. The manual will tell you the wrenches needed for the probe being repaired.

The test equipment needed to check high frequency compensation is dependent upon the bandwidth of the probe to be checked. If you don't have the equipment called for in the manual, contact your Field Engineer for alternatives.

CURRENT PROBES

There are three general types of current probes manufactured by TEKTRONIX: high-frequency current probes which use a current transformer permanently wired into the circuitry as a test point, clip-on AC current probes and clip-on DC current probes. We will concern ourself with only the latter two. Let's look first at AC current probes.

AC Current Probes

The two clip-on AC current probes which we will discuss are the P6021 and P6022. They are similar in construction but differ in bandwidth capability and physical size.

The most common problem encountered with these probes is dirt or some other foreign substance on the pole faces, causing poor low-frequency response or noise. The probe should be taken apart and cleaned if you have these symptoms.

The manual describes how to disassemble the probe. However, there are a few techniques which will simplify the task. The probes contain some small parts so it would be well to work with a clean cloth or piece of felt on the workbench to avoid losing parts. You will note that the thumb-controlled slider which opens and closes the transformer core, is spring loaded. As with most spring loaded devices you can experience some surprises when taking the probes apart unless you exercise care.

The first step is to remove the rubber boot at the end of the probe body. With the probe body held in the left hand, firmly grasp the boot with the thumb and forefinger of the right hand on the sides of the boot and working the boot from side to side slide it to the rear. It's a firm fit and will take a little effort.

Next, carefully lift the upper half of the probe body slightly at the rear and slide it off the front of the probe. Here's where the surprises come in. You will need to keep firm pressure down on the thumb cam of the slider or the slider spring will pop the slider out. This is especially true of the P6022. The next thing to watch for is the small metal ball setting in a detent on top of the slider. It's easy to lose this unless you're working over a surface where the ball won't roll. Remove the ball if it hasn't already fallen out.

You may have difficulty getting the top cover over the probe nose on the P6021. This is due to the insulating sleeve in the lower transformer core. Squeezing the top and bottom of the front portion of the top cover will help in removing the cover. Remember this also when you reassemble the probe.

To remove the slider it's best to turn the probe so that the slider portion is on the bottom. This prevents the components in the slider from falling out. With the P6022, you will probably want to remove the spring and spring retainer before turning the probe over to remove the slider.

It is a simple matter to remove the printed circuit board and current transformer in the P6021. After removing the two Phillips-head screws securing the plastic spring retainer, just pull up gently on the cable at the rear of the probe. Lift the circuit board, transformer, and cable straight up out of the probe body as a unit. A scribe can be used to work the header free at the front of the circuit board if necessary. When replacing the Phillips-head screws, tighten them so they are just snug; excessive torque will strip the plastic threads.

It's a little more of a chore to remove the board and transformer in the P6022. There are two points you will need to unsolder before lifting out the cable, board, and transformer as a unit. You should use a small iron to avoid applying excessive heat to the cable and printed circuit board.

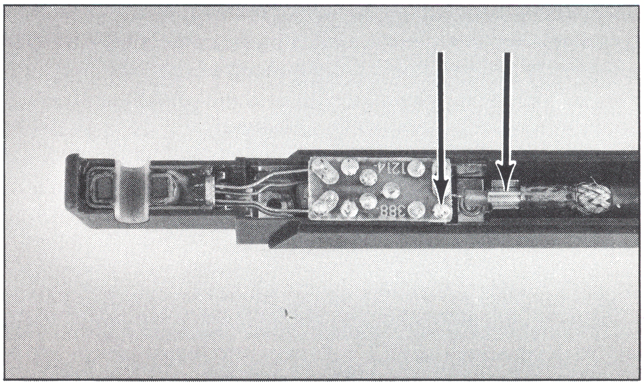

Fig. 3. *Arrows point to the two points to be unsoldered in the P6022 when removing the cable, circuit board and transformer.*