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AM 502
DIFFERENTIAL AMPLIFIER

Francais Deutsch 日本語

INSTRUCTION MANUAL

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Product Group 75

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INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektronix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

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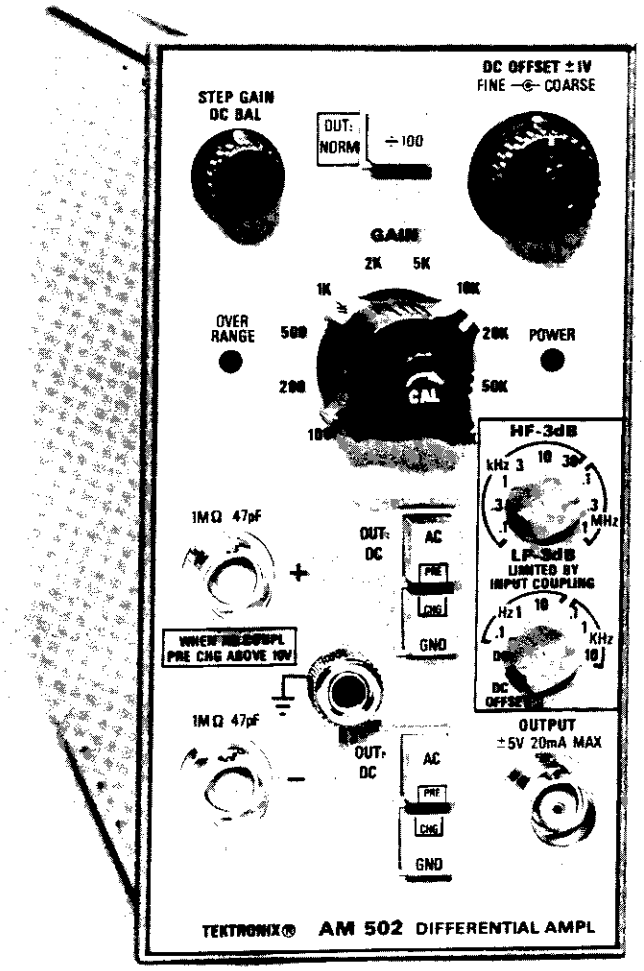


1582-1

AM 502 Differential Amplifier plug-in module.

OPERATING INSTRUCTIONS

INTRODUCTION

Description

The AM 502 is a dc-coupled differential amplifier with excellent common-mode rejection capabilities and high gain for low voltage measurements. The dc offset capability permits nulling up to 1 volt dc, so that low level, low frequency signals impressed on a dc level can be amplified without the degradation often introduced by ac input coupling. High and low frequency −3 dB points can be selected at the front panel to suit the application. Signal inputs and outputs are available at the rear connector as well as at the front panel. A front panel lamp indicates most overrange conditions of excessive input signal, excessive gain, or excessive offset.

The input circuit can be represented by approximately 1 megohm to ground paralleled by approximately 47 picofarads. The input impedance can be raised to about 200 megohms with the removal of a jumper.

Overload protection is provided by fuses in series with the input which open when large amounts of current flow due to overloading conditions.

A STEP GAIN DC BALANCE control is provided to adjust for zero shift as the gain switch is changed from one position to another.

The DC OFFSET COARSE and FINE controls give offset up to ±1 volt dc potential difference at the input connectors. The amplifier internal bias is changed to accomplish the offset. The LF −3 dB switch must be in the DC OFFSET position to actuate these controls.

The HF −3 dB switch is used to reduce the upper bandwidth limit as necessary to improve the signal-to-noise ratio when using the AM 502 in low-frequency applications. The LF −3 dB control increases the lower bandwidth frequency.

Use of the pre-charging feature prevents surge currents, due to charging the ac coupling capacitor, from damaging the circuit under test.

Installation and Removal

CAUTION

Turn the power module off before inserting the plug-in; otherwise, damage may occur to the plug-in circuitry. Because of the high current drawn by the AM 502, it is also recommended that the power module be turned off before removing the AM 502. Refer to Fig. 1-1. Check to see that the plastic barriers on the interconnecting jack of the selected power module compartment match the cut-outs in the AM 502 circuit board edge connector.

Align the AM 502 chassis with the upper and lower guides of the selected compartment. Push the module in and press firmly to seat the circuit board in the interconnecting jack.

To remove the AM 502, pull on the release latch located in the lower left corner, until the interconnecting jack disengages and the AM 502 will slide out.

Controls and Connectors

Refer to Fig. 1-2. Even though the AM 502 is fully calibrated and ready to use, the functions and actions of the controls and connectors should be reviewed before attempting to use it. Pull the Power switch on the power module to apply power to the AM 502. The POWER indicator light indicates when power is applied to the AM 502.

OPERATING CONSIDERATIONS

Overheating

The AM 502 is designed to operate at an ambient temperature from 0° to +50° C. However, when operating several power supplies in a multi-plug-in power module, especially at low output voltages, or when operating close to other heat-producing equipment, internal temperature may exceed safe limits and actuate a thermal cutout in the power module. Refer to the power module instruction manual for more complete information.

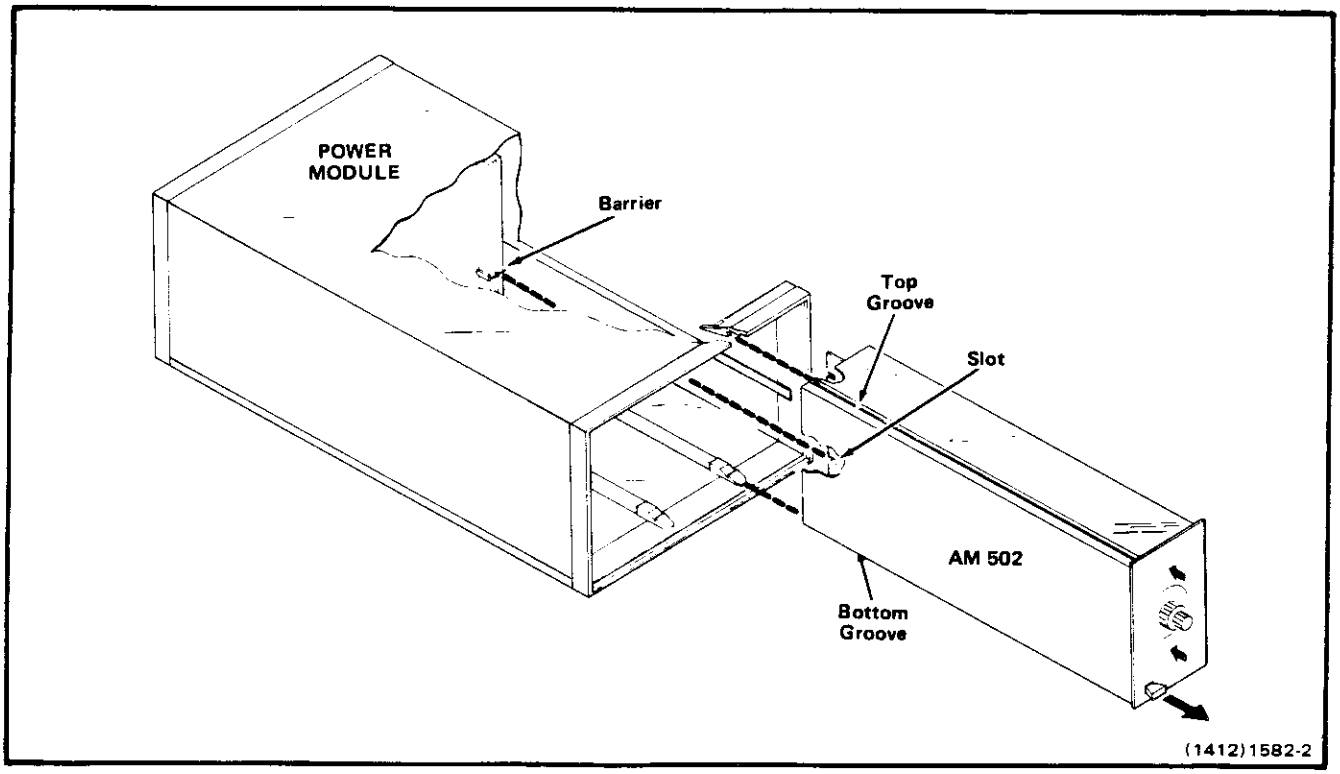


Fig. 1-1. Plug-in installation and removal.

Input Connections

Unshielded test leads can be used to connect the AM 502 to a signal source when a high-level, low-frequency signal is monitored at a low impedance point. However, when any of these factors is missing, it becomes increasingly important to use shielded signal cables. In all cases, the signal-transporting leads should be kept as short as practical.

When making single-ended input measurements (conventional amplifier operation), be sure to establish a common ground connection between the device under test and the AM 502. The shield of a coaxial cable is normally used for this purpose. See Fig. 1-3 for reference. Push the GND button for the input not connected to the device under test.

In some cases differential measurements require no common chassis ground connection, and therefore are less susceptible to interference by ground-loop currents.

Consider the change in the source operating characteristics due to loading by the signal input cables. The circuit at the input connectors can be represented by approximately 1 megohm to ground paralleled by approximately 47 picofarads. Two feet of 50 ohm coaxial cable increases the parallel capacitance by about 60 picofarads, which could be excessive in many situations. To minimize these effects, use a higher impedance cable or an attenuator probe.

Probes

Attenuator probes decrease the resistive-capacitive loading of a signal source. They also extend the measurement range of the AM 502 to substantially higher voltages. Some measurements require a higher resistance input to the AM 502, with very little source loading or signal attenuation. In such situations use a FET probe or the high-impedance input provision of the AM 502. Contact your Tektronix Representative for further information on probes.

High Impedance Input

To raise the internal input impedance of the AM 502 to about 200 megohms, remove the P40 plug (Fig. 3-1). Make certain the attenuator is in the NORM mode. Signal source impedance now becomes an important factor. For example, a 100 picoampere gate current through 10 megohms produces a one-millivolt offset. This offset may result in significant error when small voltages are measured.

Input Overloading

When measuring unknown dc voltages, push the ÷100 pushbutton in, and start with the 100 position on the GAIN switch. Increase the GAIN switch setting and finally release the ÷100 pushbutton until a suitable output signal is obtained. If the input circuit of the AM 502 is overdriven, large amounts of current will flow, opening the protective fuses.

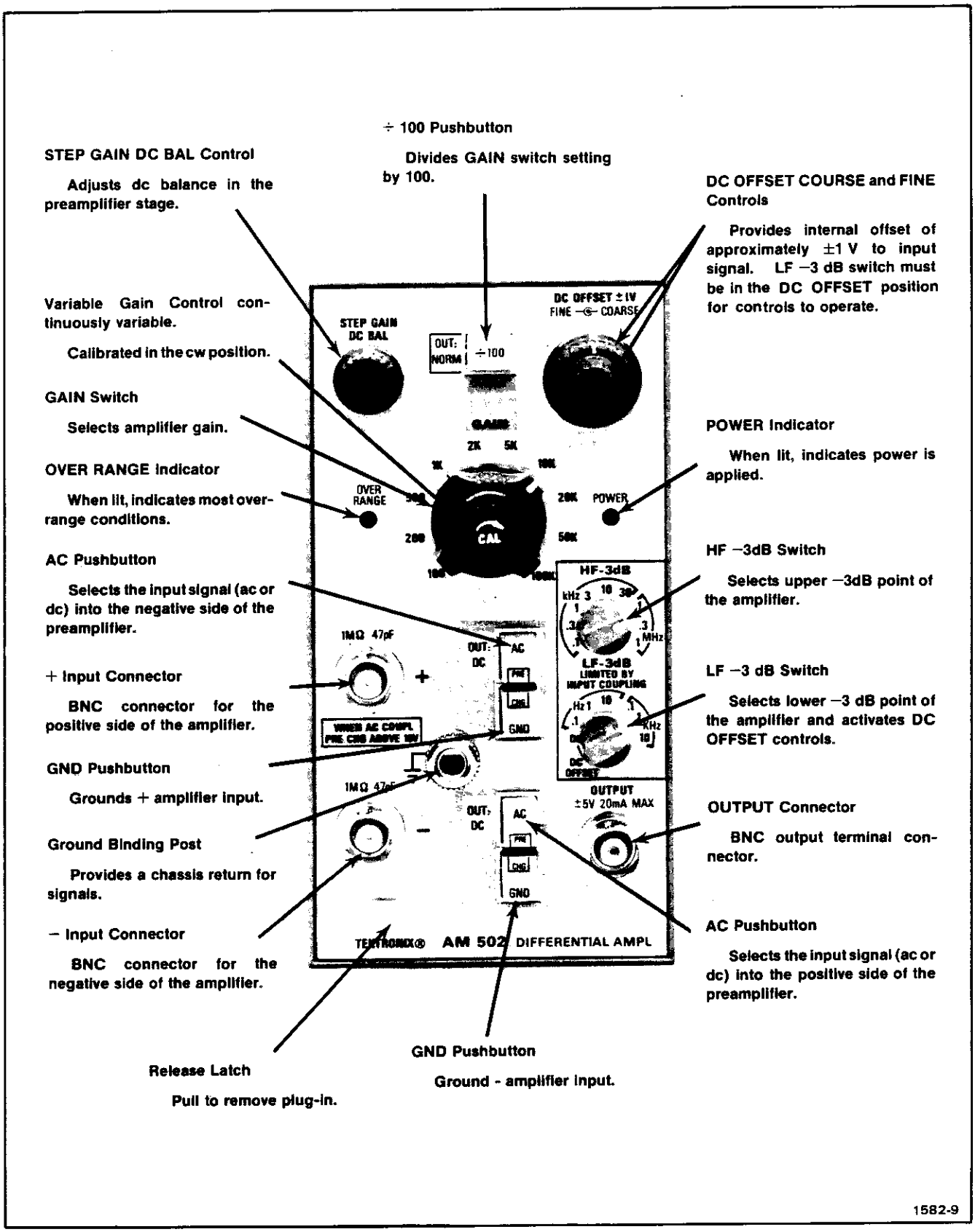


Fig. 1-2. AM 502 controls and connectors.

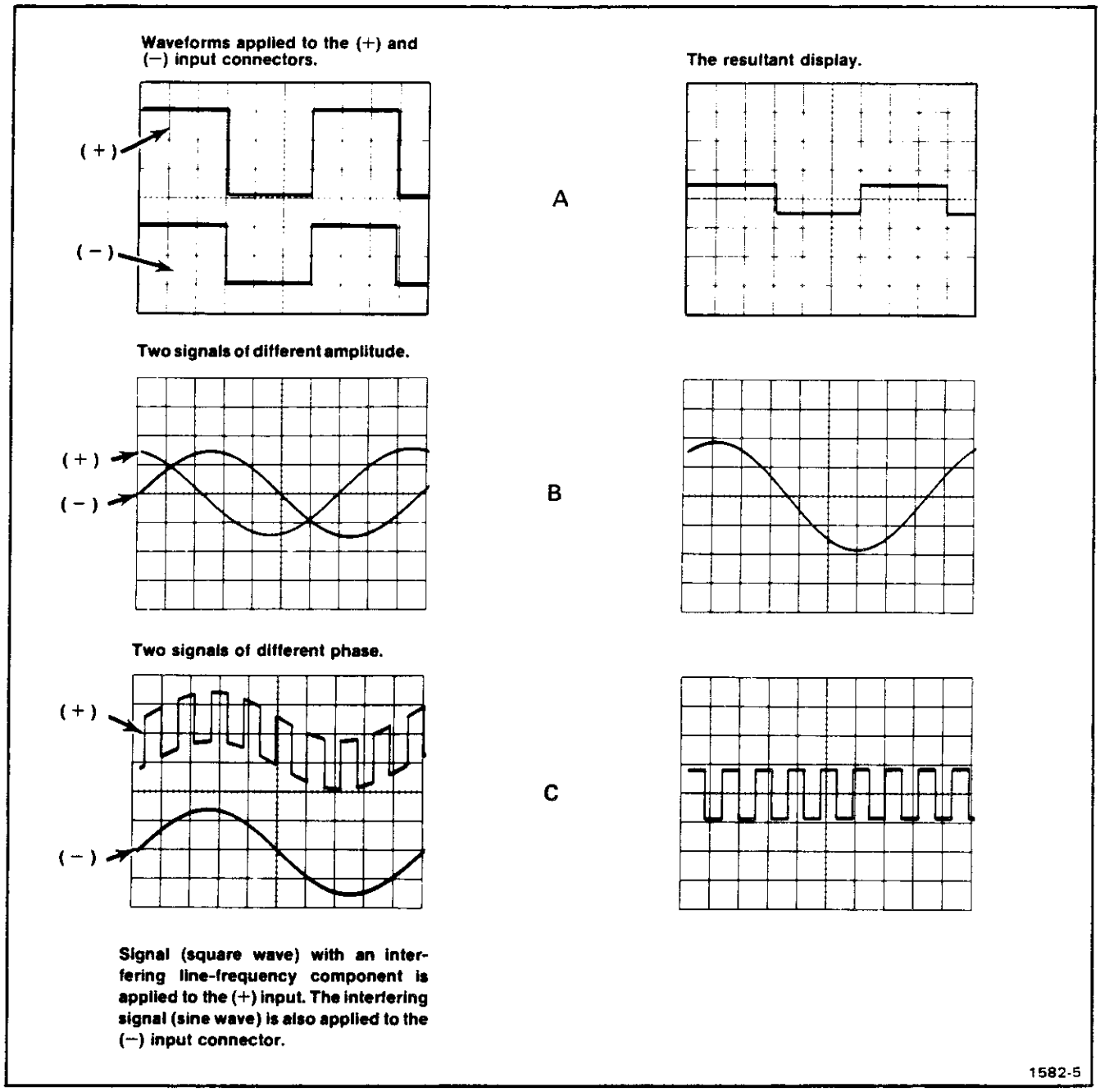


Fig. 1-3. Waveforms showing differential rejection of a common-mode signal. Resultant waveforms show the difference between the two signals.

Output Connections

Make output connections using a bnc to dual binding post connector, or a coaxial cable with at least one bnc connector. To prevent current limiting in the output stage, do not load the output with less than 250 ohms. Output current is limited to 20 milliamperes.

Step Gain DC Balance

If this control is misadjusted, the dc output level will shift as the GAIN switch position is changed. Push both GND buttons and place the GAIN switch in the 100 position. Rotate the GAIN switch from stop to stop while adjusting the STEP GAIN DC BAL control for no dc shift at the OUTPUT terminal.

DC Offset Coarse and Fine

Use these controls to offset up to ±1 volt dc potential difference at the input connectors. The amplifier internal bias is changed to accomplish the offset. The differential rejection capabilities of the AM 502 are not affected. The LF −3dB switch must be in the DC OFFSET position to activate these controls.

HF and LF Bandwidth Reduction

Use the HF −3dB switch to reduce the upper bandwidth limit, as necessary, to improve the signal-to-noise ratio when using the AM 502 in low-frequency applications. The LF −3dB control increases the lower bandwidth frequency. Use this control to reduce dc drift, when raising the lower bandwidth does not undesirably reduce the bandwidth for the signal being measured.

Pre-Charging

Use of this feature prevents surge currents, due to charging the ac coupling capacitor in the AM 502, from damaging the circuit under test. Before connecting the AM 502 to a signal containing a dc component, push the AC and GND pushbuttons. Connect the input to the circuit under test. Wait about one second for the coupling capacitor to charge. Release the GND pushbutton, and the coupling capacitor is charged to the value of the dc voltage to be measured.

Differential Operation

A differential measurement is made by connecting each of the two inputs to selected points in the test circuit. The input to the amplifier will then be the difference in voltage of the two selected points. Consideration should be given to the proper connection method used between the AM 502 and the circuit under test; otherwise improper measurement results may occur. See Fig. 1-4 for reference.

Differential voltage measurements are made by applying the signals to the +input and −input connectors. Set the input coupling switches to the same position, AC or DC, depending on the measurement being made. In differential measurements, only the voltage difference between the two signals is amplified. Common mode signals (common in amplitude, phase, and frequency) are rejected. See Fig. 1-3 A, B, and C for reference.

Single-ended measurements often yield unsatisfactory results because of the interference resulting from ground-loop currents between the AM 502 and the device under test. In other cases, it may be desirable to eliminate a dc voltage by means other than the use of a blocking capacitor, which could limit the low-frequency response. The limitations of single-ended measurements are effectively eliminated by using differential measurements.

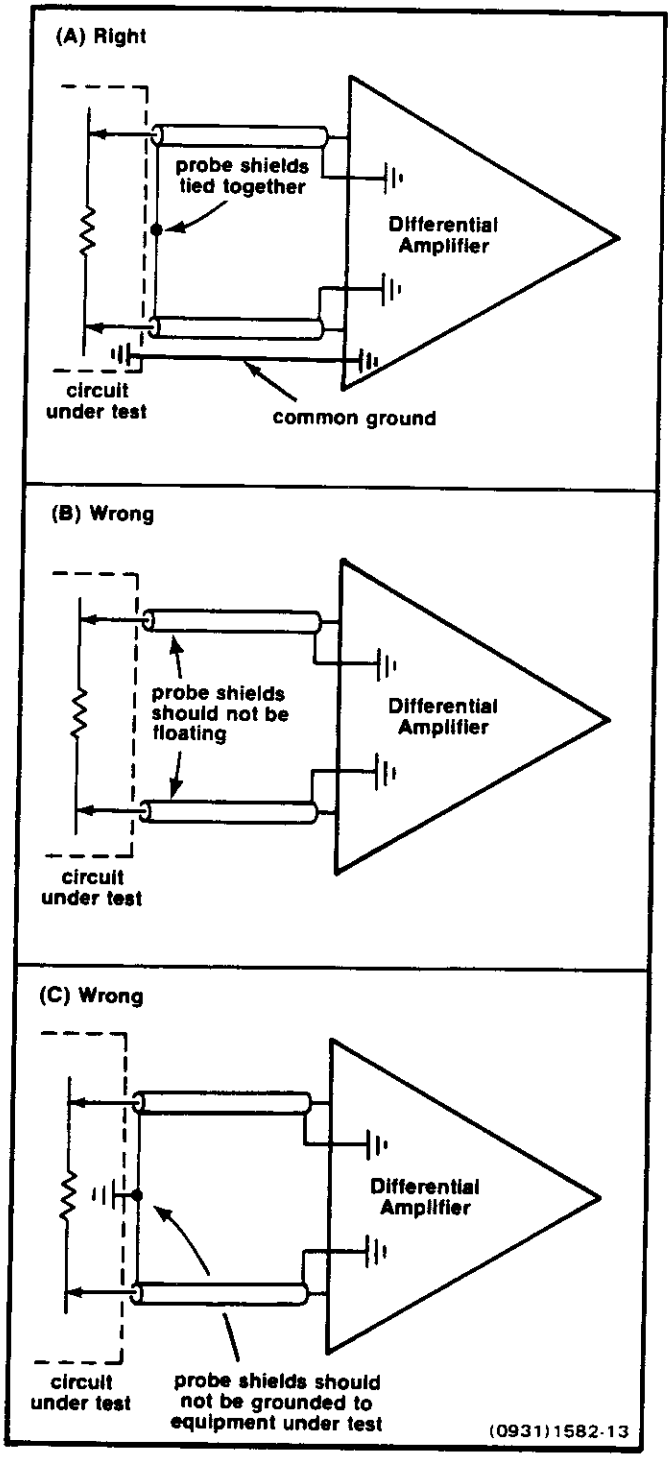


Fig. 1-4. Connecting a differential amplifier to a signal source.

DC Offset Operation

By using the FINE and COARSE DC OFFSET controls, it is possible to use the AM 502 differentially in a slide-back mode, to observe a small signal whose dc potential difference may be considerable. The offset voltage is continuously adjustable from plus 1 volt to minus 1 volt, and is internally available for all of the GAIN switch positions. The LF −3dB switch must be in the DC OFFSET position to activate the offset circuit.

Common Mode Rejection Ratio

The ability of the AM 502 to reject common-mode signals is indicated by the common-mode rejection ratio (cmrr). For example, assume that a signal consists of unwanted 60 hertz at 10 volts peak-to-peak (common mode connected to both inputs), plus a desired signal at 1 millivolt peak-to-peak (differentially connected to one input). The AM 502 gain is set at 200. The output of the AM 502 shows the desired signal at an amplitude of 0.2 volt (1 millivolt X 200), and the 60 hertz signal is viewed at an amplitude of 0.02 volts. The cmrr in this application is 100,000 to 1. This figure is calculated by multiplying the value of the common-mode signal (10 volt) by the gain of the amplifier (200) for a product of 2000 volts. This product is divided by the observed 60 hertz voltage at the output (0.02 volt) and result is the cmrr, 100,000 to 1. It would, of course be impossible to view the 1 millivolt signal superimposed on the 60 hertz signal by using single input methods.

Degradation of Common Mode Rejection

There are a number of factors that degrade common-mode rejection ratio (cmrr). The principal requirement for maximum rejection is for the common-mode signal to arrive at the input FET gates at the same phase and amplitude. A difference of only 0.01% in the attenuation ratios of the input attenuators will reduce the rejection ratio to 10,000 to 1. Also, any difference in source impedance will degrade the rejection ratio. Figures 1-5 and 1-6 show common-mode rejection degradation due to differences in source impedance. The frequency of the common-mode signal also affects the common-mode rejection ratio. Generally, as the frequency of the input signal increases, the common-mode rejection ratio is more difficult to maintain.

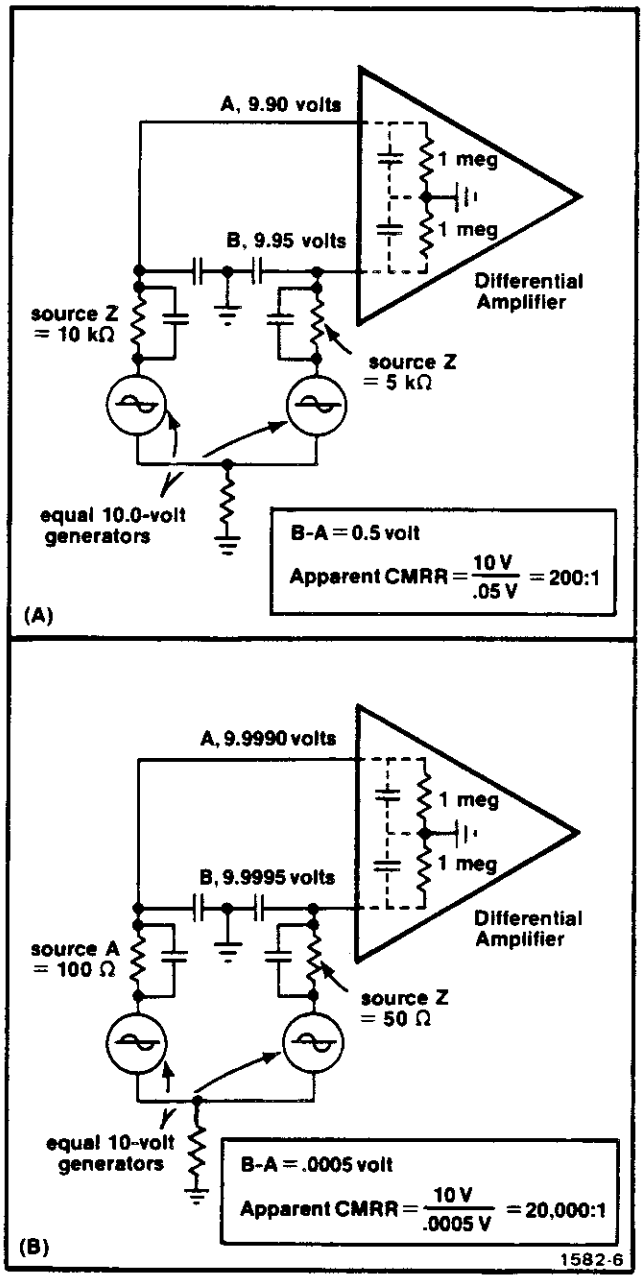
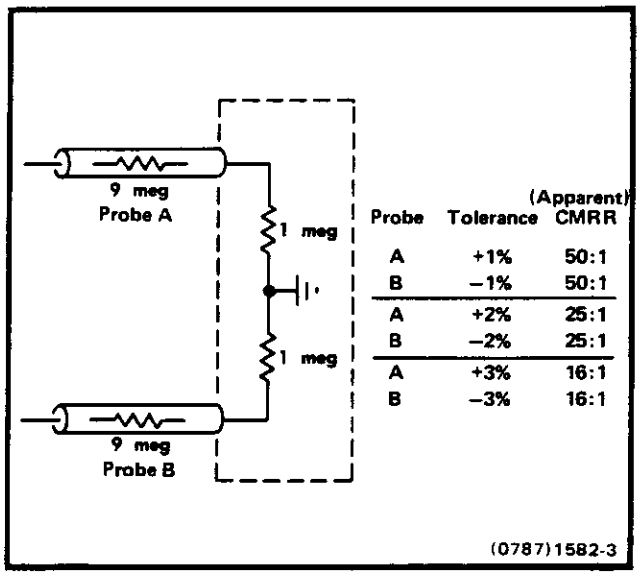


Fig. 1-5. Relationship of test point source impedance to the amplifier input impedance and the apparent CMRR caused by (A) large difference between test-point impedances and (B) low impedance test points.



Probe	Tolerance	(Apparent) CMRR
A	+1%	50:1
B	−1%	50:1
A	+2%	25:1
B	−2%	25:1
A	+3%	16:1
B	−3%	16:1

Fig. 1-6. Simplified input circuit and table showing the change in apparent CMRR due to 10X probes that are within 1, 2, and 3% of their attenuation values (with matched 1 megohm resistors).

The high frequency cmrr will also depend upon the signal source impedance, since various shunt capacitances between the source and the input gate must charge and discharge through that impedance.

Outside influences such as magnetic fields can also degrade the performance, particularly when low level signals are involved. Magnetic interference may be reduced by using identical signal transporting leads to the two inputs. Twist the two leads together over as much of their length as possible. Low-frequency measurements can be similarly protected by using a shielded cable that contains a twisted pair of conductors.

INSTRUCTIONS D'UTILISATION

INTRODUCTION

Description

Le tiroir AM 502 est un amplificateur différentiel à couplage continu présentant un excellent taux de réjection en mode commun ainsi qu'un gain élevé. Ces caractéristiques destinent cet appareil tout particulièrement aux mesures à bas niveau. Il possède également une commande de décalage de tension continue, la plage de compensation de cette composante continu étant ± 1 V. Cette compensation permet d'amplifier les signaux à bas niveau et à faible fréquence et superposés à une composante continue, tout en évitant les distorsions souvent introduites par un couplage de type alternatif. Les limites inférieure et supérieure de la réponse en fréquence (à −3 dB) peuvent être sélectionnées sur le panneau avant, en fonction de l'application. Les entrées et sorties des signaux sont disponibles à la fois sur le connecteur de l'interface et sur les bornes d'entrée du panneau avant. Une lampe, située sur le panneau avant, indique, en s'allumant, la plupart des conditions de surcharge provoquées par une trop grande amplitude du signal, l'emploi d'un gain ou d'une tension de décalage excessifs.

Le circuit d'entrée peut être représenté par une résistance d'environ 1 MΩ en parallèle avec une résistance d'environ 1 MΩ en parallèle avec une capacité d'environ 47 pF. L'impédance d'entrée peut être augmentée jusqu'à 200 MΩ (cavalier interne). Des fusibles en série constituent un système de protection en cas de surcharge.

En continu, une commande d'équilibrage de gain (STEP GAIN DC BALANCE) permet de minimiser le décalage lorsque le commutateur de gain passe d'une position à une autre.

Les commandes de réglage de tension de décalage principal et fin (DC OFFSET COARSE et FINE) permettent de compenser une composante continue à l'entrée dans une plage de ± 1 V. Le changement de la polarisation de l'amplificateur permet ce décalage de tension. Le commutateur LF −3 dB doit être sur la position DC OFFSET pour mettre ces commandes en service.

Le commutateur −3 dB est utilisé pour réduire la limite supérieure de la bande passante de façon à améliorer le rapport signal/bruit lorsque l'on utilise l'AM 502 pour des applications basse fréquence. Le commutateur LF −3 dB accroît la bande passante basse fréquence.

L'emploi du dispositif de précharge évite les surcharges et les risques de détérioration en mode couplage alternatif.

Installation et extraction

ATTENTION

Couper l'alimentation du châssis avant d'insérer le tiroir afin d'éviter de détériorer les circuits de ce dernier. L'AM 502 nécessitant un fort courant d'alimentation, il est également recommandé de couper l'alimentation avant d'ôter le tiroir du châssis. Se reporter à la figure 1-1. Vérifier que les détrompeurs s'adaptent bien aux encoches du connecteur de l'AM 502. Aligner les rails de guidage de l'AM 502 avec les guides du compartiment sélectionné. Engager le tiroir à fond et appuyer fermement jusqu'à ce que le circuit imprimé se place correctement.

Pour extraire l'AM 502, tirer sur la barrette de verrouillage située sur le coin inférieur gauche jusqu'à ce que l'AM 502 puisse glisser à l'extérieur.

Commandes et bornes

Se reporter à la figure 1-2. Bien que l'appareil soit livré étalonné et prêt à être utilisé, il est nécessaire de se familiariser avec le rôle et les fonctions des commandes et bornes avant de mettre l'appareil en service. Appuyer sur le commutateur POWER (position ON) pour mettre l'appareil sous tension. Le voyant lumineux POWER s'allume pour indiquer que l'appareil est sous tension et prêt à fonctionner.

UTILISATION

Surchauffe

L'AM 502 est conçu pour fonctionner à une température comprise entre 0°C et +50°C. Cependant, lorsque l'on utilise plusieurs alimentations dans un châssis plus particulièrement à faibles tensions de sortie ou à proximité d'un équipement produisant de la chaleur, la température interne peut excéder les limites de sécurité et mettre en service le disjoncteur thermique du châssis d'alimentation. Se reporter au manuel d'instructions du châssis d'alimentation pour information complémentaire.

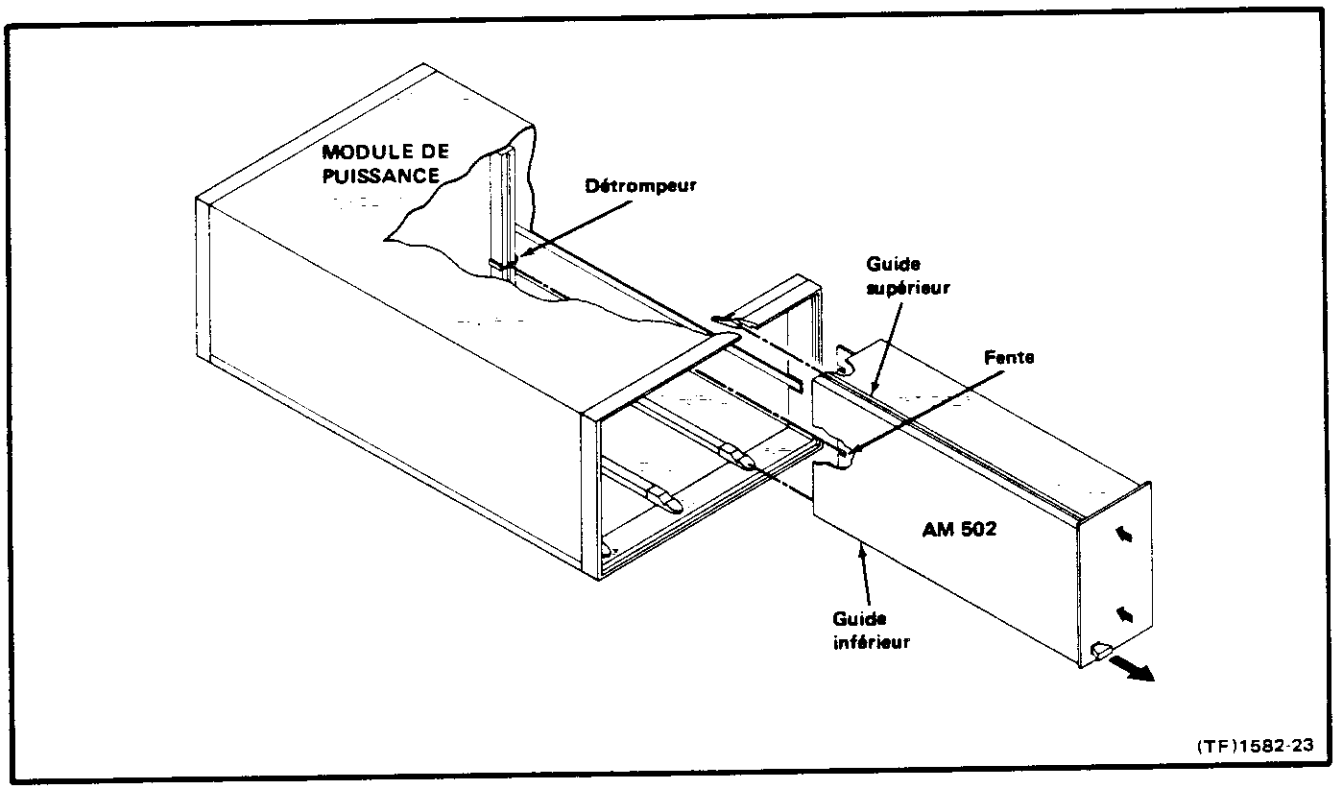


Fig. 1-1. Installation et extraction du tiroir.

Connexions d'entrée

Il est possible d'utiliser des câbles non blindés pour connecter l'AM 502 à une source de signal à grande amplitude et basse fréquence lorsque le signal est issu d'une source à basse impédance. Cependant, lorsque l'une de ces conditions n'est pas remplie, il devient très important d'utiliser des câbles blindés. Dans tous les cas, les conducteurs véhiculant le signal doivent être aussi courts que possible.

Lorsque l'on effectue des mesures à l'aide d'une seule entrée (utilisation en amplificateur conventionnel), il est indispensable d'établir une connexion de masse commune entre l'équipement sous test et l'AM 502. Le blindage d'un câble coaxial est généralement utilisé à cet effet. Pour information détaillée voie la figure 1-3. Appuyer sur le bouton GND pour déconnecter l'entrée de l'équipement.

Dans certains cas de mesures en mode différentiel, une masse commune n'est pas indispensable. En conséquence, ces types de mesures sont moins susceptibles d'être perturbées par les problèmes posés par l'interconnexion de masse.

Il est nécessaire de tenir compte de l'influence des câbles de liaisons sur les signaux à mesurer. Le circuit d'entrée de l'AM 502 est équivalent à une résistance d'environ 1 MΩ en parallèle avec une capacité d'environ 47 pF. Un câble coaxial d'impédance caractéristique 50 Ω et de longueur 0,60 m augmente la capacité parallèle d'environ 60 pF ce qui pourrait être excessif dans de nombreuses applications. Pour minimiser ces effets, il faut utiliser un câble à haute impédance ou une sonde atténuatrice.

Sondes

L'emploi de sondes atténuatrices permet de réduire la charge (résistance-capacité) apportée à une source de signal. Elles permettent également d'élargir la gamme de mesures de l'AM 502 dans le domaine des mesures de tensions élevées. Certaines mesures exigent une résistance d'entrée plus élevée que celle de l'AM 502 de façon à charger très faiblement la source des signaux. Dans de tels cas, il faut utiliser une sonde FET (transistor à effet de champ) ou disposer d'une entrée à haute impédance sur l'AM 502. Pour toute information complémentaire, contacter votre représentant local Tektronix.

Entrée à haute impédance

Pour porter l'impédance d'entrée de l'AM 502 à 200 MΩ environ, ôter la prise P40 (Fig. 3-1). S'assurer que les atténuateurs sont en mode normal (NORM). L'impédance de la source du signal devient alors un facteur important. Par exemple, un courant de 100 pA avec une charge de 10 MΩ produit un décalage de tension de 1 mV. Cette chute de tension peut constituer une source d'erreur non négligeable lorsque l'on mesure des tensions à faible niveau.

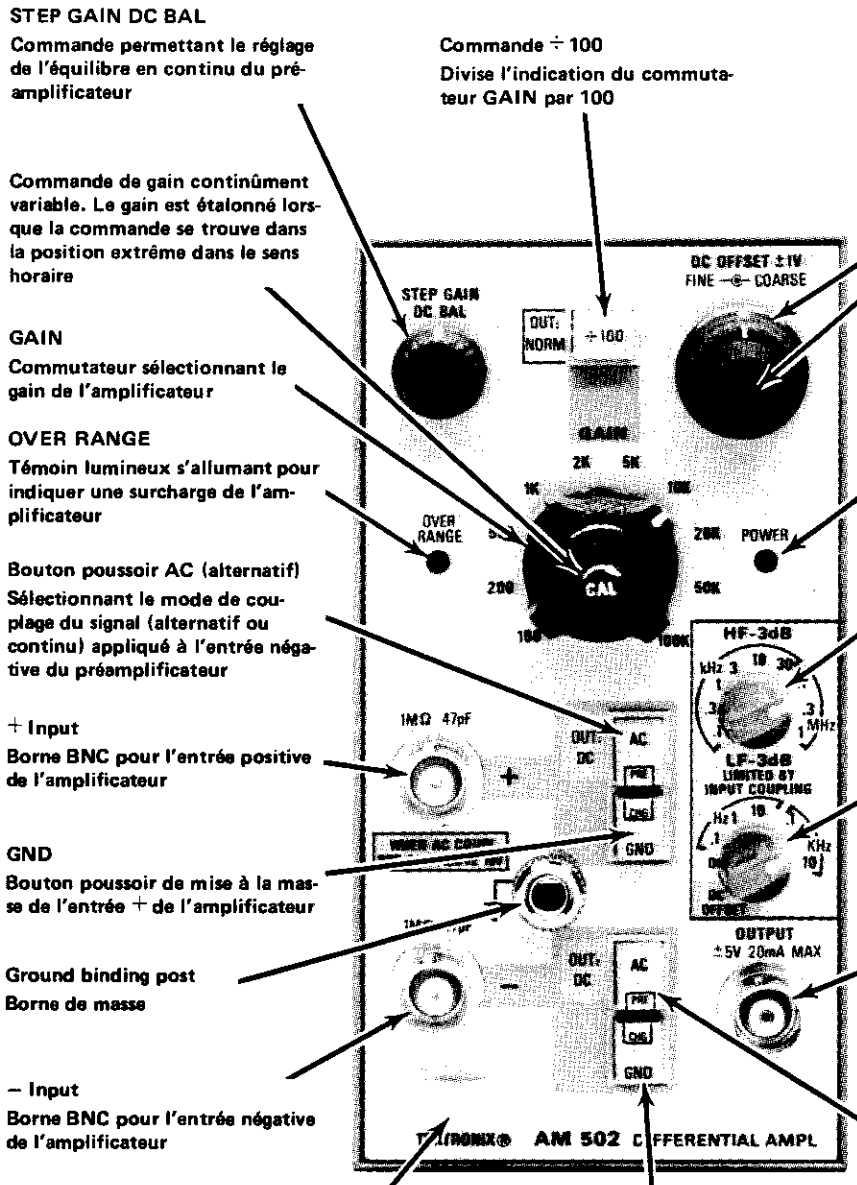


Fig. 1-2. Commandes et bornes de l'AM 502.

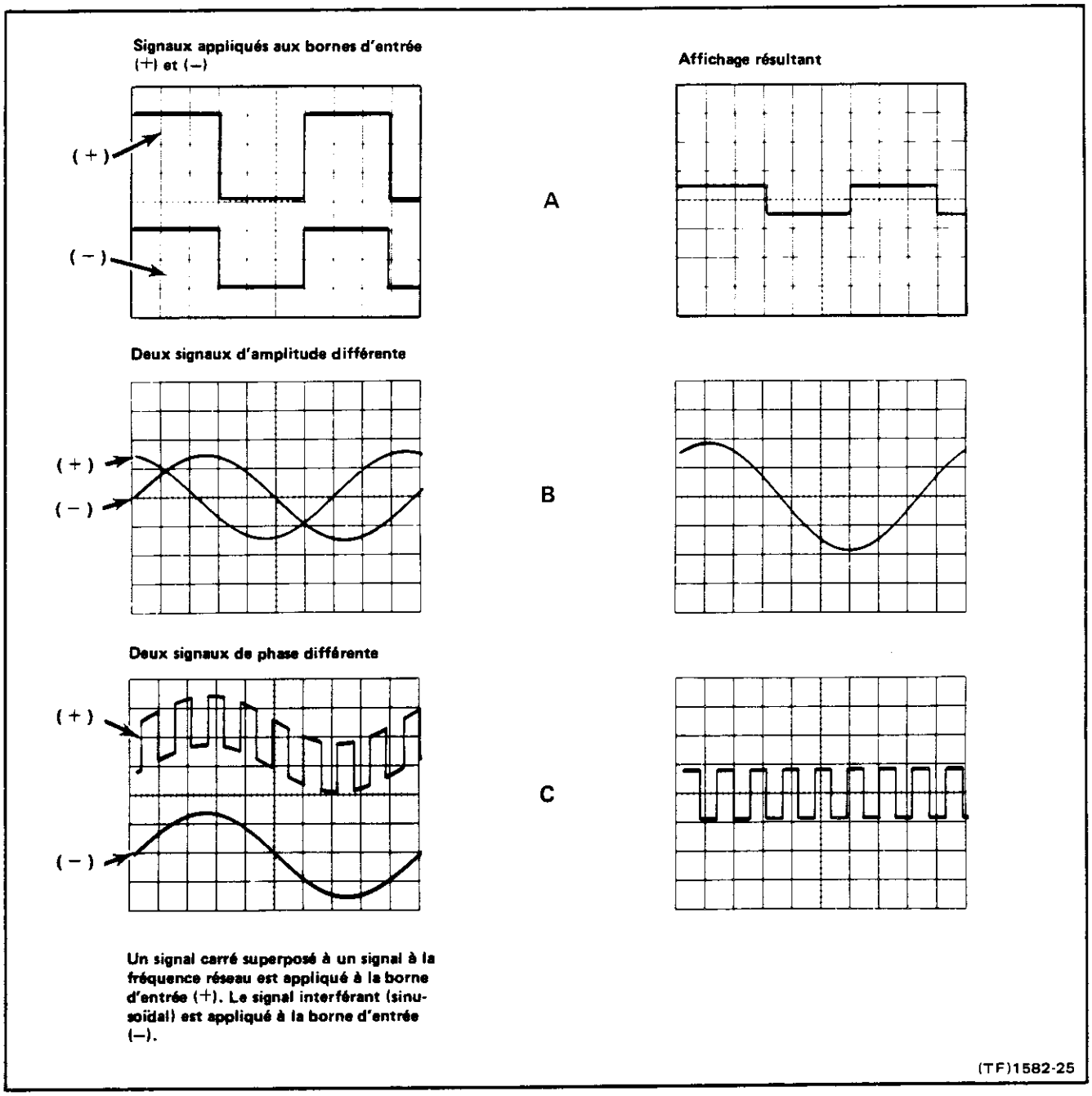


Fig. 1-3. Signaux, en mode différentiel, montrant la réjection d'un signal de mode commun. Les formes d'ondes qui en résultent montrent la différence entre les deux signaux.

Surcharge à l'entrée

Lorsque l'on mesure des tensions continues dont l'ordre de grandeur n'est pas connu engager le bouton poussoir ÷ 100 et positionner la commande de gain sur 100. Augmenter alors le gain pour finalement relacher le bouton poussoir ÷ 100 jusqu'à obtention du signal de sortie voulu. Si le circuit à l'entrée de l'AM 502 est surchargé, le courant d'entrée sera important, entraînant la fusion des fusibles de protection.

Branchements de sortie

Pour connecter le signal de sortie, utiliser un adaptateur BNC fiches bananes ou un câble coaxial muni d'un adaptateur BNC classique. Pour éviter la limitation du courant de l'étage de sortie, la charge ne doit pas être inférieure à 250 Ω. Le courant de sortie est limité à 20 mA.

Equilibrage en continu en fonction de la commande de gain

Un déréglage de cette commande provoque des variations du niveau de sortie continu en fonction de la position du commutateur de gain. Appuyer sur les deux boutons GND et placer le commutateur GAIN sur la position 100. Agir sur le commutateur GAIN tout en réglant la commande STEP GAIN DC BAL de façon à éliminer le décalage de la tension continue sur la borne OUTPUT.

DC offset COARSE et FINE

Utiliser ces commandes pour compenser une composante continue présente sur les bornes d'entrée dans une plage de ± 1 V. La polarité de l'amplificateur est modifiée pour permettre ce décalage de tension. Les capacités de réjection de l'AM 502, en mode différentiel, ne sont pas affectées. Le commutateur LF –3 dB doit être sur la position DC OFFSET pour mettre ces commandes en service.

Réduction de la bande passante en haute et basse fréquence

Utiliser le commutateur HF –3 dB pour réduire la bande passante supérieure, si nécessaire, afin d'améliorer le rapport signal /bruit lorsque l'on utilise l'AM 502 dans des applications à basse fréquence. Le commutateur LF –3 dB réduit la fréquence de coupure inférieure de la bande passante. Utiliser cette commande pour réduire la dérive en continu dès que la fréquence de coupure basse peut être augmentée en évitant tout influence sur le signal lui-même.

Circuit de précharge

L'emploi de ce dispositif évite que le courant de charge de la capacité utilisée en couplage alternatif ne détériore le circuit sous test. Avant d'appliquer à l'AM 502 un signal contenant une composante continue, engager les boutons poussoirs AC et GND. Relier ensuite l'entrée au circuit sous test. Attendre environ une seconde pour laisser la capacité de couplage se charger. Relâcher le bouton poussoir GND, la capacité de couplage est chargée à la valeur de la tension continue à mesurer.

Fonctionnement en mode différentiel

Une mesure différentielle s'effectue en reliant chacune des deux entrées aux points sélectionnés du circuit à tester. Les entrées de l'amplificateur sont soumises à la différence de tension entre les deux points sélectionnés. Il est nécessaire d'utiliser une méthode de connexion appropriée pour relier le circuit à tester à l'AM 502, sinon la mesure peut être aléatoire.

Les mesures de tension en mode différentiel s'effectuent en appliquant les signaux aux bornes d'entrée + (positive) et – (négative). Placer les commutateurs de couplage d'entrée sur la même position : AC (alternative) ou DC (continue) en fonction de la mesure à effectuer. Dans les mesures en mode différentiel, seule la différence de tension entre les deux signaux est amplifiée. Les signaux en mode commun (même amplitude, même phase et même fréquence) sont éliminés. Pour information détaillée, se reporter à la figure 1-3A, B, C.

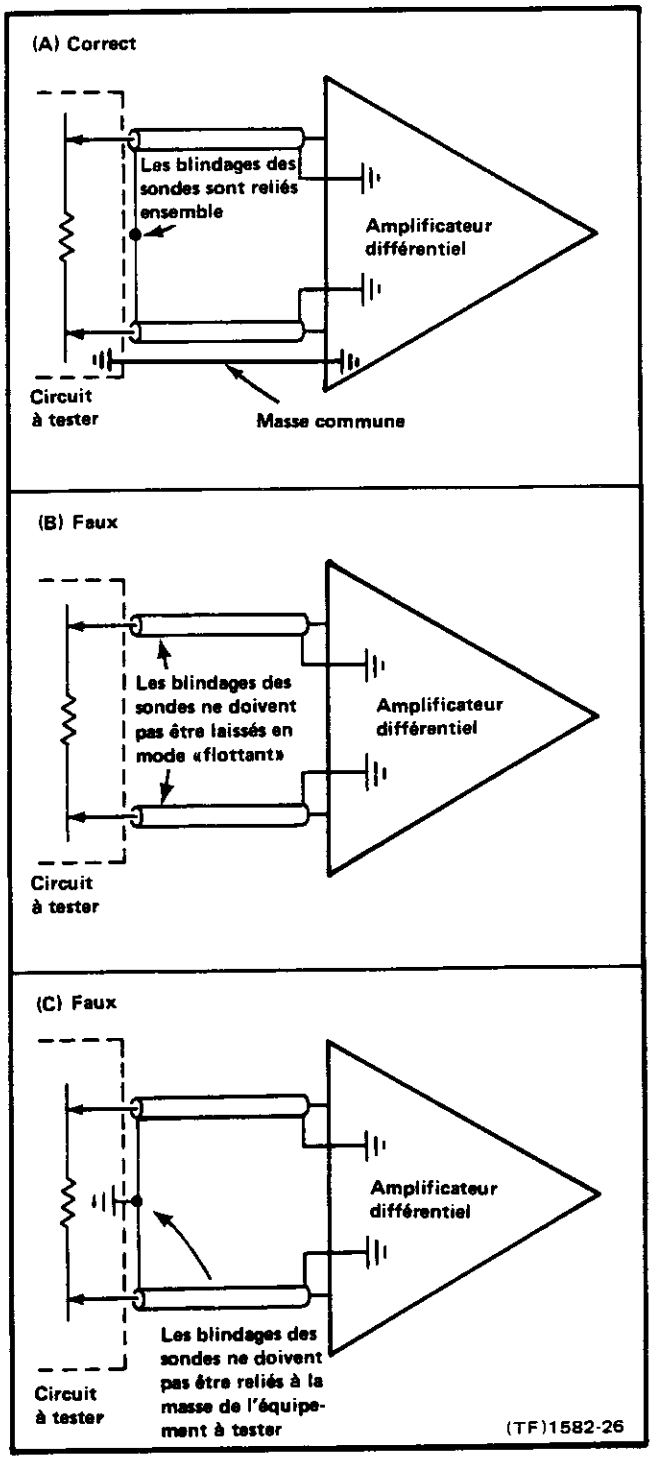


Fig. 1-4. Connexion d'un amplificateur différentiel à un signal.

Des mesures effectuées en utilisant une entrée unique donnent souvent des résultats peu satisfaisants en raison des perturbations provoquées par les courants de masse circulant entre l'AM 502 et l'équipement sous test. Dans d'autres cas, il peut être souhaitable d'éliminer une tension ayant une composante continue autrement que par l'utilisation d'une capacité bloquant cette composante et réduisant ainsi la réponse en basse fréquence.

Décalage de la composante continue

En utilisant les commandes FINE et COARSE DC OFFSET, il est possible d'utiliser l'AM 502 en mode différentiel (slide back) afin d'observer un faible signal dont la composante continue peut être considérable. La tension de décalage est continûment réglable sur une plage de ± 1 V. Elle est disponible pour toutes les positions du commutateur GAIN. Le commutateur LF –3 dB doit être placé sur la position DC OFFSET pour mettre ce mode en service.

Taux de réjection en mode commun

L'aptitude de l'AM 502 à éliminer des signaux en mode commun est définie par le taux de réjection en mode commun (TRMC). Par exemple : supposons qu'un signal soit composé d'un signal indésirable de 10 V crête-à-crête à la fréquence de 60 Hz (le mode commun étant connecté aux deux entrées) plus un signal à mesurer de 1 mV crête-à-crête appliqué à une entrée en mode différentiel. Le gain de l'AM 502 est réglé à 200. Le signal de l'AM 502 obtenu en sortie montre ce signal avec une amplitude de 0,2 V (1 mV x 200) et le signal à la fréquence de 60 Hz présente une amplitude de 0,02 V. Dans cette application, le taux de réjection en mode commun est de 100 000 : 1. Ce chiffre s'obtient en multipliant la valeur du signal en mode commun (10 V) par le gain de l'amplificateur (200) soit 2 000 V. Ce nombre est ensuite divisé par la valeur du signal 60 Hz obtenu en sortie (0,02 V). Ceci donne un taux de réjection en mode commun de 100 000 : 1. Il aurait été, bien sûr, impossible de visualiser un signal de 1 mV superposé au signal de 60 Hz en utilisant une seule entrée de l'amplificateur.

Dégradation de la réjection en mode commun

Un certain nombre de facteurs peuvent dégrader le taux de réjection en mode commun. La principale condition nécessaire pour obtenir une réjection maximale est que le signal en mode commun soit appliqué aux entrées avec la même phase et la même amplitude. Une différence de seulement 0,01 % dans les taux d'atténuation à l'entrée diminue le taux de réjection de 10 000 : 1. De même, n'importe quelle différence dans l'impédance de source dégrade le taux de réjection. Les figures 1-5 et 1-6 illustrent la dégradation de l'élimination du mode commun due aux différences d'impédance des sources. La fréquence du signal en mode commun affecte également le taux de réjection en mode commun. Généralement, au fur et à mesure que la fréquence du signal d'entrée augmente, le taux de réjection en mode commun est plus difficile à maintenir.

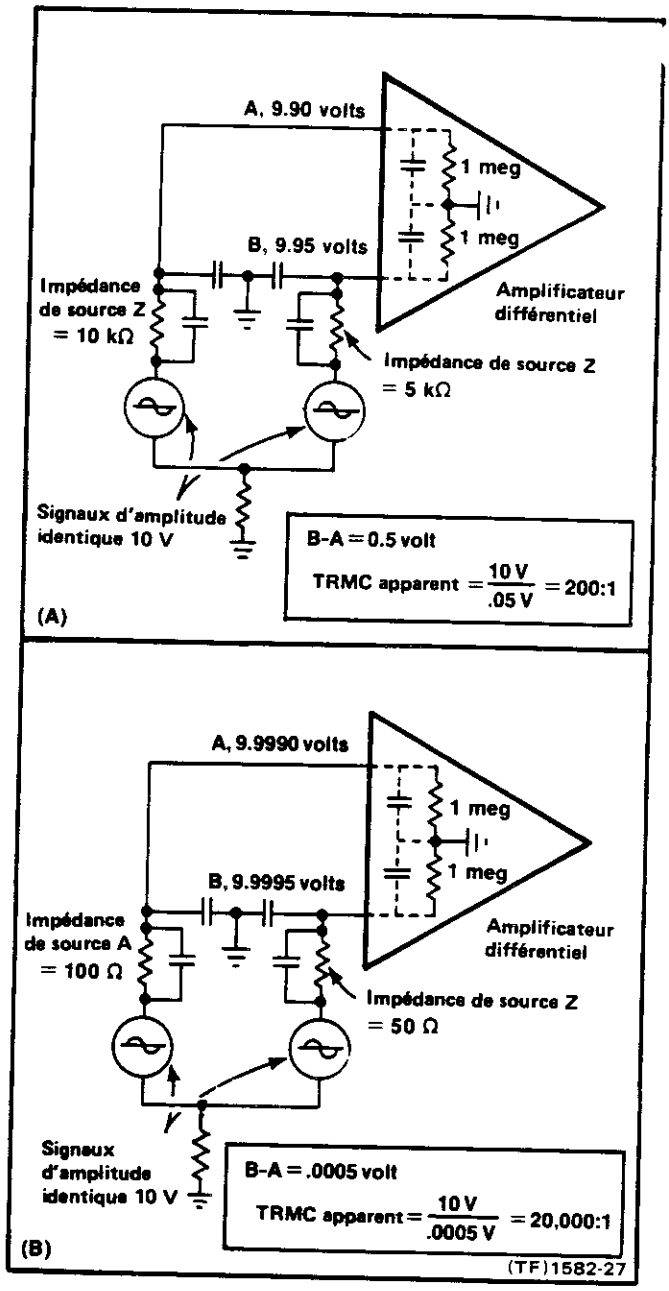
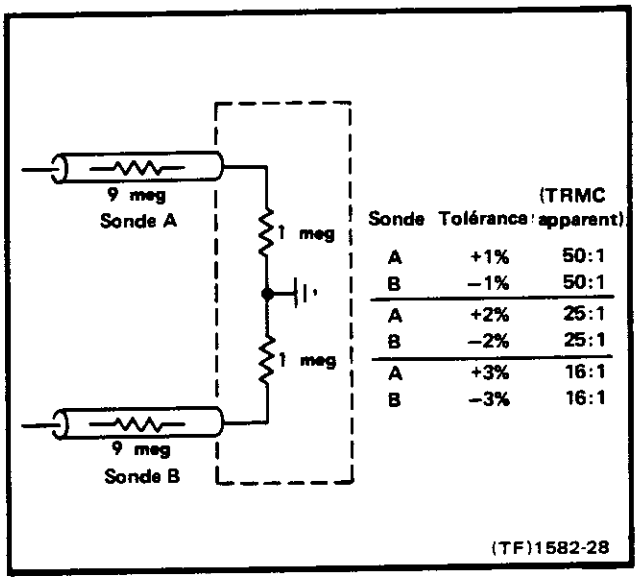


Fig. 1-5. Relation existant entre l'impédance au point de test et l'impédance d'entrée de l'amplificateur. Taux de réjection apparent en mode commun dû à (A) la différence importante entre les impédances au point de test et (B) points de test à faible impédance.

Le taux de réjection en mode commun en haute fréquence est également fonction de l'impédance de la source du signal car les diverses capacités «shunt», entre la source et l'entrée doivent se charger et se décharger à travers cette impédance.



Sonde	Tolérance	(TRMC apparent)
A	+1%	50:1
B	−1%	50:1
A	+2%	25:1
B	−2%	25:1
A	+3%	16:1
B	−3%	16:1

Fig. 1-6. Circuit d'entrée simplifié et tableau indiquant la variation du TRMC apporté par des sondes 10X dont la précision est inférieure à 1, 2, 3 % (avec des résistances d'entrée de 1 MΩ).

Des causes extérieures telles que les champs magnétiques peuvent également dégrader les performances, particulièrement lorsque l'on mesure des signaux à bas niveau. L'interférence magnétique peut être diminuée en utilisant des liaisons identiques pour les deux entrées. Torsader les deux fils ensemble sur la plus grande longueur possible. Des mesures en basse fréquence peuvent être améliorées de manière similaire en utilisant un câble blindé comportant une paire de conducteurs torsadés.

BEDIENUNGS-ANLEITUNG

EINFÜHRUNG

Beschreibung

Der AM 502 ist ein gleichspannungsgekoppelter Differenzverstärker mit sehr guter Gleichtaktunterdrückung und hoher Verstärkung für die Messung kleiner Spannungen. Eine Gleichspannungsoffseteinstellung arbeitet bis zu 1 V, wodurch gleichspannungsunterlegte Signale mit geringem Pegel und niedriger Frequenz, ohne die durch Wechselspannungskopplung auftretenden Dämpfungen, verstärkt werden können. Über frontseitige Schalter lassen sich verschiedene obere und untere Grenzfrequenzen (–3 dB) wählen, wodurch der AM 502 an verschiedene Meßprobleme angepaßt werden kann. Die Ein- und Ausgangssignale sind sowohl frontseitig, als auch an der rückseitigen Kontaktleiste abnehmbar. Über eine Signallampe werden Übersteuerungszustände – wie zu hohes Eingangssignal, zu hohe Verstärkung oder zu großer Offset – angezeigt.

Die Eingangsimpedanz beim AM 502 beträgt 1 MΩ‖ 47 pF. Durch Entfernen einer Brücke läßt sich die Eingangsimpedanz auf 200 MΩ steigern.

Ein Überlastschutz erfolgt duch Sicherungen im Eingangsbereich, die bei zu hohem Stromfluß im Übersteuerungsfall unterbrechen.

Die bei verschiedenen gewählten Verstärkungen auftretende Verschiebung in der Gleichspannungsbalance läßt sich durch ein frontseitiges Potentiometer einstellen.

Mit den Gleichspannungsoffseteinstellreglern (grob und fein) ist am Eingang eine Potentialdifferenz von ±1 V einstellbar, die die interne Verstärker-Vorspannung beeinflußt. Für diese Einstellung ist der Schalter der unteren Grenzfrequenzwahl in die Position DC-OFFSET zu bringen.

Der Wahlschalter für die obere Grenzfrequenz dient zur Reduzierung der Bandbreite am oberen Bereich, um bei der Verarbeitung von niedrigen Frequenzen einen guten Störspannungsabstand zu erhalten. Die untere Grenzfrequenzwahl gestattet eine Verringerung der Bandbreite am unteren Bereich.

Bei Anwendung der Wechselstromankopplung durch einen Kondensator, verhindert eine Voraufladevorrichtung am AM 502 Verschiebeströme in dem Kondensator, die eine Beschädigung des Testobjektes hervorrufen könnten.

Ein- und Ausbau

VORSICHT

Vor dem Einsetzen des AM 502 in eine Vorsorgungseinheit, ist diese unbedingt auszuschalten, da durch die hohe Stromentnahme des AM 502 evtl. Schäden an der Schaltung auftreten könnten. Es ist ebenfalls vor der Entnahme des AM 502 empfehlenswert, die Versorgungseinheit abzuschalten.
Beziehen Sie sich auf Abb. 1-1 und überprüfen Sie, ob die Plastikisolierstege auf der Steckverbindungsleiste in der gewählten Versorgungseinheit mit den Ausschnitten aus der Platinenkontaktleiste des AM 502 übereinstimmen.

Setzen Sie nun das Chassis des AM 502 in die obere und untere Führung des gewählten Faches und schieben es mit dem nötigen Druck soweit ein, bis die rückseitige Steckverbindungsleiste einrastet.

Zum Herausnehmen des AM 502 ziehen Sie die Entriegelungsklinke an der linken unteren Ecke des Einschubes, bis sich die rückseitige Steckverbindung löst.

Bedienungselemente und Steckverbindungen

Beziehen Sie sich auf Abb. 1-2. Der AM 502 ist bei Lieferung kalibriert und gebauchsfertig. Bevor Sie jedoch das Gerät bedienen, sollten Sie sich mit den Funktionen der Bedienungselemente vertraut machen. Zum Einschalten des AM 502 ist der Netzschalter an der Versorgungseinheit zu ziehen, wonach am AM 502 die Netz-Anzeigelampe leuchtet.

BEDIENUNGSHINWEISE

Überhitzung

Der AM 502 ist für einen Umgebungstemperaturbereich von 0°C bis +50°C konzipiert. Arbeiten jedoch in einer Versorgungseinheit mehrere Einschübe oder befinden sich in der Nähe weitere hitzeentwickelnde Geräte, so kann die innere Temperatur den zulässigen Bereich überschreiten und in der Versorgungseinheit einen Übertemperaturschalter auslösen. Beziehen Sie sich daher für weitere Informationen auf die Bedienungsanleitung der verwendeten Versorgungseinheit.

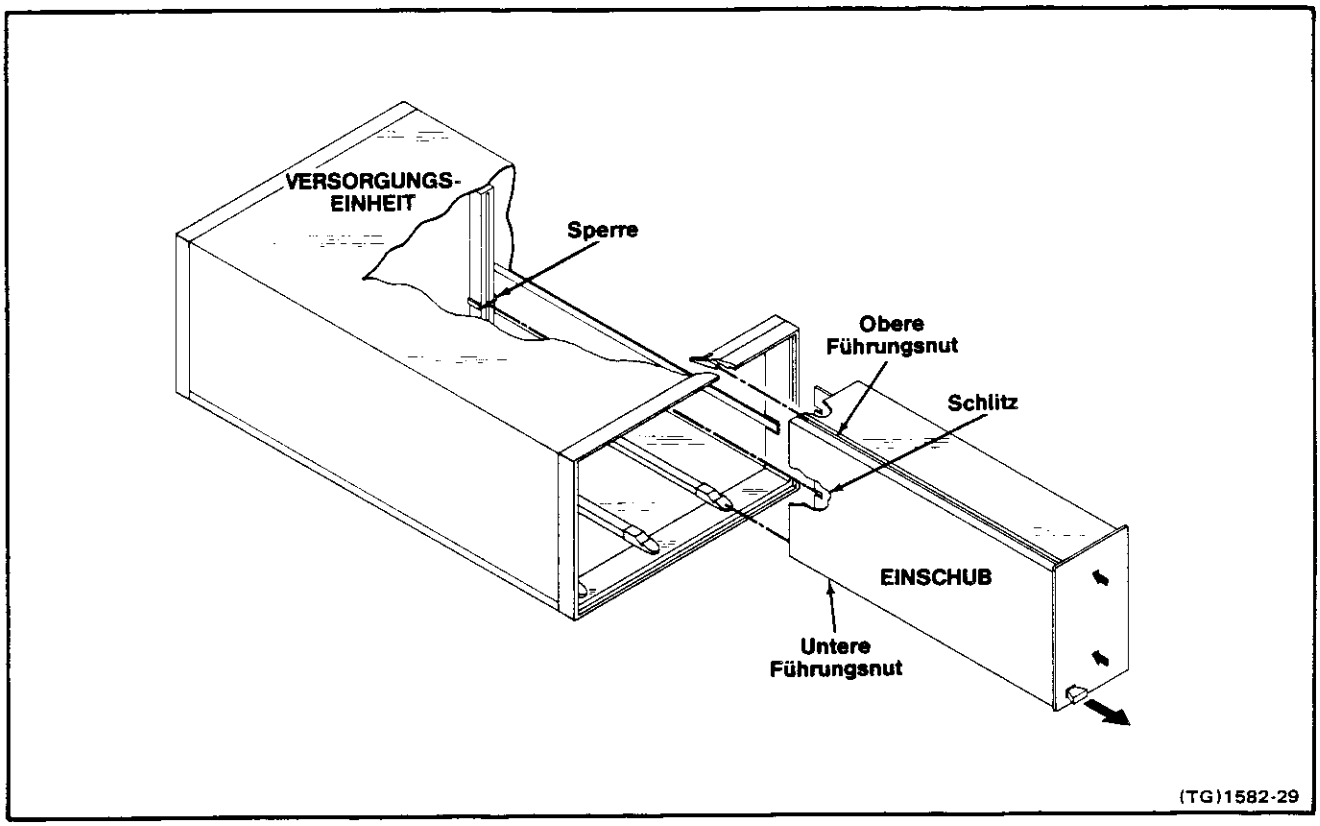


Abb. 1–1. Ein- und Ausbau des Einschubs.

Eingänge

Wird in den AM 502 ein Signal mit hoher Amplitude, geringer Frequenz und geringer Quellenimpedanz eingespeist, so kann das mit ungeschirmten Verbindungskabeln erfolgen. Fehlt jedoch eine der obengenannten Bedingungen, so muß abgeschirmtes Kabel verwendet werden. Es ist dabei auf möglichst kurze Kabelverbindungen zu achten.

Wird eine Meßung im Eintaktbetrieb vorgenommen (konventionelle Betriebsart), so muß eine Masseverbindung zwischen dem Testobjekt und dem AM 502 hergestellt werden. Das kann üblicherweise über die Abschirmung eines Koaxialkabels erfolgen. Der nichtbenutzte Eingang des AM 502 ist mit dem mit GND bezeichneten Schalter auf Massepotential zu legen.

In manchen Fällen ist bei Differenzbetrieb keine Masseverbindung erforderlich, wobei auch keine Masseschleifenströme auftreten können.

Beachten Sie die geänderten kapazitiven Belastungen des Testobjektes bei der Verwendung längerer Anschlußkabel. Die Eingangsimpedanz des AM 502 beträgt 1 MΩ‖ 47 pF. Durch Verwendung eines Koaxialkabels von ca. 70 cm Länge erhöht sich die Parallelkapazität um ca. 60 pF, was in manchen Fällen zu hoch sein kann. Es ist dann ein Kabel mit höherer Impedanz oder ein Teilertastkopf zu verwenden.

Tastköpfe

Teilertastköpfe verringern die kapazitive Belastung des Testobjektes und erweitern den Eingangsspannungsbereich des AM 502 zu höheren Spannungen hin. In Anwendungsfällen, wo eine hohe Eingangsimpedanz bei geringster kapazitiver Belastung der Signalquelle jedoch ohne Signalabschwächung erforderlich ist, ist ein FET-Tastkopf oder die Hochimpedanzvorrichtung am AM 502 zu verwenden. Für weitere Informationen über Tastköpfe wenden Sie sich bitte an ihre Tektronix-Vertretung.

Hochimpedanz-Eingang

Um die Eingangsimpedanz des AM 502 auf >200 MΩ zu steigern, ist der Stecker P 40 (siehe Abb. 3-1) zu entfernen und der Teiler in die Betriebsart NORM zu bringen. In diesem Fall ist die Signalquellenimpedanz von großer Bedeutung. So erzeugt z. B. ein Gatestrom von 100 pA durch 10 MΩ eine Offset-Spannung von 1 mV. Bei der Messung von geringen Spannungen kann diese Offsetspannung zu bedeutenden Fehlern führen.

Eingangsüberlastung

Vor der Messung nichtbekannter Gleichspannungen ist die ÷ 100 Taste zu betätigen und der Verstärkungsschalter GAIN in die Position 100 zu stellen. Die Einstellung der Verstärkung ist zu steigern und schließlich die ÷ 100 Taste zu lösen, bis ein verwertbares Ausgangssignal am AM 502 vorliegt. Bei Übersteuerung des Eingangs verursachen höhere Eingangsströme ein Auslösen der Schutzsicherungen.

STEP GAIN DC BAL
Gleichspannungsbalance

Gleichspannungsbalance-Einstellung für die verschiedenen Verstärkungsfaktoren.

÷100 – Drucktaste

Im gedrückten Zustand ist der Verstärkungsfaktor am Schalter GAIN durch 100 zu teilen.

DC OFFSET FINE / COARSE – Fein/Grob-Einsteller für Gleichspannungsoffset

Hiermit kann eine interne Offsetspannung von ±1 V dem Eingangssignal unterlegt werden. Dazu ist der LF −3 dB Schalter in die Position DC OFFSET zu bringen.

Kontinuierliche Verstärkungseinstellung.
Kalibriert bei Rechtsanschlag.

GAIN-Verstärkungsschalter
wählt die Verstärkung.

OVER RANGE – Übersteuerungsanzeige.

Beim Leuchten der Lampe liegt eine Übersteuerung vor.

AC-Kopplungsartenwahltaste

Bei gedrückter Taste liegt für den positiven Verstärkereingang Wechselspannungskopplung, bei gelöster Taste Gleichspannungskopplung vor.

+ (positiver) Verstärkereingang

BNC-Buchse für positive Verstärkerseite.

GND-Druck-Taste

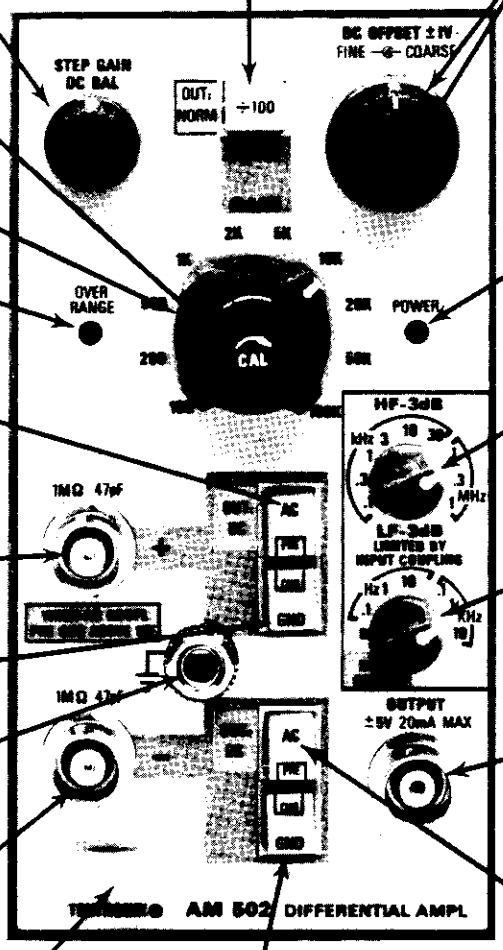
Im gedrückten Zustand wird der positive Eingang auf Massepotential gelegt.

Masseanschlußbuchse

Masseanschluß für Signale.

− (negativer) Verstärkereingang

BNC-Buchse für negative Verstärkerseite.



POWER – Betriebsspannungsanzeige

Das Leuchten zeigt an, daß Versorgungsspannung anliegt.

HF −3 dB

Wahlschalter für die obere Grenzfrequenz.

LF −3 dB

Wahlschalter für die untere Grenzfrequenz (−3 dB) und Aktivierung der Gleichspannungsoffseteinstellung.

OUTPUT – Ausgangs-BNC-Buchse

AC-Kopplungsartenwahltaste

Bei gedrückter Taste liegt für den negativen Verstärkereingang Wechselspannungskopplung, bei gelöster Taste Gleichspannungskopplung vor.

Release LATCH – Entriegelungsklinke

Zum Herausnehmen des AM 502 ist an der Entriegelungsklinke zu ziehen.

GND-Drucktaste

Im gedrückten Zustand wird der negative Eingang auf Massepotential gelegt.

(TG)1582-30

Abb. 1-2. Bedienungselemente und Anschlußbuchsen des AM 502.

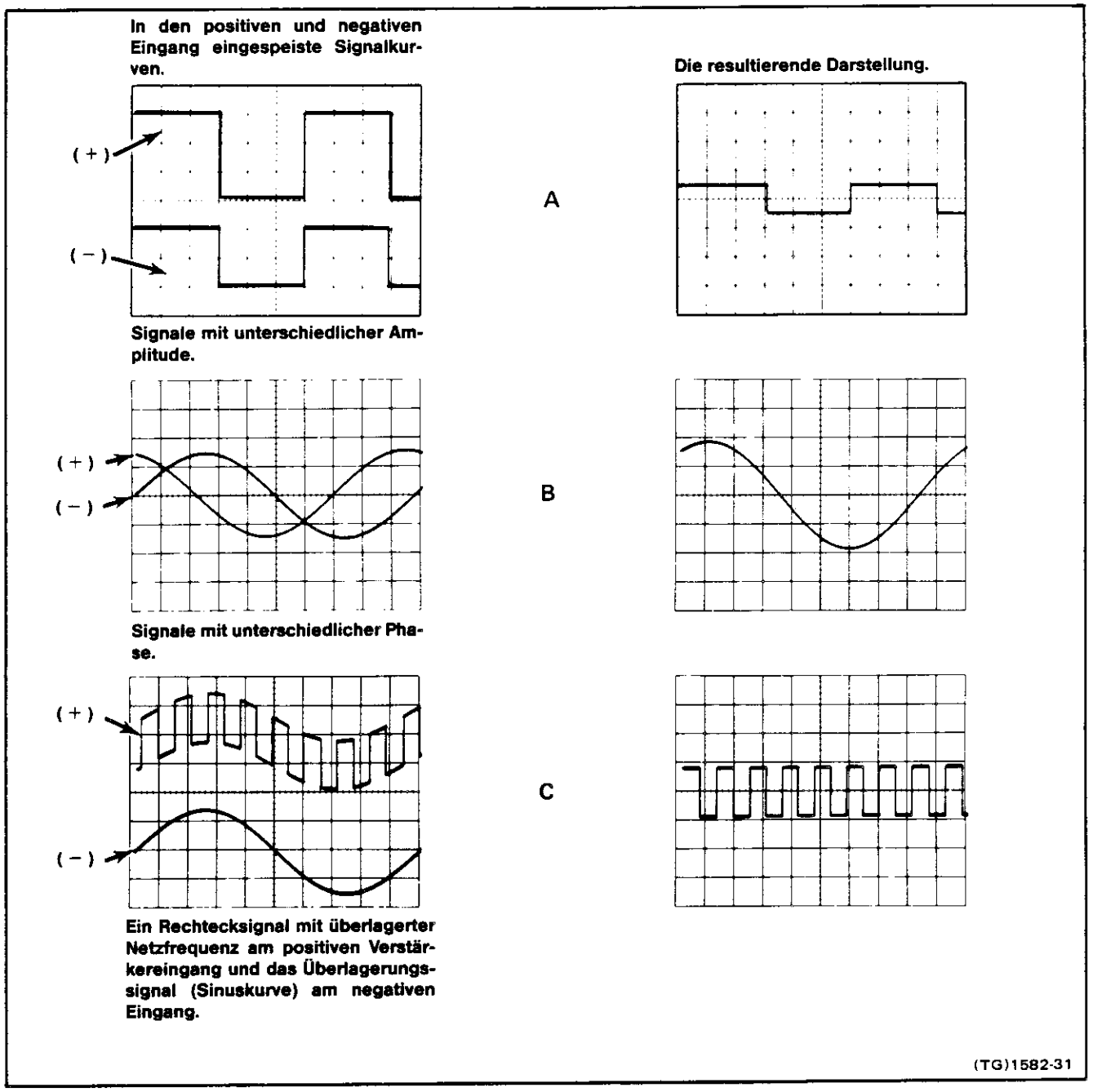


Abb. 1-3. Die Kurven zeigen die Unterdrückung eines Gleichtaktsignals durch Differenzbildung. Die resultierende Kurve ist die Differenz der beiden Kurven.

Ausgangsverbindungen

Das Ausgangssignal kann über einen Adapter BNC/Bananenstecker oder Koaxialkabel mit mindestens einem BNC-Stecker abgegriffen werden. Dabei ist der Ausgang mit nicht weniger als 250 Ω zu belasten zur Vermeidung der bei 20 mA einsetzenden Strombegrenzung.

Gleichspannungsbalance-Einstellung

Bei unkorrekt eingestellter Gleichspannungsbalance springt der Ausgangsgleichspannungspegel beim Umschalten der Verstärkungsfaktoren. Zur korrekten Einstellung am Gleichspannungsbalance-Regler ist der Verstärkungswahlschalter von Anschlag bis Anschlag hin- und herzudrehen, bis am Ausgang keine Gleichspannungsverschiebung mehr auftritt.

Gleichspannungsoffset Grob/Fein

Diese Einstellregler dienen der Kompensation eines Spannungsoffsets am Eingang bis zu ±1 V durch interne Vorspannungsänderung. Dabei werden die Gleichtaktunterdrückungseigenschaften nicht beeinflußt. Zu dieser Einstellung muß sich der Schalter für die untere Grenzfrequenz (LF −3 dB) in Position DC OFFSET befinden.

Bandbreitenreduzierung

Mit dem Regler HF −3 dB ist die obere Grenzfrequenz abzusenken, bei Anwendungen des AM 502 im niederfrequenten Bereich. Man erreicht damit einen höheren Störspannungsabstand.
Der Regler LF −3 dB erhöht die untere Grenzfrequenz, wodurch Drifterscheinungen beseitigt werden können.

Voraufladung

Diese Einrichtung am AM 502 verhindert Verschiebeströme im Koppelkondensator bei Wechselspannungskopplung, die eine Beschädigung des Testobjektes hervorrufen könnten.

Zur Anwendung sind vor der Einspeisung eines mit Gleichspannungskomponenten behafteten Signals an den AM 502 die Drucktasten AC und GND zu betätigen. Das Signal ist nun anzulegen und ca. 1 Sekunde Aufladungszeit abzuwarten. Dann ist die GND-Taste wieder zu lösen. Der interne Koppelkondensator ist damit auf den Wert der Gleichspannungskomponente des Meßsignals aufgeladen.

Differenzbetrieb

Eine Messung im Differenzbetrieb liegt vor, wenn beide Eingänge gespeist werden. Im Verstärker wird dann die Differenz der an den Meßpunkten liegenden Spannungen verarbeitet. Es ist dabei auf korrekte Signaleinspeisung in den AM 502 zu achten, da sonst Fehlmessungen auftreten können. Siehe hierzu Abb. 1-4.

Im Differenzbetrieb sind die Kopplungsartenschalter der beiden Eingänge, entsprechend der geforderten Kopplungsart, in gleiche Positionen zu bringen. Es wird nur die Spannungsdifferenz zwischen den Eingangssignalen verstärkt. Gleichtaktsignale (gleich in Amplitude, Phase und Frequenz) werden unterdrückt. Siehe dazu Abb. 1-3. A, B und C.

Eintaktmessungen ergeben oft durch Überlagerung von Brummspannungen, bedingt durch Masseschleifen, unzufriedenstellende Meßergebnisse. In anderen Fällen ist die Verwendung eines Koppelkondensators zur Elimination einer Gleichspannungskomponente, wegen der Anhebung der unteren Grenzfrequenz, oft nicht wünschenswert. In diesen Fällen können diese Fehler durch die Anwendung des Differenzbetriebes beseitigt werden.

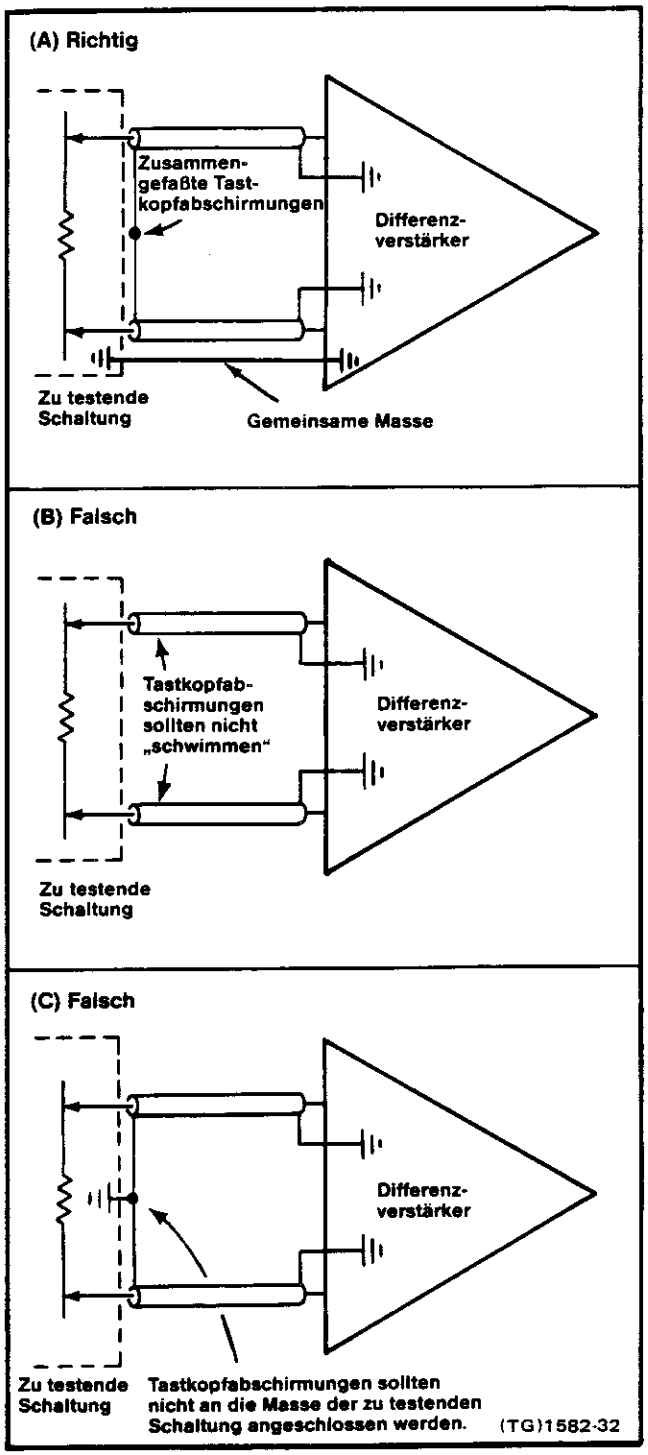


Abb. 1-4. Anschluß eines Differenzverstärkers an eine Signalquelle.

Gleichspannungsoffset-Betrieb

Unter Verwendung der Gleichspannungsoffset-Einsteller ist es möglich, den AM 502 im Kompensationsbetrieb anzuwenden, wenn ein kleines Meßsignal mit einer erheblichen Gleichspannungsdifferenz behaftet ist. Die Offsetspannung ist im Bereich ±1 V einstellbar und für alle Verstärkungswerte verfügbar. Bei der Einstellung ist der Schalter LF –3 dB in die Position DC OFFSET zu bringen.

CMRR Gleichtaktunterdrückungsverhältnis

Die Fähigkeit des AM 502 Gleichtaktsignale zu unterdrücken, wird durch das Gleichtaktunterdrückungsverhältnis CMRR ausgedrückt.
Ein Beispiel: Man nehme an, ein Signal bestehe aus einem unerwünschten 60 Hz Anteil mit einer Amplitude von 10 V_{SS} (im Gleichtakt an beiden Eingängen liegend) und einem Netzsignal mit einer Amplitude von 1 mV_{SS} (eingespeist im Differenzbetrieb an einem Eingang). Die Verstärkung des AM 502 ist auf 200 eingestellt. Das Ausgangssignal zeigt das Netzsignal mit einer Amplitude von 0,2 V_{SS} (1 mV x 200) und das unerwünschte 60 Hz-Signal mit einer Amplitude von 20 mV. In diesem Fall ist das CMRR 100.000 : 1. Dieser Wert entsteht durch Multiplikation des Amplitudenwertes von 10 V (des unerwünschten Signals) mit der Verstärkung von 200 zu einem Produkt von 2.000 V. Dieses Produkt wird nun durch den Amplitudenwert der unerwünschten Ausgangsspannung von 20 mV dividiert und man erhält 100.000 : 1. Bei Anwendung von Eintaktbetrieb wäre es natürlich unmöglich, das Netzsignal von 1 mV_{SS} überlagert mit dem 60 Hz-Signal von 10 V_{SS}, darzustellen.

Verringerung der Gleichtaktunterdrückung

Die grundsätzliche Bedingung zur Erreichung einer maximalen Gleichtaktunterdrückung ist das Vorliegen des Signals in gleicher Phase und Amplitude an den Eingangs-FET's. Nun gibt es zahlreiche Faktoren, die das CMRR verringern können. Eine Differenz von nur 0,01% im Teilerverhältnis der Eingangsteiler verringert das CMRR auf 10.000 : 1. Also jede Differenz in der Quellimpedanz führt zu einer Verringerung. Die Abbildungen 1-5 und 1-6 zeigen Fälle, wo Differenzen in den Quellimpedanzen zu Verringerungen des CMRR führen. Auch die Frequenz eines Gleichtaktsignals beeinflußt das CMRR.
Je höher die Signalfrequenz ist, desto schwieriger ist es, das CMRR zu erhalten.

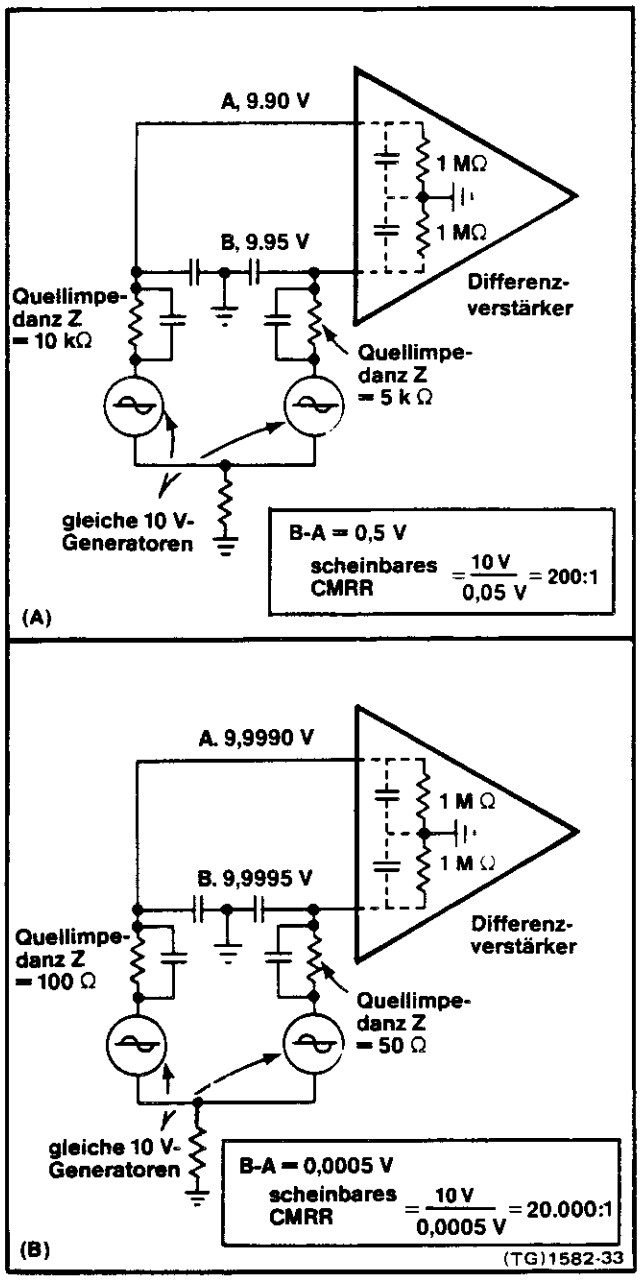
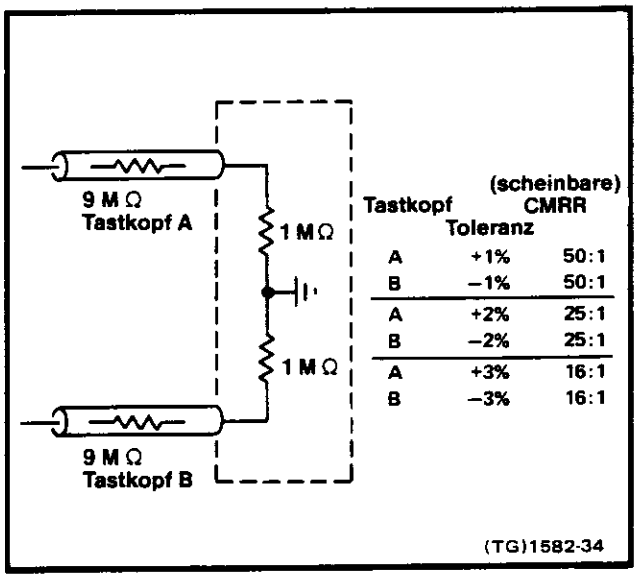


Abb. 1-5. Beziehung zwischen der Testpunktquellimpedanz und der Verstärkereingangsimpedanz und des scheinbaren Gleichtaktunterdrückungsverhältnisses (CMRR). (A) mit großer Differenz in hohen Quellimpedanzen und (B) bei niedrigen Quellimpedanzen.



Tastkopf	Toleranz	(scheinbare) CMRR
A	+1%	50:1
B	−1%	50:1
A	+2%	25:1
B	−2%	25:1
A	+3%	16:1
B	−3%	16:1

Abb. 1-6. Ein vereinfachter Eingangskreis und eine Tabelle zeigen die Veränderung des scheinbaren CMRR bei der Verwendung von x 10 Teilertastköpfen an 1 M Ω-Eingängen, die in ihren Teilerverhältnissen um 1, 2 und 3% abweichen.

Das hochfrequente CMRR hängt auch von der Quellimpedanz ab, insbesondere daher, daß verschiedene Parallelkapazitäten zwischen der Quelle und dem Eingangsgate durch die Impedanz auf- und entladen werden.

Äußere Einflüsse wie z. B. magnetische Felder können auch die Leistung herabsetzen, besonders bei sehr kleinen Signalen. Solche Einflüsse lassen sich durch Verwendung gleicher Anschlußleistungen für beide Eingänge und darüberhinaus durch Verdrillen der Leitungen auf ihrer Gesamtlänge, verringern. Die Messung von Signalen niedriger Freqzenz läßt sich einfach schützen, durch Verwendung von abgeschirmten zweiadrig verdrillten Kabeln.

取扱説明

はじめに

概要

AM502型は、すぐれた同相除去機能と高利得の低電圧測定に最適なDC結合差動増幅器です。零点を1VDCまで上げられるDCオフセット機能を備え、AC結合の増幅器ではしばしば減衰してしまうDCレベル上の低振幅で周波数の低い信号を増幅できます。高周波および低周波の－3dB点は測定内容に応じて前面パネルで選択することができます。信号入力と出力は、前面パネルと同様に後部コネクタでも扱うことができます。過大な入力信号、利得、オフセットに対しては、前面パネルのランプが点燈して、オーバレンジの状態を知らせます。

入力回路のインピーダンスは約1MΩと並列に約47pFです。ジャンパの移動により入力インピーダンスを約200MΩにすることができます。

過負荷保護のため入力回路にはヒューズが取り付けられています。過負荷によって過電流が流れると回路は開放状態になります。

STEP GAIN DC BALANCEコントロールでは、ゲイン・スイッチを他の位置に切り換えた時に起こる零シフトの調整を行います。

DC OFFSET COARSE および FINEコントロールでは、入力コネクタの電位を±1VDCまで調節できます。増幅器の内部バイアスはオフセットによりかえられます。これらのコントロールはLF－3dBスイッチがDC OFFSET位置に設定されている時のみ作動します。

HF－3dBスイッチは、**AM502型**を低周波のアプリケーションに使用する際、S/N比を改善するため高い方の周波帯域制限を減少するのに使用します。LF－3dBコントロールは低周波の帯域幅を増大します。

プリチャージング機能は、AC結合キャパシタをかえることによってサージ電流による被測定回路の損傷を防止します。

取付と取りはずし

注　意

プラグインを抜き差しする場合には本体の電源を切ってから行って下さい。切らずに抜き差ししますとAM502型に大電流が流れてプラグインの回路に悪影響を与えます。1－1図を参照して、本体のコネクタ内に入っているプラスチックの位置決めスペーサとAM502型のエッジ・コネクタのカット部分とが一致していることを確認します。

本体のプラグイン・ホールの上下のガイドに沿ってAM502型を押し込み、さらに本体のコネクタにAM502型のエッジ・コネクタがしっかりと固定されるまで押して下さい。

AM502型を取りはずす場合には、左下隅にあるつまみを引っぱりそのまま引き抜きます。

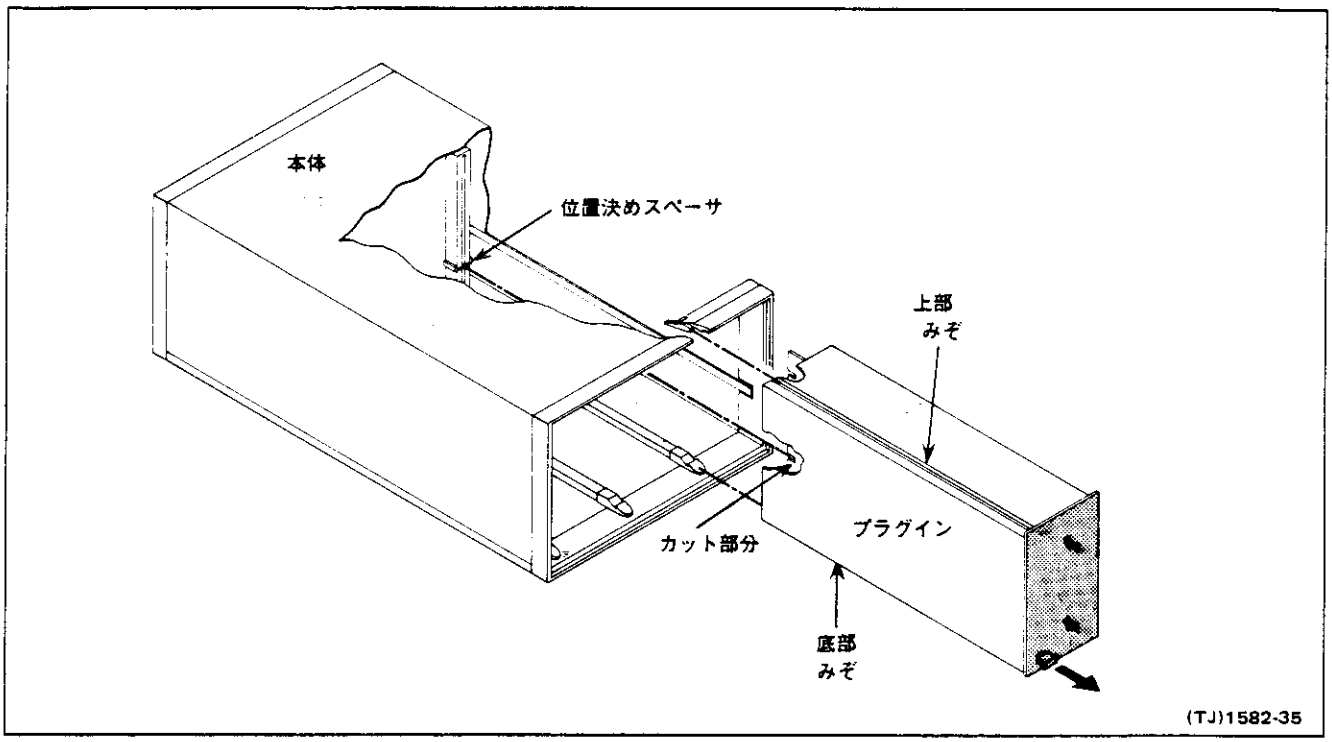
コントロールとコネクタ

AM502型は出荷時に完全に校正されていますので、そのままご使用になれます。コントロールやコネクタの機能や動作については**1－2図**をご参照下さい。まず本体の電源スイッチを引き出して**AM502型**に電源を入れます。**AM502型**に電源が投入されるとPOWERインジケータが点燈します。

操作上の注意

過熱について

AM502型は0℃～＋50℃の周囲温度で作動します。しかし、本体にいくつかの電源プラグインが組み込まれている時、特に出力電圧を低くして使用する場合、または熱を発生する機器が近くにある場合は、内部温度が安全範囲を超えることがありますが、その時は本体のサーマル・カットアウトが作動します。くわしくは本体のインストラクション・マニュアルをご覧下さい。



1－1図　プラグインの取付と取りはずし

入力接続

高レベル、低周波の信号を低インピーダンス点でモニタする場合は、**AM502型**を信号源に接続するのに、シールドされていないテスト・リードを用いることができます。しかし、上記の条件が1つでも満たされていない時は、シールドされた信号ケーブルを使用することが必要になります。どのような場合でも、リード線はできる限り短くする必要があります。

シングル・エンド入力の測定（通常の増幅器の作動）を行うには、被測定物（ＤＵＴ）と**AM502型**の間のコモン・グラウンド接続をしっかり行って下さい。同軸ケーブルのシールドは、通常このために使われています。1－3図参照。ＤＵＴに接続されない入力に対しては、GNDボタンを押して下さい。

ある種の差動測定ではコモン・グラウンド接続を必要としないことがあります。これによってグラウンド・ループ電流による干渉は減少します。

信号を接続する場合、信号入力ケーブルの負荷効果による特性変化を配慮する必要があります。入力コネクタでのインピーダンスは約1MΩと並列に47pFであらわされます。2フィートの50Ω同軸ケーブルを接続すると容量は約60pFに増大しますが、多くの場合、これは好ましくないことです。この効果を減少させるため、高インピーダンス・ケーブル、または減衰プローブを用います。

プローブ

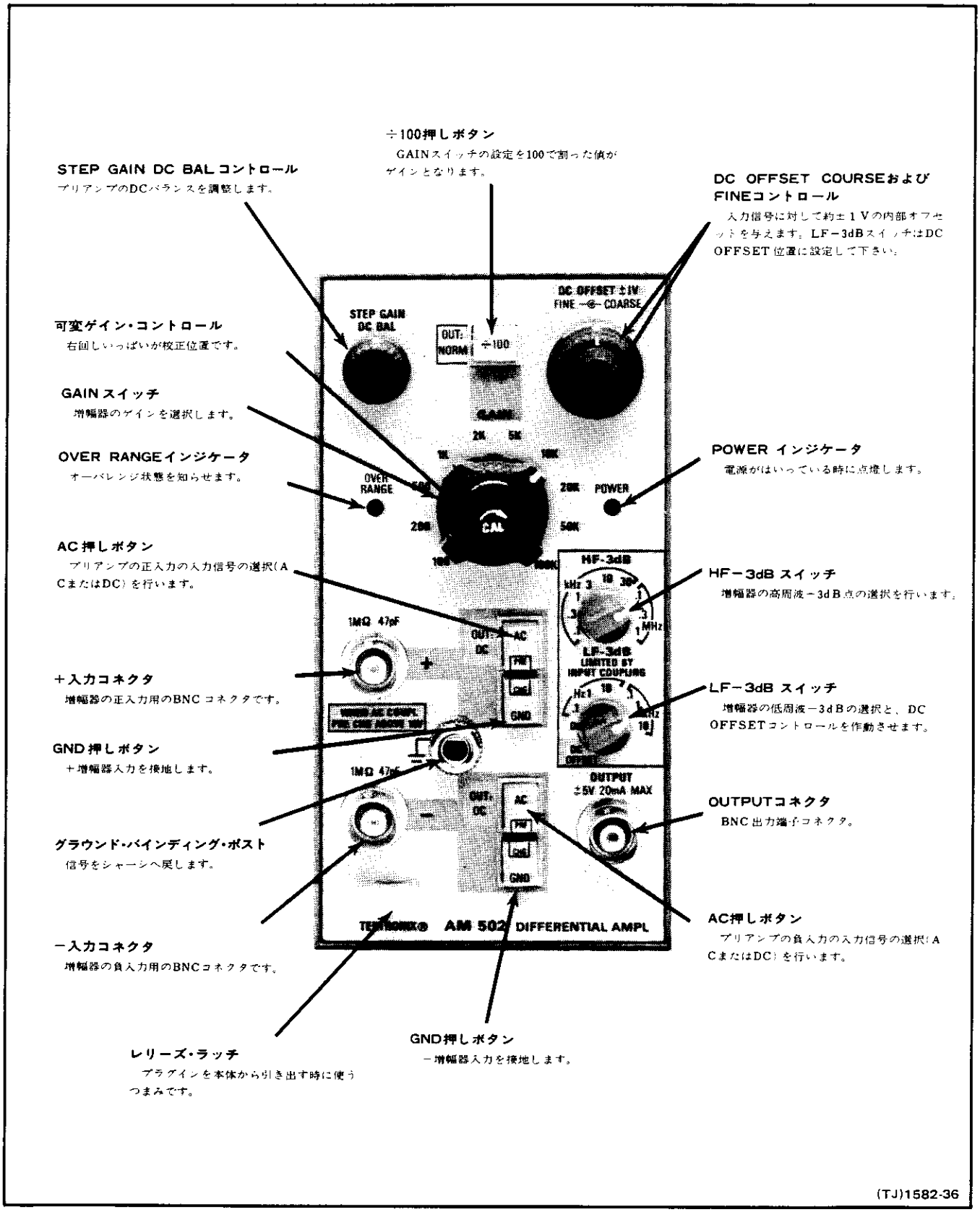
減衰プローブは抵抗－容量負荷を減少させ、**AM502型**の測定範囲をより高い電圧まで拡張します。測定によっては、信号源負荷または信号の減衰を極力小さくして、**AM502型**への抵抗入力をより高くする必要があります。このような場合はＦＥＴプローブを使用するか、**AM502型**の高インピーダンス入力を使用します。くわしくは当社フィールド・エンジニアにおたずねください。

高インピーダンス入力

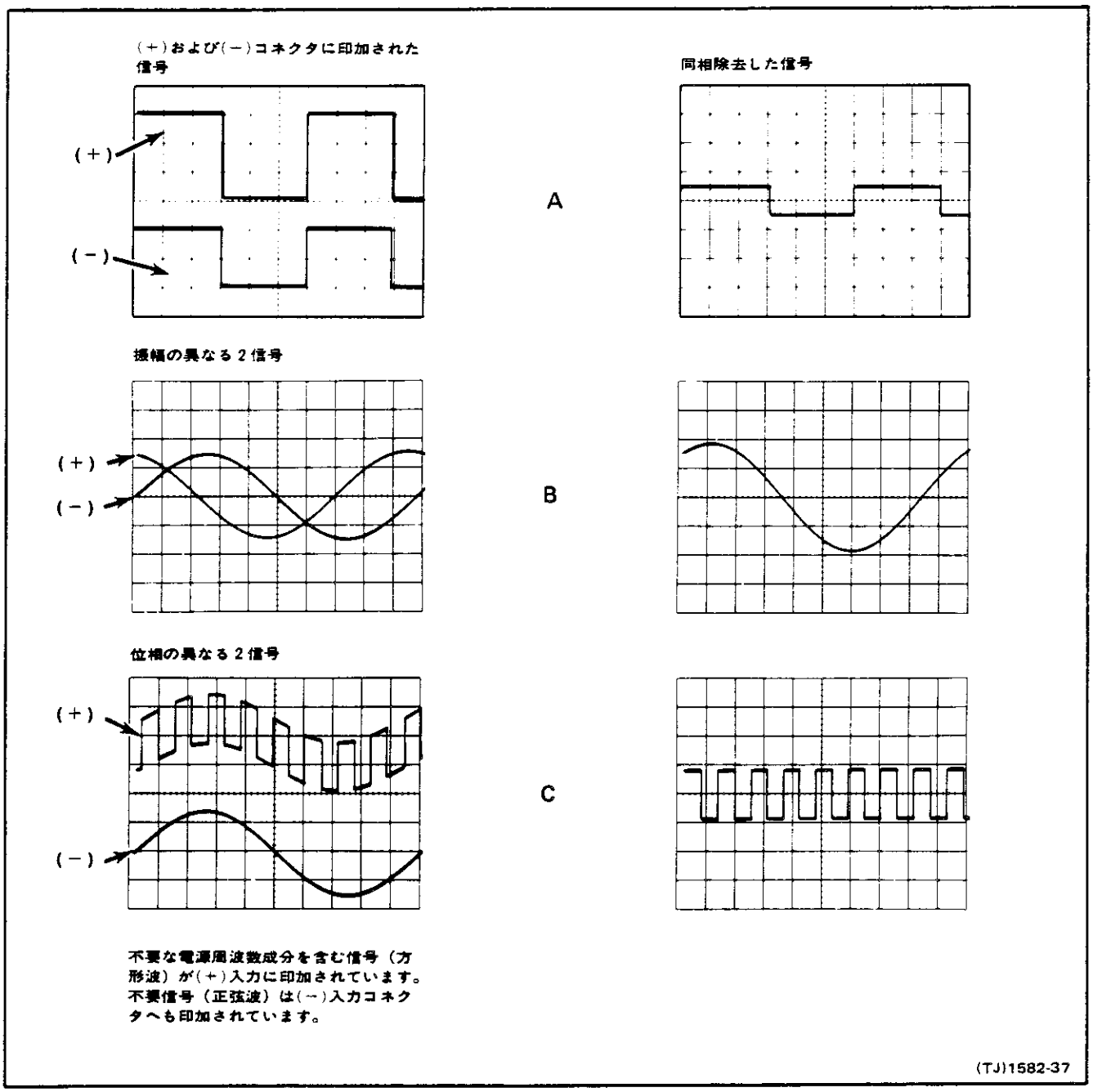
AM502型の内部入力インピーダンスを200MΩまで上げるには、P40プラグを取りはずします。（3－1図参照）アテネータがNORMモードになっているかを確めます。この時、信号源インピーダンスが重要な要素となります。たとえば10MΩに100pAのゲート電流が流れると、1mVのオフセットが生じます。このオフセットは、小電圧測定の際には大きな誤差となります。

入力過負荷

未知のＤＣ電圧を測定するには、まず÷100ボタンを押し込み、GAINスイッチを100の位置に設定します。GAINスイッチを設定値が大きくなるように回していき、適当な出力信号が得られたら÷100ボタンを解除します。**AM502型**をオーバドライブすると、大電流が流れて、保護用ヒューズが切れます。



1-2図　コントロールとコネクタ



1-3図　同相除去。右の図は2信号の差です。

出力接続

出力はデュアル・バインディング・ポスト・コネクタまたは少くとも一方がBNCコネクタになっている同軸ケーブルをBNCコネクタに接続して得ることができます。出力段での電流制限を防止するため、出力側の負荷は250Ω以下にしないで下さい。出力電流は20mAに制限されます。

STEP GAIN DC BAL コントロール

このコントロールの調整が正しく行われないと、GAINスイッチ位置を切り換えるたびにDC出力レベルがシフトします。両方のGNDボタンを押して、GAINスイッチを100の位置に設定します。OUTPUT端子でのDCシフトをなくすため、STEP GAIN DC BAL コントロールを調整する際はGAIN スイッチを端から端まで回して下さい。

DC OFFSET COURSE 及び FINE コントロール

これらのコントロールによって、±１Ｖのオフセットを与えることができます。オフセットによって増幅器の内部のバイアスが変わります。**AM502型**の差動除去機能には影響はありません。このコントロールを機能させるには、LF－3dBスイッチはDC OFFSET位置にします。

高域および低域周波数除去

HF－3dBスイッチは、**AM502型**を低周波のアプリケーションに使用する時には、上限周波数を下げ、S/N比を改善します。LF－３dBコントロールは、下限周波数を上げます。このコントロールは、測定しようとする信号に対して影響しない程度に下限周波数の－3dB点を上げてＤＣドリフトを取り除きます。

プリチャージ

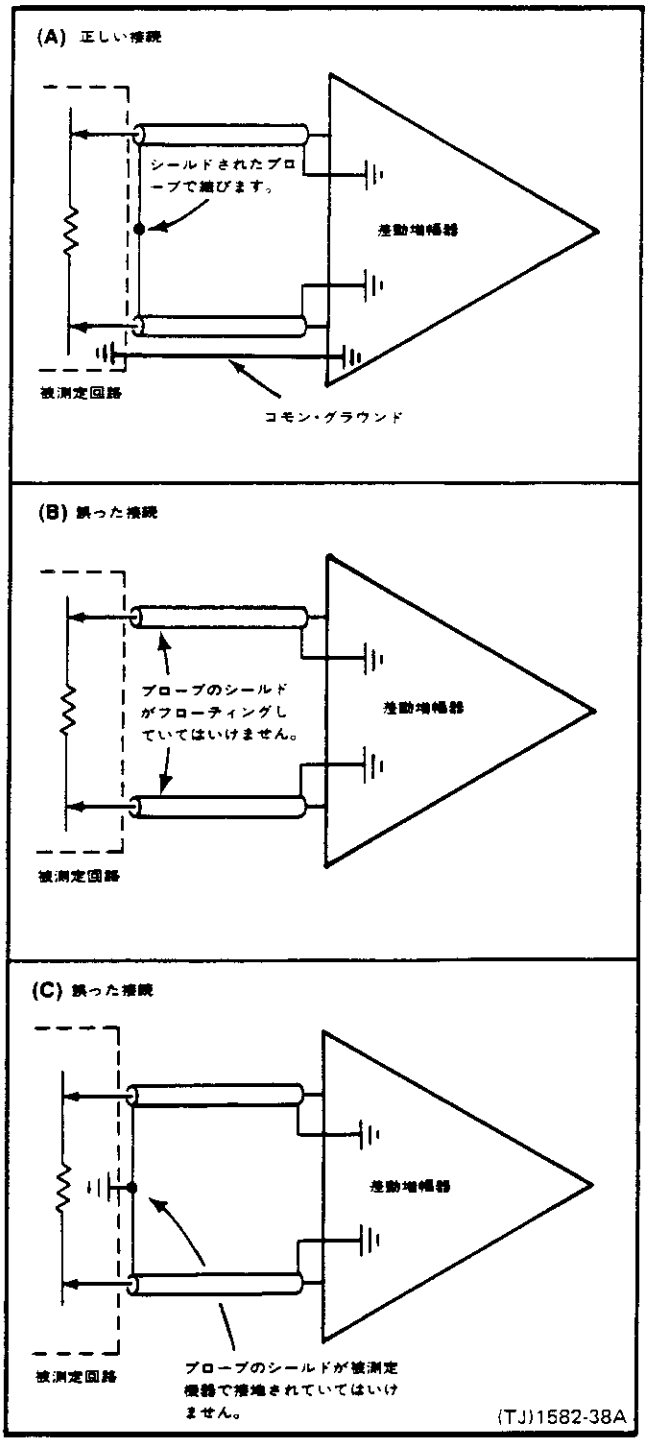
この機能は**AM502型**のカップリング・キャパシタをチャージすることにより、サージ電流を防止し、測定回路の損傷を防ぎます。**AM502型**にＤＣ成分を含んだ信号を接続する前に、ACおよびGNDボタンを押して下さい。次に入力信号を接続します。カップリング・キャパシタが、チャージされる間、約１秒待ちます。GNDボタンを押します。カップリング・キャパシタは測定すべきＤＣ電圧にチャージされています。

差動操作

差動測定は測定回路の２点を各入力に接続して行います。増幅器へは２点間の電圧差が入力されます。**AM502型**と測定回路の接続方法に注意して、正確な測定を行って下さい。**１－４図**をご参照下さい。

差動電圧測定は、信号を＋および－入力コネクタに印加して行います。入力カップリング・スイッチは、測定に応じてACまたはDCのいずれか、どちらも同じ位置に設定して下さい。差動測定においては、２信号間の電圧差のみが増幅されます。同相信号（振幅、位相、周波数が同じ）は除去されます。**１－３図**のＡ、Ｂ、Ｃをご参照下さい。

シングル・エンド測定は、**AM502型**と被測定物間のグラウンド・ループ電流の影響によって、しばしばエラーを起こします。その他の場合は、低周波成分を制限するキャパシタを使用することによってＤＣ電圧を除去できるので便利です。シングル・エンド測定における制限は差動測定を行うことによってほとんど取り除くことができます。



1-4図　信号源の差動増幅器への接続

DCオフセット作動

FINEおよびCOARSE DC OFFSETコントロールの使用によって、**AM502型**をスライドバック・モードで差動操作させることができます。DC成分に注意すれば、このモードで微小信号の観測ができます。オフセット電圧は−1Vから−1Vまで連続的に調整でき、GAINスイッチのすべての位置に対し、内部的にオフセットを与えることができます。オフセット回路を作動させるには、LF−3dBスイッチをDC OFFSET位置に設定して下さい。

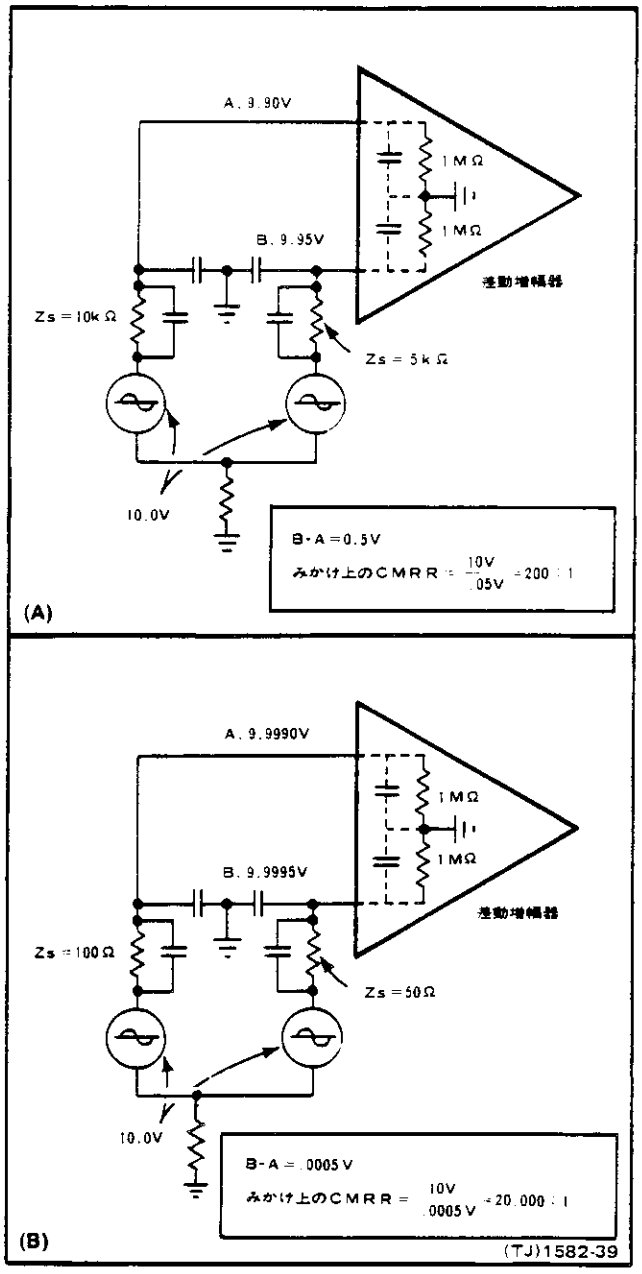
同相除去モード

AM502型の同相信号を除去する機能は同相除去比（CMRR）によって示されます。たとえば60Hzで10Vp−pの好ましくない信号（両入力に同相信号を印加）に、測定すべき1mVp−pの信号（片方の入力にのみ印加）が重畳しているとします。**AM502型**のゲインを200に設定します。**AM502型**の出力には測定信号が振幅0.2V（1mV×200）の信号となってあらわれ、60Hzの信号は振幅0.02Vとなります。この場合の同相除去比は100,000：1です。この計算は、まず、同相信号の電圧（10V）とゲイン（200）の積（2000V）を求め、これを出力における60Hz信号の振幅（0.02V）で割ります。この結果が同相除去比で、100,000：1となります。60Hzの信号に重畳している1mVの信号を、通常の方法で観測することはできません。

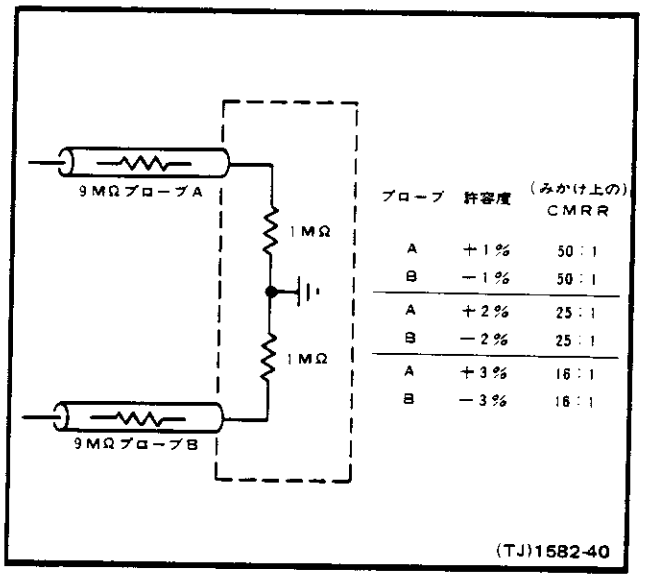
同相除去比の低下

同相除去比（CMRR）の低下には、いくつかの要因があります。まず同相除去に最も大切なことは、入力FETゲートに同相、同振幅の信号が印加されることです。入力アテネータ間の減衰比に0.01％の差があると除去比が10,000：1に低下します。ソース・インピーダンスの違いも除去比を低下させます。**1−5図**と**1−6図**は、ソース・インピーダンスの違いにより、同相除去比が低下することを説明しています。同相信号の周波数も同相除去比に影響を及ぼします。一般的には、周波数が高くなると、同相除去比は低下します。

高周波においては、同相除去比は信号源インピーダンスによっても左右されます。信号源と入力ゲート間の分路キャパシタに信号源インピーダンスを通して充放電が行われるためです。



1-5図　測定点のソース・インピーダンスと増幅器の入力インピーダンスの関係、および(A)測定点インピーダンス間に大きな差がある場合、(B)測定点インピーダンスが小さい場合のみかけ上のCMRR



プローブ	許容度	(みかけ上の) CMRR
A	+1%	50:1
B	−1%	50:1
A	+2%	25:1
B	−2%	25:1
A	+3%	16:1
B	−3%	16:1

1-6図　減衰比の許容度が1,2,3%の×10プローブ（1MΩに整合）によるみかけ上のCMRRの変化

磁界のような外部からの影響によっても同相除去比は低下します。特に低レベルの信号が含まれている場合は顕著です。磁界の干渉を取り除くには2つの入力に同じ信号リードを使用します。2本のリード線をできる限り長くたいにねじり合わせます。低周波の測定には、同様にして、ねじり合わせた導線をシールドしたケーブルを用いて外部の悪影響を防止します。

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO. REFER TO OPERATORS SAFETY SUMMARY AND SERVICE SAFETY SUMMARY PRIOR TO PERFORMING ANY SERVICE.

SPECIFICATION AND PERFORMANCE CHECK

SPECIFICATION

Performance Conditions

The electrical characteristics are valid only if the AM 502 has been calibrated at an ambient temperature between +20° C and +30° C and is operating at an ambient temperature between 0° C and +50° C unless otherwise noted.

Items listed in the Performance Requirements column of the Electrical Characteristics are verified by completing the Performance Check in this manual. Items listed in the Supplemental Information column are not verified in this manual; they are either explanatory notes or performance characteristics for which no limits are specified.

Table 2-1

ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
Gain		
Normal Mode	100 to 100,000 within 2%, 10 steps in 1, 2, 5 sequence.	
÷100 Mode	1 to 1000 within 2%.	
Variable Range		Continuously variable uncalibrated gain to at least 2.5 times the calibrated gain setting.
Frequency Response		
Direct Coupled	dc to 1 MHz	With Gain control set to 20K or less, selectable HF −3dB points are within +1dB, −2dB. Upper −3dB point reduces to 500 KHz at 50K gain, and 250 KHz at 100K gain.
AC Coupled	2 Hz or less, at lower frequency −3dB point to 1 MHz.	
Bandwidth		
HF −3dB	100 Hz to 1 MHz, 9 steps in 1-3 sequence.	Reference approximately 5.0 V peak-to-peak output at 1 KHz.
Accuracy	+1dB, −2dB	Reading range −2dB to −5dB.
LF −3dB	0.1 Hz to 10 kHz 6 steps in 1-10 sequence.	
Accuracy	+1dB, −2dB	Reading range −2dB to −5dB.

Table 2-1 (Con't)

Characteristics	Performance Requirements	Supplemental Information
Output		
Voltage Swing	±5 V.	
Current		±20 mA
R_o		5 Ω or less
Minimum Load Impedance		250 Ω
Common Mode		
Normal Mode Range	±5 V.	
Rejection Range	100 dB, dc to 50 kHz.	Direct coupled with inputs shorted together.
÷100 Mode Range	±50 V.	
Rejection Range	50 dB, dc to 50 kHz.	Direct coupled with less than 100 V peak-peak sine-wave input.
DC Offset Range		At least + and − 1 V.
Maximum Safe Input Voltage		
Direct Coupled Normal Mode		15 V (dc plus peak ac) to 5 MHz or less.
÷100 Mode		350 V (dc plus peak ac) to 5 MHz or less.
AC Coupled		350 V (dc plus peak ac) with coupling capacitor precharged.
Maximum Input Gate Current (each input)		50 pA at 25° C.
Noise (Referred to Input)		
NORM mode	≤25 μV, tangentially measured with 25 Ω or less source resistance.	10 Hz to 1 MHz selected bandwidth. Typically ≤6.0 nV/$\sqrt{\text{Hz}}$ above 1 kHz.
÷100 Mode		Typically ≤2.0 μV/$\sqrt{\text{Hz}}$ from 1 kHz to 9 kHz, decreasing in a 1/F fashion to ≤600 nV/$\sqrt{\text{Hz}}$ above 30 kHz.
Voltage Drift with Time		
Short Term		10 μV (peak-to-peak) per hour

Table 2-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Long Term		20 μV (peak-to-peak) per hour.
Voltage Drift with Temperature		100 μV per °C.
Input R and C		Resistance, 1 MΩ. Capacitance, Approximately 47 pF.

Table 2-2

ENVIRONMENTAL

Characteristics	Information
Temperature	
Operating	0°C to +50°C
Storage	−40°C to +75°C
Altitude	
Operating	To 15,000 feet; maximun operating temperature decreased by 1°C/1000 feet from 5000 to 15,000 feet.
Storage	To 50,000 feet.
Vibration	
Operating and Non-operating	With the instrument complete and operating, vibration frequency swept from 10 to 55 to 10 Hz at 1 minute per sweep. Vibrate 15 minutes in each of the three major axes at 0.015 inch total displacement. Hold 10 minutes at any major resonanace, or in none, at 55 Hz. Total time 75 minutes.
Shock	
Operating and Non-operating	30 g's 1/2 sine, 11 ms duration, 2 shocks in each direction along 3 major axes, for a total of 18 shocks.

Table 2-3

PHYSICAL CHARACTERISTICS

Characteristics	Information
Overall Dimensions (measured at maximum points)	
Height	5.0 inches 12.7 centimeter
Width	2.5 inches 6.35 centimeter
Length	11.8 inches 30.0 centimeter
Net Weight (Instrument Only)	1.8 lbs. .82 kilograms

PERFORMANCE CHECK

Introduction

This procedure checks the electrical characteristics of the AM 502 that appear in the Specification section of this manual. If the instrument fails to meet the requirements given in this performance check, the calibration procedure should be performed. This procedure can also be used by an incoming inspection facility to determine acceptability of performance.

The electrical characteristics in Section 2 are valid only if the AM 502 is calibrated at an ambient temperature of +20° C to +30° C and operated at an ambient temperature of 0° C to +50° C. Forced air circulation is required for ambient temperature above +40° C.

Tolerances that are specified in this performance check procedure apply to the instrument under test and do not include test equipment error.

Test Equipment Required

The following test equipment, or equivalent, is required to perform the performance check. Test equipment characteristics listed are the minimum required to verify the performance of the equipment under test. Substitute equipment must meet or exceed the stated requirements. All test equipment is assumed to be operating within tolerances.

Special test devices are used where necessary to facilitate the procedure. Most of these are available from Tektronix, Inc. and can be ordered through your local Tektronix Field Office or representative.

Table 2-4

LIST OF TEST EQUIPMENT REQUIREMENTS

Description	Performance Requirements	Applications	Example
Oscilloscope	Bandwidth, dc to 2 MHz; Minimum deflection factor, 20 mV/div; sweep rate, .2 ms/div to 1 μs/div; accuracy, within 3%.	Used throughout procedure to provide display.	TEKTRONIX 5110. 5A13N, 5B10N.
Power Module	Three compartments or more.	All tests	TEKTRONIX TM 503 or TM 504.
Calibration Generator	Amplitude calibration, 5 mV to 10 V; accuracy, ±0.25% into 1 MΩ; output, square wave at approximately 1 kHz.	Amplifier gain check	TEKTRONIX PG 506 Calibration Generator.*
Function Generator	Waveforms, sine and square; voltage amplitude, 10 V p-p; frequency range, 1 kHz to 50 kHz; accuracy, within 3%.	Signal generation for cross neutralization and high frequency cmrr check.	TEKTRONIX FG 501 Function Generator.*
Termination	Impedance, 50 Ω; accuracy, within 2%; connectors, bnc.	Output termination for signal generator.	Tektronix Part No. 011-0049-01
Attenuator, 10X (4 required)	Impedance, 50 Ω; accuracy, within 2%; connectors, bnc.	Output attenuation for signal generator. Noise check.	Tektronix Part No. 011-0059-02
Coaxial cable (2 required)	Impedance, 50 Ω; length, 36 inches; connectors, bnc.	Provides signal interconnection.	Tektronix Part No. 012-0057-01

* **Requires TM 500-Series power module**

Preliminary Procedure

1. Ensure that all test equipment and the AM 502 under test are suitably adapted to the line voltage to be applied. Refer to the installation section of the power module manual.

2. Ensure that all test equipment is suitably adapted to the applied line voltage.

3. Install the AM 502 into the power module, and if applicable, install the TM 500 series test equipment into the test equipment power module.

4. Connect the equipment under test and the test equipment to a suitable line voltage source. Turn all equipment on and allow at least 20 minutes for the equipment to stabilize.

Initial Control Settings

Set the following controls during warm-up time:

AM 502

STEP GAIN DC BAL	midrange
÷100	pushbutton out
DC OFFSET	
FINE and COARSE	midrange
GAIN	100
CAL	fully clockwise (cal)
HF −3dB	1 MHz
LF −3dB	DC OFFSET
+ AC	pushbutton out
+ GND	pushbutton out
− AC	pushbutton out
− GND	pushbutton in

Oscilloscope

Intensity, Focus	Set for well-defined trace and normal brightness.

Vertical Amplifier

Volts/Div	1 V
+ Input	dc
Variable	fully clockwise (cal)

Time Base Plug-In

Time/Div	.5 ms
Variable	(cal in)
Triggering	
+ Slope	selected
Mode	p-p auto
Coupling	ac
Source	internal
Position	Set so trace starts at left side of graticule.
Display Mode	main sweep
Magnifier	X1

Calibration Generator

Amplitude	1 V

PERFORMANCE CHECK PROCEDURE

NOTE

The oscilloscope vertical amplifier system gain, the 50-ohm termination, and 50-ohm attenuator are required to be calibrated within 0.5% accuracy prior to proceeding with Steps 1 and 2. The PG 506 calibration generator may be used to set the system to 0.5% accuracy.

1. Check Amplifier Gain. Gain Accuracy is within 2%

a. Connect the calibration generator to the AM 502 + input connector through a 50-ohm cable, a 50-ohm 10X attenuator and 50-ohm terminator.

b. Connect a 50-ohm cable from the AM 502 OUTPUT connector to the vertical amplifier input connector.

c. Adjust the AM 502 DC OFFSET controls (FINE and COARSE) until the OVERRANGE indicator light goes out. Position the crt display to the center of the graticule with the vertical amplifier position control.

d. Check—using the AM 502 GAIN and calibration generator amplitude settings given in Table 2-5, check the vertical deflection within the given limits.

NOTE

The OVER RANGE indicator light must remain off during all switch settings. Adjust the DC OFFSET controls as required during the check procedure.

NOTE

Install both plug-in side covers and insert plug-in into power module for checking gain below 5K setting to minimize noise on the display.

Table 2-5

AMPLIFIER GAIN ACCURACY

AM 502 GAIN Setting	AM 502 HF −3 dB Switch Setting	Calibration Generator Amplitude Setting	Vertical Deflection in Divisions
100	1 MHz	1 V	4.9 - 5.1
200	1 MHz	.5 V	4.9 - 5.1
500	1 MHz	.2 V	4.9 - 5.1
1K	1 MHz	.1 V	4.9 - 5.1
2K	1 MHz	50 mV	4.9 - 5.1
5K	1 MHz	20 mV	4.9 - 5.1
10K	10 kHz	10 mV	4.9 - 5.1
20K	10 kHz	5 mV	4.9 - 5.1
50K	10 kHz	2 mV	4.9 - 5.1
100K	10 kHz	1 mV	4.9 - 5.1

2. Check ÷100 Amplifier Gain Accuracy. Gain Accuracy is within 2%

a. Disconnect all cables and repeat Step 1 parts a, b, c, and d.

b. Set the AM 502 GAIN switch to 10K and the HF −3 dB switch to 1 MHz; push in the ÷100 pushbutton.

c. Set the calibration generator amplitude control to 1 V. Adjust the AM 502 DC OFFSET control (FINE and COARSE) until the OVERRANGE indicator light goes out.

d. Position the crt display to the center of the graticule with the vertical amplifier position control.

e. Check—the crt display amplitude for 4.9 to 5.1 divisions.

f. Disconnect the 50-ohm terminator from the AM 502 + input connector and connect it to the − input connector. Push in the + input GND pushbutton and push and release the − input GND pushbutton.

g. Check—repeat parts d, e, and f of this step.

h. Disconnect the 50-ohm termination, 10X attenuator, and cable.

3. Check Common Mode Rejection. Rejection Ratio is 100 dB, dc to 50 kHz

a. Connect a dual-input connector cable between the AM 502 + input and − input connector.

b. Set the AM 502 ÷100 pushbutton out; the + input and − input AC and GND pushbuttons out, and the GAIN switch to 100.

c. Set the AM 502 HF −3 dB switch to .3 MHz and the LF −3 dB switch to DC.

d. Set the vertical amplifier deflection factor for 10 mV/div.

e. Connect a 50-ohm cable from the function generator to the center connector of the dual-input connector. Set the function generator for a 10 V, 50 kHz sine-wave output signal, with DC offset set to 0 at <1 V.

f. Adjust vertical amplifier position to center display on screen.

g. Check—the crt display for one division of vertical deflection or less.

4. Check ÷100 Common Mode Rejection. Rejection Ratio is 50 dB, dc to 50 kHz

a. Disconnect the 50-ohm cable from the function generator and connect it to the calibration generator output. Press in the ÷100 pushbutton.

b. Set the vertical amplifier deflection factor for 100 mV/div.

c. Set the calibration generator for a 100 volt, square-wave output signal.

d. Check—crt display for 3.1 divisions or less of vertical deflection.

e. Disconnect the dual-input connector and 50-ohm cable from the AM 502 input connectors.

5. Check HF −3 dB Bandwidth. Accuracy is +1 dB, −2 dB

a. Set the AM 502 HF −3 dB switch to 1 MHz, the − input pushbutton to GND, and ÷100 pushbutton out.

b. Set the vertical amplifier deflection factor to 1 V/div, and the time-base sweep rate to 1 ms/div.

c. Set the function generator controls for a 50 mV, 1 kHz sine-wave output signal. (Use appropriate attenuation to eliminate input overdrive condition.)

d. Connect a 50-ohm cable from the function generator to the AM 502 + input connector. Adjust the vertical deflection amplitude for a five-division display.

e. Set the function generator output frequency to 1 MHz.

f. Check—the amplitude of the crt display for 3.15 to 3.85 divisions.

NOTE

The specification in part f of this step must be met before proceeding with part g of this step.

g. Check—the remaining settings of the HF −3 dB switch, using Table 2-6 as reference. (Change time-base sweep rate as needed for lower frequencies.)

Table 2-6

HF −3 dB BANDWIDTH ACCURACY

AM 502 HF −3 dB Switch Setting	Function Generator Output Frequency	Vertical Deflection in Divisions
.3 MHz	300 kHz	3.15 - 3.85
.1 MHz	100 kHz	3.15 - 3.85
30 kHz	30 kHz	3.15 - 3.85
10 kHz	10 kHz	3.15 - 3.85
3 kHz	3 kHz	3.15 - 3.85
1 kHz	1 kHz	3.15 - 3.85
.3 kHz	300 Hz	3.15 - 3.85
.1 kHz	100 Hz	3.15 - 3.85

i. Set the HF −3 dB switch to 1 MHz.

6. Check LF −3 dB Bandwidth. Accuracy is +1 dB, −2 dB

a. Check—the settings of the LF −3 dB switch, using Table 2-7 as reference. Adjust the time-base sweep rate to obtain an appropriate display.

Table 2-7

LF −3 dB BANDWIDTH ACCURACY

AM 502 LF −3 dB Switch Setting	Function Generator Output Frequency	Vertical Deflection in Divisions
10 kHz	10 kHz	3.15 - 3.85
1 kHz	1 kHz	3.15 - 3.85
.1 kHz	.1 kHz	3.15 - 3.85
10 Hz	10 Hz	3.15 - 3.85
1 Hz	1 Hz	3.15 - 3.85

NOTE

The components used in the .1 Hz position are also used in the other positions of the switch; therefore, the tolerance of the .1 Hz position is checked.

b. Press in the AM 502 + input AC pushbutton. Set the function generator controls for a 2 Hz output signal.

c. Check—the amplitude of the crt display for 3.15 to 3.85 divisions.

d. Disconnect the 50-ohm cable from the AM 502 + input connector and connect it to the − input connector.

e. Press in the AM 502 + input GND pushbutton and − input AC pushbutton. Press to release the − input GND pushbutton.

f. Check—the amplitude of the crt display for 3.15 to 3.85 divisions.

g. Set the LF −3 dB switch to the DC OFFSET position. Press in the AM 502 − input GND pushbutton.

h. Disconnect the 50-ohm cable from the AM 502 − input connector.

7. Check Overall Noise (Tangentially Measured)

a. Set the AM 502 GAIN control to 100K; press in to release the + input AC and GND pushbutton, and the − input AC pushbutton.

b. Set the vertical amplifier deflection factor to 5 V/div. Set the time-base sweep rate to 10 μs/div, and the trigger source switch to external.

c. Connect a 50-ohm termination to the AM 502 + input connector; connect four series-connected 10X attenuators to the 50-ohm termination.

d. Connect a 50-ohm cable from the calibration generator fast-rise output connector to the end of the attenuator string. Set the pulse duration control for 1 ms.

e. Adjust the AM 502 DC OFFSET controls (FINE and COARSE) until the OVER RANGE indicator light goes out.

f. Adjust the calibration generator pulse amplitude control and observe two noise bands as shown in Fig. 2-1A (remove one attenuator if necessary, to produce the desired display).

g. Decrease the calibration generator pulse amplitude until the noise bands just merge. See Fig. 2-1B.

h. Remove three of the attenuators and connect the signal through the 50-ohm attenuator (including the 50-ohm termination), to the vertical amplifier input and measure the pulse amplitude. Calculate the tangentially measured display noise as follows:

$$\text{Noise (in } \mu\text{V)} = \frac{\text{Signal level (measured in part h)}}{\text{Attenuation Removed}}$$

Typical figures are:

$$\frac{12 \text{ mV}}{10^{+3}} = 12 \times 10^{-6} = 12 \ \mu\text{V of noise}$$

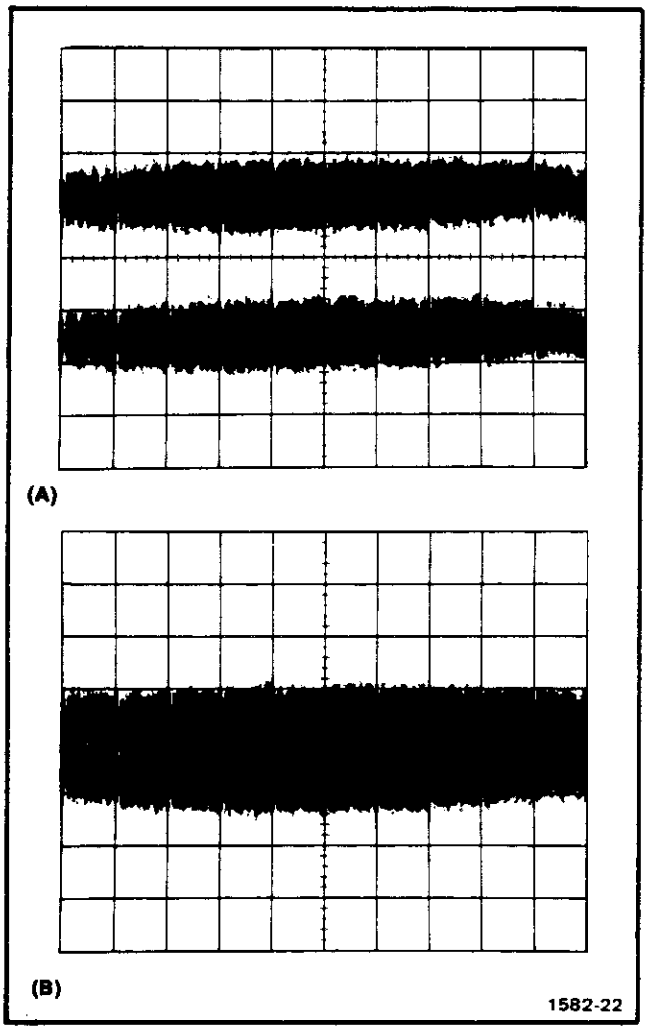


Fig. 2-1. Typical display of (A) two noise bands and (B) noise bands merged.

i. Disconnect all cables and equipment.

This completes the Performance Check of the AM 502 Differential Amplifier.

ADJUSTMENT

Introduction

This adjustment procedure is to be used to restore the AM 502 to the original performance specification. Adjustment need not be performed unless the instrument fails to meet the Performance Requirements of the Electrical Characteristics listed in the Specification section, or the Performance Check cannot be completed satisfactorily.

Completion of all adjustment steps in this procedure ensures that the instrument will meet the performance requirements listed in the Specification section. However, to fully ensure satisfactory performance, it is recommended that the Performance Check be performed after any adjustment is made.

Services Available

Tektronix, Inc. provides complete instrument repair and adjustment at local Field Service Centers and at the Factory Service Center. Contact your local Tektronix Field Office or representative for further information.

Test Equipment Required

The test equipment listed in Table 3-1, or equivalent, is required for adjustment of the AM 502. Specifications given for the test equipment are the minimum necessary for accurate adjustment and measurement. All test equipment is assumed to be correctly calibrated and operating within specification.

If other test equipment is substituted, control settings or calibration setup may need to be altered to meet the requirements of the equipment used.

A flexible plug-in extender, Tektronix Part No. 067-0645-03, is useful for troubleshooting or adjusting the AM 502; however, the complete Adjustment Procedure can be performed without use of the extender. Remove the power module cabinet to make adjustments to the AM 502 inside the power module.

Table 3-1

LIST OF TEST EQUIPMENT REQUIREMENTS

Description	Performance Requirements	Applications	Example
Oscilloscope	Bandwidth, dc to 2 MHz; minimum deflection factor, 20 mV/div; sweep rate, .2 ms/div to 1 μs/div; accuracy, within 3%	Used throughout procedure to provide display	TEKTRONIX 5110. 5A13N, 5B10N
Digital Voltmeter	Range, 0 to 50 V; accuracy, within 0.1%	Voltage measurements. Output voltage flatness check.	TEKTRONIX DM 501 Digital Multimeter.*
Power Module	Three compartments or more.	All tests	TEKTRONIX TM 503 or TM 504.
Calibration Generator	Amplitude calibration, 5 mV to 10 V; accuracy, ±0.25% into 1 MΩ; output, square wave at approximately 1 kHz.	Amplifier gain check	TEKTRONIX PG 506 Calibration Generator.*
Function Generator	Waveforms, sine and square; voltage amplitude, 10 V p-p; frequency range, 1 kHz to 50 kHz; accuracy, within 3%.	Signal generation for cross neutralization and high frequency cmrr check.	TEKTRONIX FG 501 Function Generator.*
Autotransformer with ac voltmeter	Capable of supplying an output voltage from 90 to 132 V, ac; 120 watts of power at the upper limit.	Power supply check.	General Radio W10MTR3W Variac Autotransformer.
Input RC normalizer	Time constant, 1 MΩ x 47 pF; connectors, bnc.	Input capacitance check.	Tektronix Part No. 067-0541-00
Termination	Impedance, 50 Ω; connectors, bnc.	Output termination for signal generator.	Tektronix Part No. 011-0049-01.
Attenuator, 10X (4 required)	Impedance, 50 Ω; connectors, bnc.	Output attenuation for signal generator. Noise check.	Tektronix Part No. 011-0059-02
Coaxial cable (2 required)	Impedance, 50 Ω; length, 36 inches; connectors, bnc.	Provides signal interconnection.	Tektronix Part No. 012-0057-01.

*Requires TM 500 Series power module

Preparation

a. Remove the left and right side covers of the AM 502 to gain access to the component side of the circuit boards. Pull the rear end of the side cover outward from the side of the instrument (the cover snaps into place).

b. Install the AM 502 into the left power module compartment, or if appropriate, connect the AM 502 to the power module by means of the flexible plug-in extender.

c. Set the power module for the line voltage to be applied (see power module manual) and connect it to the variable autotransformer; connect the autotransformer to the line voltage source. Be sure that the power switch is off.

d. Install the TM 500-series equipment, including the AM 502 into the power module.

e. Connect all test equipment to a suitable line voltage source.

f. Turn on all test equipment and allow at least 20 minutes for the equipment to warm up and stabilize.

Initial Control Settings

Set the following controls during warm-up time:

AM 502

STEP GAIN DC BAL	midrange
÷100	pushbutton out
DC OFFSET (FINE and COARSE)	midrange
GAIN	100
CAL	fully clockwise (cal)
HF −3dB	.1 kHz
LF −3dB	10 kHz
+ AC	pushbutton out
+ GND	pushbutton in
− AC	pushbutton out
− GND	pushbutton in

Oscilloscope

Intensity, Focus	Set for well-defined trace and normal brightness.

Vertical Amplifier

Volts/Div	1 V
+ Input	dc
Variable	fully clockwise (cal)

Time Base Plug-In

Time/Div	.5 ms
Variable	(cal in)
Triggering	
+ Slope	selected
Mode	peak-to-peak Auto
Coupling	ac
Source	internal
Position	Set so trace starts at left side of graticule.
Display Mode	main sweep
Magnifier	X1

ADJUSTMENT PROCEDURE

1. Check +15 Volt Power Supply

a. Connect the digital voltmeter between the +15 V test point on the Main circuit board, and chassis ground. See Fig. 3-1 for voltage test point location.

b. Check—for a meter reading of +14.25 to +15.75 volts.

c. Disconnect the digital voltmeter.

2. Check −15 Volt Power Supply

a. Connect the digital voltmeter between the −15 V test point on the Main circuit board, and chassis ground. See Fig. 3-1 for voltage test point location.

b. Check—for a meter reading of −14.25 to −15.75 volts.

c. Disconnect the digital voltmeter.

3. Check +5 Volt Power Supply

a. Connect the digital voltmeter between the +5 V test point on the Main circuit board, and chassis ground. See Fig. 3-1 for voltage test point location.

b. Check—for a meter reading of +4.50 to +5.50 volts.

c. Adjust the autotransformer output voltage from the low limit to the high limit as indicated in Table 3-2. Meter reading should not vary more than ±500 millivolts. Repeat this check for the +15 volt and −15 volt supplies, except the meter reading should not vary more than ±750 millivolts. Return the autotransformer to the nominal line voltage setting.

d. Disconnect the digital voltmeter.

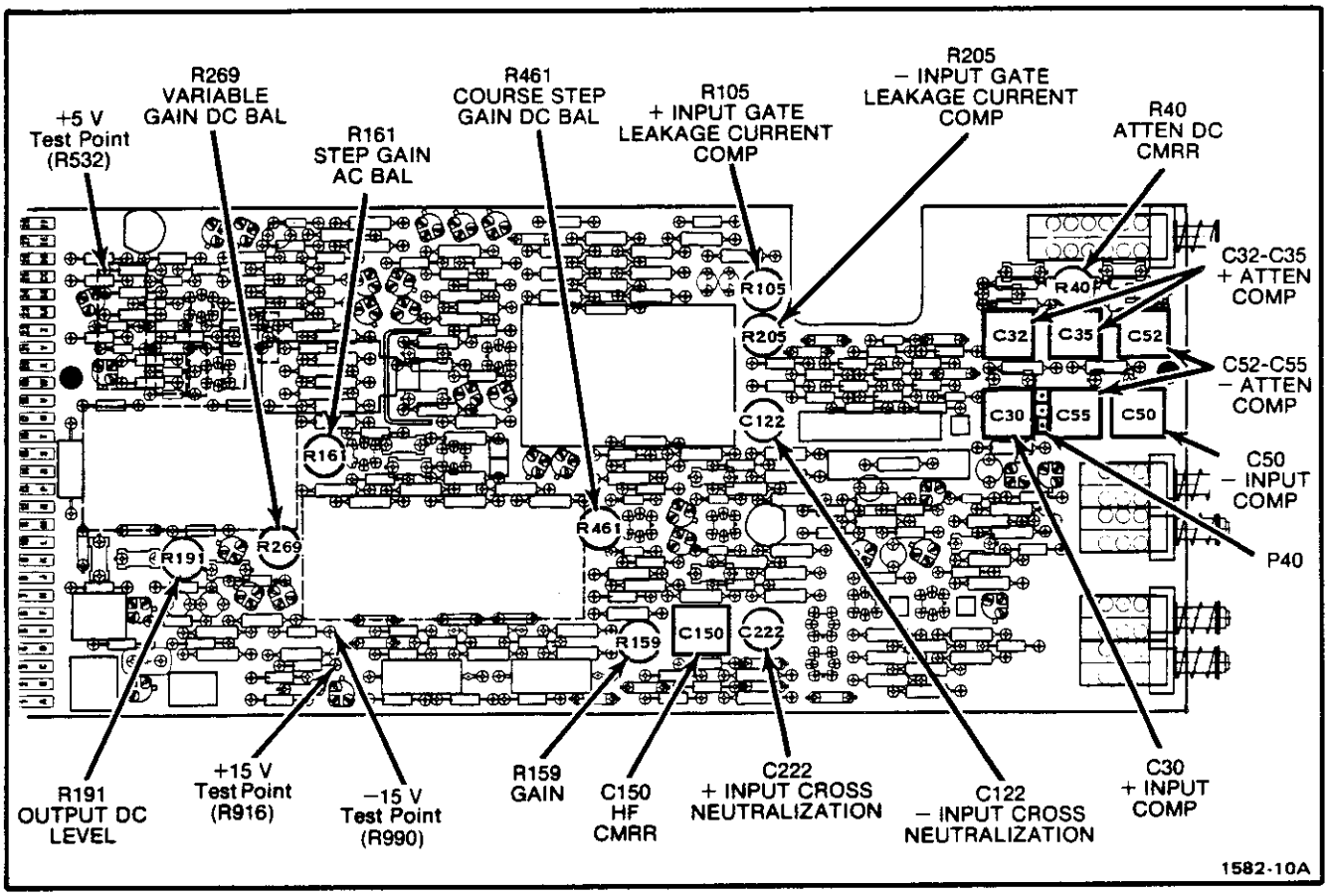


Fig. 3-1. Location of power supply test points, and all adjustments.

Table 3-2

POWER MODULE UNIVERSAL TRANSFORMER

Line Selector Block Position	Regulating Ranges	
	110-Volts Nominal	220-Volts Nominal
L	90 V ac to 110 V ac	180 V ac to 220 V ac
M	99 V ac to 121 V ac	198 V ac to 242 V ac
H	108 V ac to 132 V ac	216 V ac to 264 V ac
Line Fuse Data	1.6 A slow-blow	0.8 A slow-blow

4. Adjust Step Gain AC Balance

a. Connect a 50-ohm cable from the AM 502 OUTPUT connector the vertical amplifier input.

b. Check—for a trace shift of not more than three divisions vertically while switching the AM 502 GAIN switch bwtween the 100 and 100K positions.

c. Adjust—Step Gain AC Bal, R161, for minimum trace shift while switching the AM 502 GAIN switch between the 100 and 100K positions. See Fig. 3-1 for adjustment location.

d. Return the AM 502 GAIN switch to the 100 position.

5. Adjust Variable Gain DC Balance

a. Set the vertical amplifier deflection factor to .1 V/div.

b. Check—for a trace shift of not more than one division vertically while rotating the AM 502 CAL control from fully clockwise to fully counterclockwise position.

c. Adjust—Variable Gain DC BAL, R269, for minimum trace shift while rotating the AM 502 CAL control from fully clockwise to fully counterclockwise position. See Fig. 3-1 for adjustment location. Return control to the fully clockwise position and note the position of the trace.

6. Adjust Output DC Level

a. Set the vertical amplifier deflection factor to 10 mV/div.

b. Without changing the AM 502 control positions from the previous step, note the position of the trace.

c. Adjust—Output DC Level, R191, to place trace at same position as was established in Step 5 part c.

7. Adjust Coarse Step Gain DC Balance

a. Set the vertical amplifier deflection factor to 2 V/div. Position the trace to the center of the graticule.

b. Set the LF −3 dB switch to the DC position (not DC OFFSET), the GAIN switch to 10K, and STEP GAIN DC BAL control to midrange. Leave the other AM 502 controls as in the previous step.

c. Adjust—Coarse Step Gain DC Bal, R461, to return trace to the center of the graticule. See Fig. 3-1 for adjustment location.

d. Turn the AM 502 STEP GAIN DC BAL control fully clockwise and fully counterclockwise, and observe trace shift of at least two divisions above and below the graticule centerline, respectfully. Return the trace to the graticule center.

8. Adjust + Input Gate Leakage Current Compensation

a. Connect a 50-ohm termination to the AM 502 + input connector.

b. Set the vertical amplifier deflection factor to .1 V/div. Press in to release the + GND pushbutton.

c. Adjust—the + Input Gate Leakage Current Comp, R105, while alternately depressing and releasing the +AC pushbutton, for minimum trace shift.

d. Press in to release the +GND and +AC pushbuttons. Remove the termination from the + input connector.

9. Adjust — Input Gate Leakage Current Compensation

a. Connect a 50-ohm termination to the AM 502 − input connector.

b. Press in to release the − GND pushbutton.

c. Adjust—the − Input Gate Leakage Current Comp, R205, while alternately depressing and releasing the − AC pushbutton, for minimum trace shift.

d. Press in the − GND pushbutton, and press in to release the −AC pushbutton. Remove the termination from the − input connector.

NOTE

The oscilloscope vertical amplifier system gain, the 50-ohm termination, and 50-ohm attenuator are required to be calibrated within 0.5% accuracy prior to proceeding with Steps 10 and 11. The PG 506 calibration generator may be used to set the system to 0.5% accuracy.

10. Check Amplifier Gain.

a. Set the vertical amplifier deflection factor to 0.2 V/div.

b. Set the AM 502 GAIN control to 100, the LF −3dB switch to DC OFFSET, and the HF −3dB switch to 1 MHz.

c. Connect the calibration generator to the vertical amplifier input, using a 50-ohm cable.

d. Set the calibration generator for a five-division, square-wave display; set the Deflection Error control for zero per cent error. Disconnect the 50-ohm cable from the vertical amplifier input.

e. Connect the calibration generator to the AM 502 + input connector through a 50-ohm cable, a 50-ohm 10X attenuator, and a 50-ohm termination. (This reduces the generator output by 50%.)

f. Connect a 50-ohm cable from the AM 502 OUTPUT connector to the vertical amplifier input connector. Set the vertical amplifier deflection factor to 1 V/div.

g. Adjust the AM 502 DC OFFSET controls (FINE and COARSE) until the OVER RANGE indicator light goes out. Position the crt display to the center of the graticule with the vertical amplifier position control.

h. Adjust—Gain, R159, for a five-division display amplitude.

i. Rotate the AM 502 CAL control fully counterclockwise and check for two divisions or less of display amplitude.

j. Set the AM 502 CAL control fully clockwise and in the detent position.

k. Check—using the AM 502 GAIN and calibration generator amplitude settings given in Table 3-3, check the vertical deflection within the given limits.

NOTE

The OVER RANGE indicator light must remain off during all switch settings. Adjust the DC OFFSET controls as required during the check procedure.

NOTE

Install both plug-in side covers and insert plug-in into power module for checking gain below 5K setting to minimize noise on the display.

Table 3-3

AMPLIFIER GAIN ACCURACY

AM 502 GAIN Setting	HF −3 dB Switch Setting	Calibration Generator Amplitude Setting	Vertical Deflection in Divisions
100	1 MHz	1 V	4.9 - 5.1
200	1 MHz	.5 V	4.9 - 5.1
500	1 MHz	.2 V	4.9 - 5.1
1K	1 MHz	.1 V	4.9 - 5.1
2K	1 MHz	50 mV	4.9 - 5.1
5K	1 MHz	20 mV	4.9 - 5.1
10K	10 kHz	10 mV	4.9 - 5.1
20K	10 kHz	5 mV	4.9 - 5.1
50K	10 kHz	2 mV	4.9 - 5.1
100K	10 kHz	1 mV	4.9 - 5.1

11. Check ÷100 Amplifier Gain Accuracy. Gain Accuracy is within 2%

a. Disconnect all cables and repeat Step 10 parts a through f.

b. Set the AM 502 GAIN switch to 10K and the HF −3dB switch to 1 MHz; push in the ÷ 100 pushbutton.

c. Set the calibration generator amplitude control to 1.0 V. Adjust the AM 502 DC OFFSET control (FINE and COARSE) until the OVER RANGE indicator light goes out.

d. Position the crt display to the center of the graticule with the vertical amplifier position control.

e. Check—the crt display amplitude for 4.9 to 5.1 divisions.

f. Disconnect the 10X attenuator from the AM 502 + input connector and connect it to the − input connector. Push in the + input GND pushbutton and push in to release the − input GND pushbutton.

g. Check—repeat parts d and e of this step.

h. Disconnect the 50-ohm termination, 10X attenuator, and cable.

12. Adjust Input Cross Neutralization

a. Set the AM 502 ÷ 100 pushbutton out, the + and − input GND pushbuttons out, the + and − AC pushbuttons in, the LF −3dB switch to DC, and the GAIN switch to 100.

b. Connect a 50-ohm termination and a 10X attenuator to the AM 502 + input connector.

c. Connect a 50-ohm cable from the fast-rise output of the calibration generator to the 10X attenuator on the + input of the AM 502.

d. Set the calibration generator amplitude control to produce a five-division crt display (1 ms period). Set the time-base triggering controls for a stable, triggered display.

e. Check—the crt display for roll-off or overshoot (upper corner of the leading edge) within 0.2 division.

f. Adjust— + Input Cross Neutralization, C222, for minimum roll-off or overshoot (upper front corner of the leading edge).

g. Disconnect the 50-ohm termination (with 10X attenuator and 50-ohm cable attached) from the + input connector, and connect it to the − input connector.

h. Repeat part e of this step.

i. Adjust— −Input Cross Neutralization, C122, for minimum roll-off or overshoot (upper corner of the leading edge).

13. Adjust Input Capacitance

a. Disconnect the 50-ohm termination from the − input and connect a 47 pF Normalizer to the − input connector; connect the 50-ohm termination to the other end of the 47 pF Normalizer.

b. Increase the signal amplitude of the calibration generator to maintain five divisions of display.

c. Check—the upper front corner of the leading edge for roll-off or overshoot, within 0.2 division.

d. Adjust— −Input Comp, C50, for the best upper corner on the leading edge of the displayed square wave.

e. Disconnect the 47 pF Normalizer, with 50-ohm termination, 10X attenuator, and 50-ohm cable from the − input connector and connect them to the + input connector.

f. Repeat part c of this step.

g. Adjust— +Input Comp, C30, for best flat top (minimum roll-off or overshoot on upper front corner) on displayed waveform. See Fig. 3-1 for adjustment location.

14. Adjust Attenuator Compensation

a. Press in the ÷ 100 pushbutton. Set the vertical amplifier deflection factor to .1 V/division.

b. Disconnect the 10X attenuator that is connected between the 50-ohm termination and the 50-ohm cable; reconnect the 50-ohm cable to the termination.

c. Readjust the calibration generator amplitude control to maintain a five-division display.

d. Check—the crt display for roll-off or overshoot (upper corner of the leading edge) within 0.2 division.

e. Adjust— + Atten Comp, C32-C35, for best flat top (minimum roll-off or overshoot on upper front corner) on displayed waveform. See Fig. 3-1 for adjustment location.

f. Disconnect the 47 pF Normalizer, 50-ohm termination, and 50-ohm cable from the + input connector and connect them to the − input connector.

g. Readjust the calibration generator amplitude control to maintain a five-division display.

h. Check—the crt display for roll-off or overshoot (upper corner of the leading edge) within 0.2 division.

i. Adjust— −Atten Comp, C52-C55, for best flat top (minimum roll-off or overshoot on upper front corner) on displayed waveform. See Fig. 3-1 for adjustment location.

j. Disconnect the 47 pF Normalizer, 50-ohm termination and cable from the AM 502 − input connector.

15. Adjust High Frequency Common Mode Rejection

a. Connect a dual-input connector cable between the AM 502 + input and the − input connector.

b. Set the AM 502 ÷ 100 pushbutton out; the + input and − input AC and GND pushbuttons out, and the GAIN switch to 100.

c. Set the AM 502 HF −3 dB switch to .3 MHz and LF −3 dB switch to DC.

d. Set the vertical amplifier deflection factor for 10 mV/div.

e. Connect a 50-ohm cable from the function generator output to the center connector of the dual-input connector. Set the function generator for a 10 V, 50 kHz sine-wave output signal.

f. Check—the crt display for one division of vertical deflection or less.

g. Adjust—HF CMRR, C150, for minimum crt display amplitude within one division or less.

16. Adjust ÷ 100 Common Mode Rejection

a. Set the AM 502 ÷ 100 pushbutton in.

b. Set the vertical amplifier deflection factor for .1 V/div.

c. Disconnect the 50-ohm cable from the function generator output and connect it to the calibration generator output. Set the calibration generator for a 100 volt output signal.

d. Check—the crt display for 3.16 divisions of vertical deflection or less. (Disregard spikes on squarewave.)

e. Adjust— − Atten Comp, C52, and Atten DC CMRR, R40, for minimum crt display amplitude within one division or less. (Interaction between C52 and R40 will occur. Adjust for optimum display.)

f. Disconnect the dual-input connector and 50-ohm cable from AM 502.

17. Check HF −3dB Bandwidth

a. Set the AM 502 HF −3dB switch to 1 MHz, the ÷ 100 pushbutton out, the − input pushbutton to GND.

b. Set the vertical amplifier deflection factor to 1 V/div, and the time-base sweep rate to 1 ms/div.

c. Set the function generator controls for a 50 mV, 1 kHz sine-wave output signal. (Use appropriate attenuation to eliminate input overdrive condition.)

d. Connect a 50-ohm cable from the function generator output to the AM 502 + input connector. Adjust the vertical deflection amplitude for a five-division display.

e. Set the function generator output frequency to 1 MHz.

f. Check—the amplitude of the crt display for 3.15 to 3.85 divisions.

NOTE

The specification in part f of this step must be met before proceeding with part g of this step.

g. Check—the remaining settings of the HF −3dB switch, using Table 3-4 as reference. (Change time-base sweep rate as needed for lower frequencies.)

Table 3-4

HF −3 dB BANDWIDTH ACCURACY

AM 502 HF −3 dB Switch Setting	Function Generator Output Frequency	Vertical Deflection in Divisions
.3 MHz	300 kHz	3.15 - 3.85
.1 MHz	100 kHz	3.15 - 3.85
30 kHz	30 kHz	3.15 - 3.85
10 kHz	10 kHz	3.15 - 3.85
3 kHz	3 kHz	3.15 - 3.85
1 kHz	1 kHz	3.15 - 3.85
.3 kHz	300 Hz	3.15 - 3.85
.1 kHz	100 Hz	3.15 - 3.85

h. Set the HF −3 dB switch to 1 MHz.

18. Check LF −3 dB Bandwidth

a. Check—the LF −3 dB switch settings, using Table 3-5 as reference. (Adjust the time-base sweep rate as needed for lower frequency settings.) Obtain a 5 division display, dc coupled, on each range before proceeding to Step b.

Table 3-5

LF −3 dB BANDWIDTH ACCURACY

AM 502 LF −3 dB Switch Setting	Function Generator Output Frequency	Vertical Deflection in Divisions
10 kHz	10 kHz	3.15 - 3.85
1 kHz	1 kHz	3.15 - 3.85
.1 kHz	.1 kHz	3.15 - 3.85
10 Hz	10 Hz	3.15 - 3.85
1 Hz	1 Hz	3.15 - 3.85

NOTE

The components used in the .1 Hz position are also used in the other positions of the switch; therefore, the tolerance of the .1 Hz position is checked.

b. Press in the AM 502 + input AC pushbutton.

c. Check—the amplitude of the crt display for 3.15 to 3.85 divisions.

d. Disconnect the 50-ohm cable from the AM 502 + input connector and connect it to the − input connector.

e. Press in the AM 502 + input GND pushbutton and − input AC pushbutton. Press to release the − input GND pushbutton.

f. Check—the amplitude of the crt display for 3.15 to 3.85 divisions.

g. Set the LF −3 dB switch to the DC OFFSET position. Press in the AM 502 − input GND pushbutton.

h. Disconnect the 50-ohm cable from the AM 502 − input connector.

19. Check Overall Noise (Tangentially Measured)

a. Set the AM 502 GAIN control to 100K; press in to release the + input AC and GND pushbutton, and the − input AC pushbutton.

b. Set the vertical amplifier deflection factor to 5 V/division. Set the time-base sweep rate to 10 μs/division and the trigger source switch to external.

c. Connect a 50-ohm termination to the AM 502 + input connector; connect four series-connected 10X attenuators to the 50-ohm termination.

d. Connect a 50-ohm cable from the calibration generator fast-rise output connector to the end of the attenuator string. Set the pulse duration control for 1 ms.

e. Adjust the AM 502 DC OFFSET controls (FINE and COARSE) until the OVER RANGE indicator light goes out.

f. Adjust the calibration generator pulse amplitude control and observe two noise bands as shown in Fig. 3-2A (remove one attenuator if necessary, to produce the desired display).

g. Decrease the calibration generator pulse amplitude until the noise bands just merge. See Fig. 3-2B.

h. Remove three of the attenuators and connect the signal through the 50-ohm attenuator (including the 50-ohm termination), to the vertical amplifier input and measure the pulse amplitude. Calculate the tangentially measured display noise as follows:

$$\text{Noise (in } \mu\text{V)} = \frac{\text{Signal level (measured in part h)}}{\text{Attenuation Removed}}$$

Typical figures are:

$$\frac{12 \text{ mV}}{10^{3}} = 12 \times 10^{-6} = 12 \ \mu\text{V of noise}$$

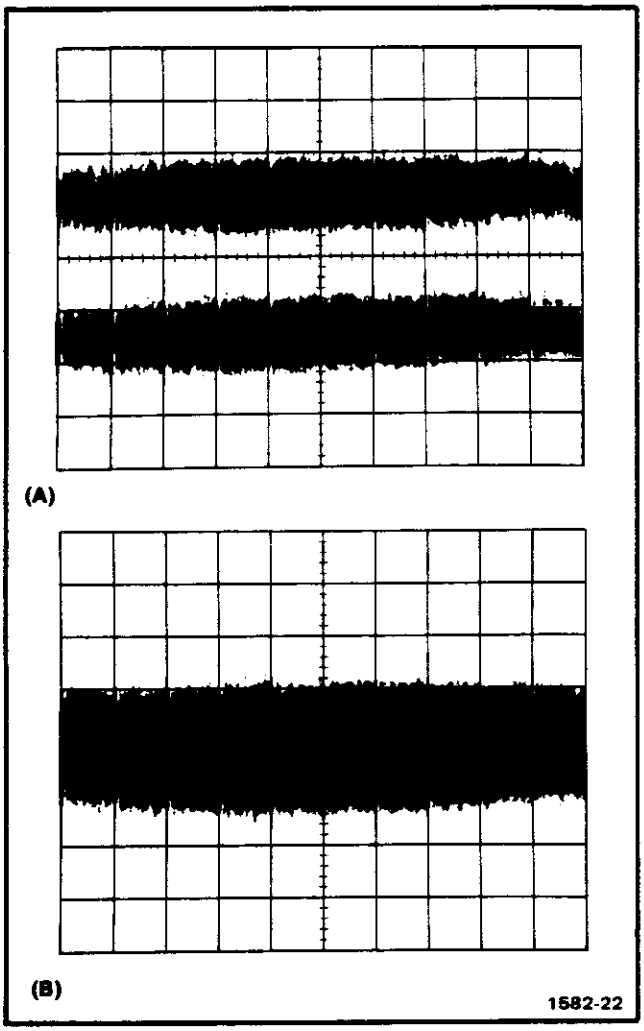


Fig. 3-2. Typical display of (A) two noise bands and (B) noise bands merged.

i. Disconnect all cables and equipment.

This completes the Adjustment procedure of the AM 502 Differential Amplifier.

MAINTENANCE AND INTERFACING INFORMATION

Preventive Maintenance

There are no special preventive maintenance procedures that apply to the AM 502. Refer to the power module instruction manual for general preventive maintenance procedures and instructions.

Corrective Maintenance

Refer to the power module instruction manual for general corrective maintenance procedures and instructions.

Troubleshooting

Use the Performance Check, Adjustment Procedure, and Circuit Description as aids to locate trouble in the event of equipment failure. The test equipment listed in the Performance Check and Adjustment Procedure will prove useful in troubleshooting the AM 502.

Functions Available at Rear Connector

A slot between pins 23 and 24 on the rear connector identifies the AM 502 as a member of the signal source family. Insert a barrier in the corresponding position of the power module jack to prevent other than signal source plug-ins from being used in that compartment; this protects the plug-in should specialized connections be made to that compartment. Consult the Building A System section of the power module manual for further information.

Signal outputs, or other specialized connections, are made to the rear interface connectors as shown in Fig. 4-1. The Signal In and Signal Ground are not factory wired. If Signal In connections are made, use coaxial cable. Connect one end to the pads as shown in Fig. 4-1 and the other end to the front panel bnc connector.

REPACKAGING FOR SHIPMENT

If the Tektronix instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing: owner (with address) and the name of an individual at your firm that can be contacted. Include complete instrument serial number and a description of the service required.

Save and re-use the package in which your instrument was shipped. If the original packaging is unfit for use or not available, repackage the instrument as follows:

Surround the instrument with polyethylene sheeting to protect the finish of the instrument. Obtain a carton of corrugated cardboard of the correct carton strength and having inside dimensions of no less than six inches more than the instrument dimensions. Cushion the instrument by tightly packing three inches of dunnage or urethane foam between carton and instrument, on all sides. Seal carton with shipping tape or industrial stapler.

The carton test strength for your instrument is 200 pounds.

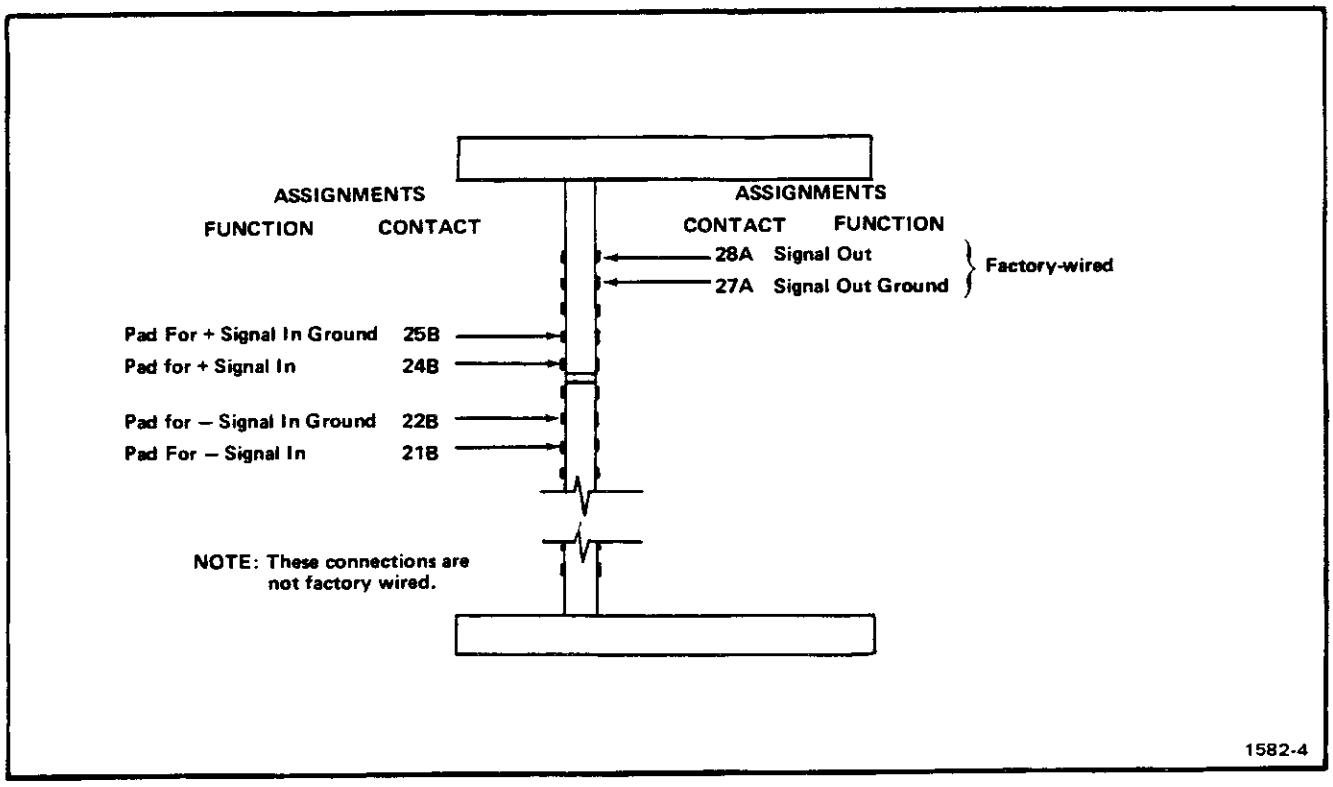


Fig. 4-1. Input/Output assignments at rear connector.

CIRCUIT DESCRIPTION

Introduction

This section of the manual contains a description of the circuitry used in the AM 502 Differential Amplifier. Individual descriptions are separated into the following parts; Input Coupling, Input Attenuators, Input Overdrive Protection, Gate Current Compensation, Preamp, Floating Power Supply, Common Mode Rejection, Cross Neutralization, DC Offset, LF −3 dB Frequency Selector, Gain Switching Amplifier, HF −3 dB Frequency Selector, Variable Gain Stage, Output Amplifier, Overrange Indicator, and Power Supplies. The circuit titles correspond to those listed in the Block Diagram. The numbered diamond by each title refers to the corresponding circuit diagram in the Diagrams section of this manual.

Input Coupling ◇1

A signal applied to the + or − input connector passes through the input-coupling selector switch to the input-attenuator circuit. The signals can be ac coupled, dc coupled or disconnected internally. The + and − inputs are identical except for circuit numbers. Except where needed for clarification, only the amplifier for the + input will be described in detail.

When the input-coupling switch is in the DC position, the input signal is coupled directly to the attenuator. In the AC position, the signal is coupled through capacitor C10. The capacitor prevents the dc component of the signal from passing to the attenuator. The GND position disconnects the input signal from the attenuators and connects it to ground through C10 and R10. This represents the same load to the signal source as was presented when the input switch was set in the AC mode. Thus, a ground reference to the input of the amplifier is provided without the need to remove the applied signal source. The PRECHG position limits the instantaneous current, caused by connecting a large signal to the input connector, by inserting R10 in series with C10.

Input Attenuators ◇1

The input attenuators for the + and − inputs are identical and are conventional RC type attenuators. The attenuators are frequency-compensated voltage dividers that provide a straight-through or NORM position, or a ÷100 position. Resistor R30 provides the 1 megohm input resistance, while C28, C30, and stray capacitance make up the 47 picofarad input capacitance in the NORM position. In the ÷100 position, R35 in series with R38 comprise the 1 megohm input resistance, and also form the 100X divider for the dc component of the signal. The parallel combination of C32 and C34 in series with C38, comprise the ac 100X circuit. Each attenuator contains an adjustable capacitor to provide correct attenuation at high frequencies, and adjustable shunt capacitance to provide correct input capacitance.

Input Overdrive Protection ◇1

Fuses F100 and F200, combined with diode clamps CR108, CR109, CR208, and CR209 provide overdrive protection for Q121A and B at the ±16.2 volt level. The ±16.2 volt level is set by zeners VR438 and VR448, through isolation diodes CR438 and CR448, and the clamp diodes. If the signal amplitude exceeds approximately 16.2 volts, depending on the duration of the excess voltage, the fuses will open.

Gate Current Compensation ◇1

The leakage associated with the gates of the input Field-Effect Transistors (FET) may be as high as 100 picoamperes. This amount of leakage current (through 1 megohm, R30 or R50, to ground) will produce an offset of 100 microvolts, which at high gain settings, drives the output into overrange. To compensate for this effect, the gates of the input FET may be adjusted to zero volts by returning R107 and R106 through variable controls R105 and R205 to a slightly negative supply voltage.

Leakage current associated with the gates of the input FET and the overdrive protection diodes, increases rapidly with temperature, approximately doubling for every 10 degree Celsius. To compensate for this increase, a temperature sensitive input-current balancing network is included, using thermistors RT104 and RT203 as sensing elements.

As the gate current increases due to a temperature increase, the resistance of the thermistors decreases, thus maintaining a constant voltage difference as a function of temperature.

Preamp ◇1

From the input attenuators, the signal is coupled to the preamp. The preamp consists of two identical feedback amplifiers connected in a differential configuration. Except where needed for clarification, only the amplifier for the + input will be described in detail.

The supply voltages for the two amplifiers are obtained from a common power supply that is bootstrapped to the input to improve the common-mode rejection ratio of the preamp.

The feedback circuit for the + input consists of comparator Q121A, error amplifier Q131A and Q136, feedback modifier R125 and R126, and output load resistor R136. R126 is the gain-setting resistor for the amplifier. Diode CR131 connected between the base-emitter of Q131A protects the transistor against reverse-bias breakdown, and also provides negative feedback to stabilize the circuit at higher frequencies.

The last stage of the preamp consists of Q152A and Q152B. Zener diode VR252 provides the collector supply voltage for this stage. The gain of this stage is approximately 5.

STEP GAIN DC BAL control, R158, balances the dc level at the output and is adjusted for minimum dc level shift when the GAIN switch is rotated throughout its range.

Floating Power Supply 

Refer to Fig. 5-1. The supply voltages for the preamp and the dc offset circuit are derived from a series-connected resistor chain consisting of R431, R433, R435, two current sources, plus a current-setting transistor, Q443. The positive current source consists of Q410A and B, and Q416. The negative current source consists of Q422A and B, and Q426.

Any common-mode changes that occur in the input amplifier, except at the output, are coupled to the power supply through Q451, which is connected as an emitter follower. It acts as a X1 bootstrap amplifier whose gain is maintained very close to unity by the minimum loading presented to its output by the high collector impedance of Q121A and B, thus achieving good bootstrap efficiency.

Quiescently, approximately 13 milliamperes of current flows through Q422A and B. R421 shunts about 4 milliamperes of this current from Q422A, leaving a balance of 9 milliamperes flowing through the positive current source, Q410A, Q410B, and Q416. Approximately 12 milliamperes of current from the negative current source also flows from Q422B and Q426, and to the dc offset circuit, Q141A and B, and Q145A and B. In any mode except the dc offset, the 12 milliamperes of current splits equally and becomes the negative current source for Q121A and B. About 4 milliamperes is shunted through Q136 and Q236. This leaves the balance of 9 milliamperes of current to flow through Q121A and B, and to the summing point at the collector of Q416.

Resistors R440, R441, R442, and R443 set the base voltage of Q443, with CR441 providing the temperature compensation. Current through R445 divides between Q443 and Q445. The current through Q445 is the negative current source for Q131A and B. After flowing through Q131A and B, it returns and passes through emitter-follower Q431, then to the summing point at the collector of Q416.

The 1.9 milliamperes of current flowing from Q443 and through resistor chain R435, R433, and R431, continues to the summing point at the collector of Q416. The voltage drop across each resistor, in reference to the emitter of Q451, sets the "floating" power supplies. The difference in the 9 milliamperes of current needed to satisfy the current demand of the positive current source, and what flows into the summing point from Q433, Q431, and Q121A and B, will come from Q451.

Common Mode Rejection 

One of the primary functions of the preamp is to reject any common-mode component in the input signals, and amplify only the difference. In the extreme case of the inputs tied together and a common voltage applied, the output of the amplifier is ideally zero, and would actually be zero provided that the characteristics of all corresponding elements on the two sides of the amplifier (see Figs. 1-5 and 1-6) were exactly matched. In practice, any mismatch will cause a differential output. Even with perfect matching, there is still a common-mode output current resulting in an undesirable common-mode signal applied to the subsequent stages of the amplifier (common mode gain).

The floating power supply eliminates these difficulties and improves the common mode rejection. It can be seen that the entire power supply and amplifier moves an amount equal to the common-mode voltage, and that no change in voltage or current levels occur anywhere within the amplifier as a result of this common-mode voltage, except for Q136 and Q236 drain to gate voltage. Thus the only mismatch of importance is that of Q136, Q236 amplification factors. Being in the third stage of the amplifier at a point of relatively large differential signal level, this causes only a small degradation in common mode rejection.

At higher frequencies the stray capacitances from various points in the preamp to ground begin to inject significant current into the amplifier as a result of common mode signals. Differential capacitor C150, connected from a point in the floating power supply to the two output lines, is used to inject adjustable currents into the output to compensate for the change.

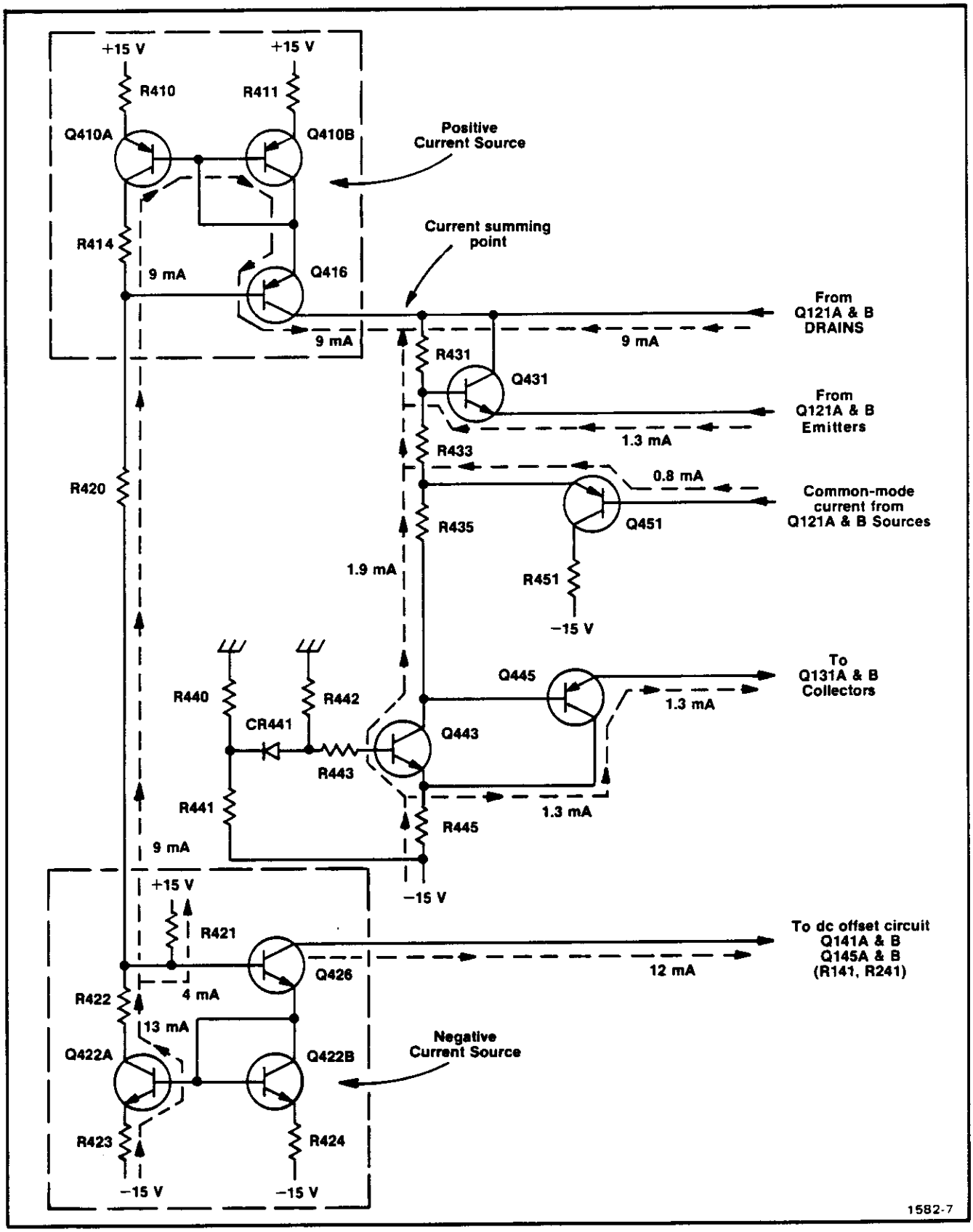


Fig. 5-1. Preamp floating power supply showing positive and negative current source.

Cross Neutralization ①

Refer to Fig. 5-2. The use of a common bootstrap power supply results in an undesirable capacitive coupling between the two inputs. Consider the effect of applying +1 volt to the + input of Q121A while keeping the − input of Q121B at zero volts.

The results are: an output current of i_o of 4 milliamperes, and a shift of all supply voltages and several other voltage levels by +0.5 volt due to the divider action of R126 and R226, operating into the bootstrapped power supply system. Specifically, the drain of Q121B also rises +0.5 volt and injects current i_s through the drain to gate capacitance, C_{dg} of Q121B, and into the − input. If there is any impedance between the − input and ground, i_s will develop a voltage across the impedance, and since it's applied to the − input, subtracts from the original + input, thereby causing an erroneous output (see Fig. 5-3).

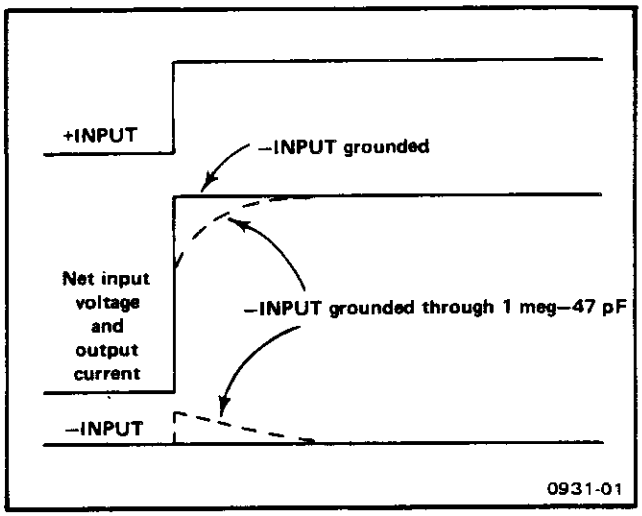


Fig. 5-3. Effects of high impedance to ground in the − input.

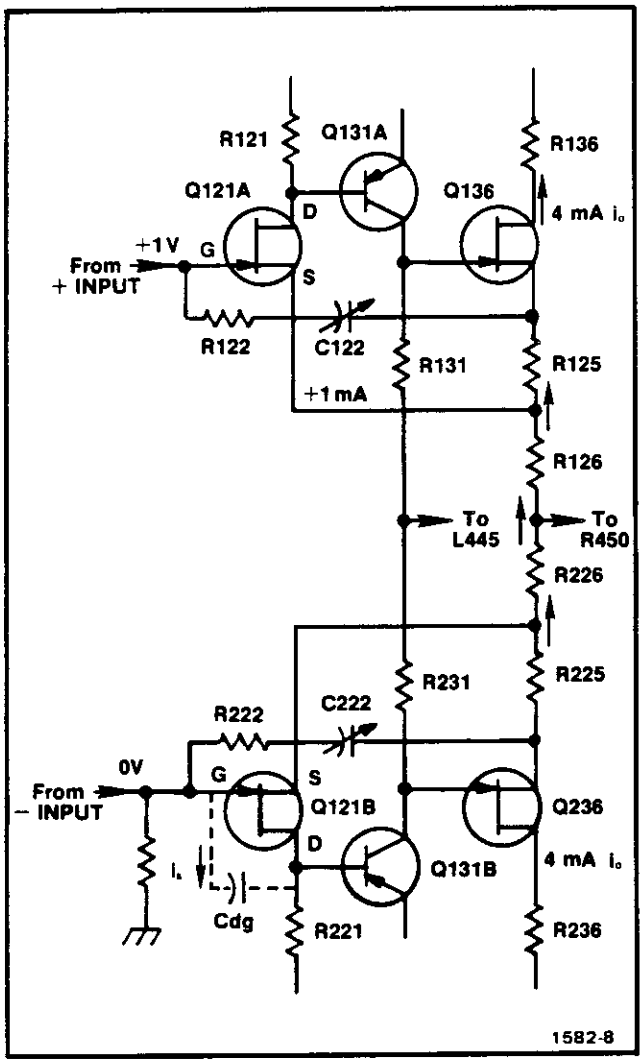


Fig. 5-2. Simplified preamp circuit showing cross neutralization circuit.

Capacitor C122, connected in the + input circuit, is adjusted to divert the undesirable capacitive current away from the input point, minimizing the unbalance. Capacitor C222 performs the same function for signals applied to the − input circuit.

DC Offset ①

The purpose of the dc offset system is to allow a differential slide-back measurement; that is, to buck out small dc components of input signals and allow the amplifier to amplify only the varying components, while keeping the differential capability. This means that when a dc voltage is applied across the inputs, some means must be found to balance out the resultant output current.

The dc offset system, with zero input signal conditions and resultant currents is illustrated in Fig. 5-4. Source and output currents remain at 2 milliamperes and 5 milliamperes respectively, thereby producing a balanced output. The amplifier and dc offset system illustrated in Fig. 5-5 shows the current conditions when a 0.25 volt dc signal voltage is applied to the + input. This voltage causes an additional 1 milliampere of current to flow through R126 and R226. However, if a 1 milliampere offset current is supplied by the offset generator, the net output current will remain at its zero signal value.

When the dc offset is not used, the dc offset controls are switched by the LF −3 dB switch, to a fixed reference voltage divider R460, R461, and R462.

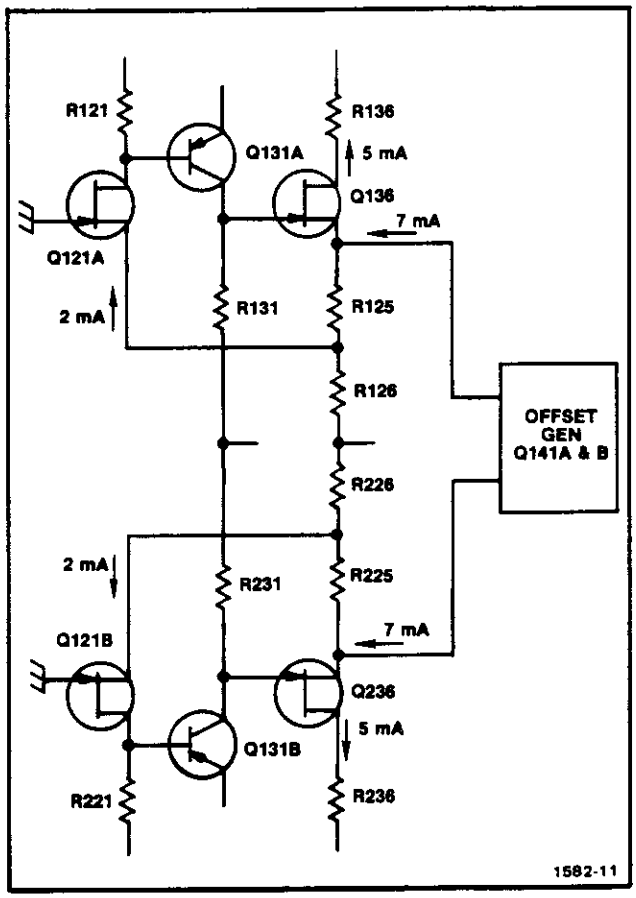


Fig. 5-4. Amplifier and dc offset system, showing balanced output conditions.

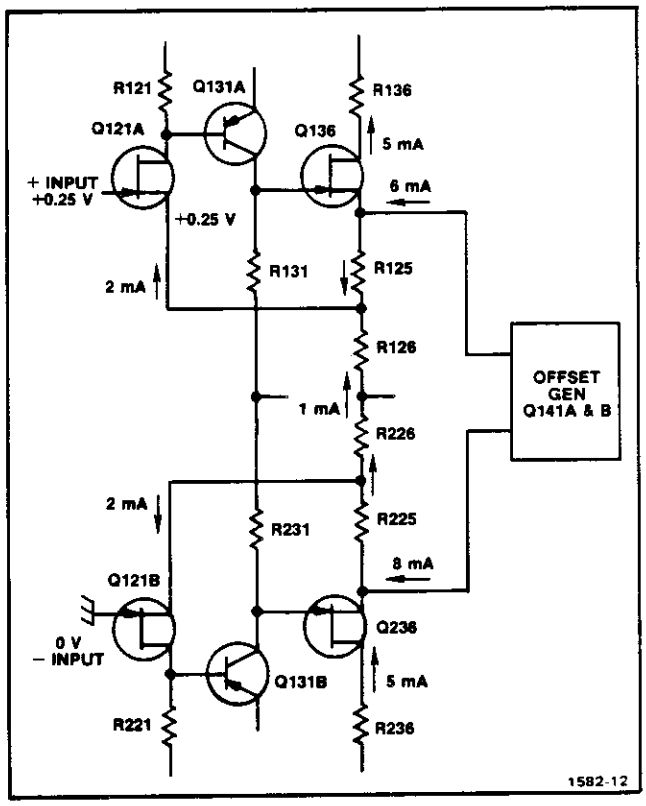


Fig. 5-5. Amplifier and dc offset system, showing a 0.25 volt dc offset and resultant current conditions.

LF −3 dB Frequency Selector ③

This switch selects the low frequency −3 dB point of the amplifier and has a range of 0.1 Hz to 10 kHz in six decade steps. Selection is done by switching the resistor and capacitor of a pair of capacitor couplings in each side of the amplifier, between the pre-amp and the gain-switching amplifier. For 100 Hz to 10 kHz, C470 is used, and resistors R474, R478, and R470 are switched to the output in the following combinations:

−3 dB frequency	100 Hz	1 kHz	10 kHz
output resistors	R470	R470 & R474	R470 & R478

Whenever R474 or R478 is not used on the output side of C258, the resistance (R474 or R478) is placed across the input to keep the high frequency load resistance, as seen by the pre-amp, constant.

Capacitor C472 is switched across C470 for the lower three ranges (0.1 Hz, 1 Hz, and 10 Hz) and C258 is shorted out for dc coupling. Resistors R474, R478, and R470 are switched in the same combination for the lower three positions as they are for the three higher positions.

Gain Switching Amplifier ②

The gain switching amplifier is a balanced differential configuration very similar to the preamp but with a fixed power supply. A gain of 0.48 to 480 is changed by switching different values of resistance with switch S480. Q162A, Q164A, and Q168 comprise the switching amplifier. Q167 and Q267 serve two functions; the base-emitter junctions serve as reverse bias protection for Q168 and Q268 and they drive the over range indicator circuitry to indicate a differential over range condition.

Step Gain AC Balance control, R161, is used to remove any initial unbalance in the gate-to-source voltages of Q162A and B, and sets the voltage across the gain-setting resistors when the differential input (gate-to-gate) voltage is zero.

Capacitors C164 and C264 are in the circuit for peaking at frequencies near 2 MHz. Inductors L164 and L264 reduce the gain at high frequencies, thus preventing oscillations.

HF −3 dB Frequency Selector ◇3

This switch selects the high frequency −3 dB point of the amplifier and has a range of 100 Hz through 1 MHz in nine steps of a 1-3 sequence. This is accomplished by simply switching different values of capacitance across the output of the gain-switched stage.

Variable Gain Stage ◇2

The variable gain stage (Q171A, Q171B and Q181, Q281) is a feedback amplifier having a gain range of approximately 2.5:1, determined by CAL control R178. Feedback resistors R173 and R273, plus gain setting resistors R177, R277, and R178 set the overall gain of the stage at 10.

The common mode signal at the output of the feedback amplifier is compared to ground by comparator Q195 and Q196. A dc feedback loop is provided to feed back the output of the comparator to Q171A and B via emitter follower Q269 to maintain the junction of R175 and R275 at a zero volt level.

Variable Gain DC Balance R269 adjusts the input levels of Q171A and B so their source voltages will be equal. With the source levels equal, rotating the front panel VAR control causes no shift of the dc output level.

Output DC Level control R191 adjusts for a zero-volt dc level at the output of the amplifier. R191 and R193 act as a current source or sink to set the voltage difference across R175 and R275. Their common junction is at zero volts due to feedback action described earlier. Q185 and Q285 act as the negative current source for the variable gain stage.

Diodes CR181 and CR182 act as peak detectors, providing a signal to the over-range detector circuit (Q501 emitter). A voltage swing greater than +6 volts on the collector of Q181 or Q281 will produce an over range indication, lighting indicator lamp DS50.

Output Amplifier ◇2

The output amplifier stage consists primarily of transistors Q561A and B and Q571A and B and provides a ±5 volt differential voltage swing with a zero-volt dc level. The output R_o is 5 ohms or less. Transistors Q555 and Q558 comprise the positive and negative current sources respectively.

The output stage is short-circuit protected to ground. If the current in R571 causes the voltage at Q571B collector to fall below the level of Q555 emitter, CR555 conducts, taking current from Q555, thereby reducing the drive to Q571B, limiting the output current.

Over Range Indicator ◇3

When the LF −3 dB switch is in a position other than DC, there is no on-screen indication of the dc conditions in the preamp or output amplifier, and it may be driven into non-linearity or overload by a dc component, leading to erroneous displays. The over range indicator circuit detects this condition and so indicates by means of indicator lamp DS50.

The over range circuit consists of three input transistors Q501, Q511, and Q521, monostable multivibrator Q532 and Q541, indicator lamp driver Q540. When any of the three input transistors become turned on by an over-range signal from the respective amplifiers, a turn-on current is supplied to the base of Q532. This starts the multivibrator action which has a minimum on time of approximately 200 milliseconds; thus the indicator lamp is held on for a minimum of 200 milliseconds regardless of the duration of the over-range signal. The timing components are C536, R536, and R531.

Power Supplies ◇4

Regulation of the +15 volt and −15 volt supply is accomplished through the respective operational amplifier, U910 and U990. Zener diode VR910 sets the reference voltage for U910; the +15 volt supply sets the reference for U990. The operational amplifiers control the current to the AM 502 through series-pass transistors located in the power module. The inputs of both integrated circuits seek common levels by varying the current supplied to the unit. Should the power supply load increase, pin 2 of U990 goes more positive, causing pin 6 to go more negative. This action increases current flow in the series-pass transistor and restores the voltage to the initial level. The +15 volt supply operates in the same manner except the polarities are different.

Transistors Q910 and Q990 act as current sensing regulators. Should the current increase to a level that the voltage drop across R970 (R920) is great enough to cause Q990 (Q910) to conduct, current is taken from the series-pass transistor until it is turned off. This action limits the current available to the amplifier, should an overload or short circuit occur.

The +5 volt supply is comprised of Q940 and Q942. The base voltage level of Q942 is set by divider R945 and R946. The base-emitter drop of the transistors produce the +5 volt supply.

OPTIONS

No options are available at this time.

REPLACEABLE ELECTRICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

ACTR	ACTUATOR	PLSTC	PLASTIC
ASSY	ASSEMBLY	QTZ	QUARTZ
CAP	CAPACITOR	RECP	RECEPTACLE
CER	CERAMIC	RES	RESISTOR
CKT	CIRCUIT	RF	RADIO FREQUENCY
COMP	COMPOSITION	SEL	SELECTED
CONN	CONNECTOR	SEMICOND	SEMICONDUCTOR
ELCTLT	ELECTROLYTIC	SENS	SENSITIVE
ELEC	ELECTRICAL	VAR	VARIABLE
INCAND	INCANDESCENT	WW	WIREWOUND
LED	LIGHT EMITTING DIODE	XFMR	TRANSFORMER
NONWIR	NON WIREWOUND	XTAL	CRYSTAL

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
00853	SANGAMO WESTON INC SANGAMO CAPACITOR DIV	SANGAMO RD P O BOX 128	PICKENS SC 29671
01121	ALLEN-BRADLEY CO	1201 SOUTH 2ND ST	MILWAUKEE WI 53204
02114	AMPEREX ELECTRONIC CORP FERROXCUBE DIV	5083 KINGS HWY	SAUGERTIES NY 12477
03508	GENERAL ELECTRIC CO SEMI-CONDUCTOR PRODUCTS DEPT	N GENESEE ST	AUBURN NY 13021
04222	AVX CERAMICS DIV OF AVX CORP	19TH AVE SOUTH P O BOX 867	MYRTLE BEACH SC 29577
04713	MOTOROLA INC SEMICONDUCTOR GROUP	5005 E MCDOWELL RD	PHOENIX AZ 85008
05397	UNION CARBIDE CORP MATERIALS SYSTEMS DIV	11901 MADISON AVE	CLEVELAND OH 44101
07716	TRW INC TRW ELECTRONICS COMPONENTS TRW IRC FIXED RESISTORS/BURLINGTON	2850 MT PLEASANT AVE	BURLINGTON IA 52601
13511	AMPHENOL CADRE DIV BUNKER RAMO CORP		LOS GATOS CA
14193	CAL-R INC	1601 OLYMPIC BLVD	SANTA MONICA CA 90404
14433	ITT SEMICONDUCTORS DIV		WEST PALM BEACH FL
14552	MICRO/SEMICONDUCTOR CORP	2830 S FAIRVIEW ST	SANTA ANA CA 92704
19396	ILLINOIS TOOL WORKS INC PAKTRON DIVISION	900 FOLLIN LANE S E	VIENNA VA 22180
19701	MEPCO/ELECTRA INC A NORTH AMERICAN PHILIPS CO	P O BOX 760	MINERAL WELLS TX 76067
24546	CORNING GLASS WORKS	550 HIGH ST	BRADFORD PA 16701
31918	ITT SCHADOW INC	8081 WALLACE RD	EDEN PRAIRIE MN 55343
32293	INTERSIL INC	10900 N TANTAU AVE	CUPERTINO CA 95014
32997	BOURNS INC TRIMPOT DIV	1200 COLUMBIA AVE	RIVERSIDE CA 92507
33095	SPECTRUM CONTROL INC	8061 AVONIA RD	FAIRVIEW PA 16415
52763	STETTNER ELECTRONICS INC	6135 AIRWAYS BLVD PO BOX 21947	CHATTANOOGA TN 37421
54473	MATSUSHITA ELECTRIC CORP OF AMERICA	ONE PANASONIC WAY	SECAUCUS NJ 07094
56289	SPRAGUE ELECTRIC CO	87 MARSHALL ST	NORTH ADAMS MA 01247
57668	ROHM CORP	16931 MILLIKEN AVE	IRVINE CA 92713
58854	GTE PRODUCTS CORP LIGHTING PRODUCTS GROUP	60 BOSTON ST	SALEM MA 01970
59660	TUSONIX INC	2155 N FORBES BLVD	TUCSON, ARIZONA 85705
59821	CENTRALAB INC SUB NORTH AMERICAN PHILIPS CORP	7158 MERCHANT AVE	EL PASO TX 79915
71400	BUSSMANN MFG CO MCGRAW EDISION CO	114 OLD STATE RD PO BOX 14460	ST LOUIS MO 63178
71590	GLOBE-UNION INC CENTRALAB ELECTRONICS DIV	HWY 20 W P O BOX 858	FORT DODGE IA 50501
71744	GENERAL INSTRUMENT CORP LAMP DIV	4433 N RAVENSWOOD AVE	CHICAGO IL 60640
73138	BECKMAN INSTRUMENTS INC HELIPOT DIV	2500 HARBOR BLVD	FULLERTON CA 92634
74970	JOHNSON E F CO	299 10TH AVE S W	WASECA MN 56093
80009	TEKTRONIX INC	4900 S W GRIFFITH DR P O BOX 500	BEAVERTON OR 97077
84411	TRW INC TRW ELECTRONICS COMPONENTS DIV TRW CAPACITORS	301 WEST O ST	OGALLALA NE 69153
87034	ILLUMINATED PRODUCTS INC	S MAIN ST	CRYSTAL LAKE IL 60014
91637	DALE ELECTRONICS INC	P O BOX 609	COLUMBUS NE 68601
91836	KINGS ELECTRONICS CO INC	40 MARBLEDALE ROAD	TUCKAHOE NY 10707
TK1036	E F JOHNSON CO	299 10TH AVE SW	WASECA MN 56093
TK1345	ZMAN AND ASSOCIATES	7633 S 180TH	KENT WA 98032

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A1	670-2733-00	B010100	B051720	CIRCUIT BD ASSY:MAIN	80009	670-2733-00
A1	670-2733-01	B051721	B052349	CIRCUIT BD ASSY:MAIN	80009	670-2733-01
A1	670-2733-02	B052350	B057429	CIRCUIT BD ASSY:MAIN	80009	670-2733-02
A1	670-2733-03	B057430	B059999	CIRCUIT BD ASSY:MAIN	80009	670-2733-03
A1	670-2733-04	B060000	B070609	CIRCUIT BD ASSY:MAIN	80009	670-2733-04
A1	670-2733-05	B070610	B071449	CIRCUIT BD ASSY:MAIN	80009	670-2733-05
A1	670-2733-06	B071450	B071936	CIRCUIT BD ASSY:MAIN	80009	670-2733-06
A1	670-2733-07	B071937		:	80009	670-2733-07
C10	295-0155-00			CAP SET,MATCHED:(2) 0.1UF,MATCHED 1%	80009	295-0155-00
C20	----- -----			(PART OF C10)		
C28	281-0663-00			CAP,FXD,CER DI:10.4PF,1%,500V	52763	2RDPLZ007 10P4LC
C30	281-0081-00			CAP,VAR,AIR DI:1.8-13PF,375VDC	74970	189-0506-075
C32	281-0081-00			CAP,VAR,AIR DI:1.8-13PF,375VDC	74970	189-0506-075
C34	281-0645-00			CAP,FXD,CER DI:8.2PF,+/-0.25PF,500V	52763	2RDPLZ007 8P20CC
C35	281-0081-00			CAP,VAR,AIR DI:1.8-13PF,375VDC	74970	189-0506-075
C38	283-0626-00			CAP,FXD,MICA DI:1800PF,5%,500V	00853	D195F182J0
C48	281-0663-00			CAP,FXD,CER DI:10.4PF,1%,500V	52763	2RDPLZ007 10P4LC
C50	281-0081-00			CAP,VAR,AIR DI:1.8-13PF,375VDC	74970	189-0506-075
C52	281-0081-00			CAP,VAR,AIR DI:1.8-13PF,375VDC	74970	189-0506-075
C54	281-0645-00			CAP,FXD,CER DI:8.2PF,+/-0.25PF,500V	52763	2RDPLZ007 8P20CC
C55	281-0081-00			CAP,VAR,AIR DI:1.8-13PF,375VDC	74970	189-0506-075
C58	283-0626-00			CAP,FXD,MICA DI:1800PF,5%,500V	00853	D195F182J0
C107	283-0005-00			CAP,FXD,CER DI:0.01UF,+100-0%,250V	04222	SR303E103ZAA
C122	281-0093-00	B010100	B039999	CAP,VAR,CER DI:5.5-18PF,350V	52763	302322237
C122	281-0092-00	B040000		CAP,VAR,CER DI:9-35PF,200V	33095	53-717-001 D9-35
C131	281-0612-00			CAP,FXD,CER DI:5.6PF,+/-0.5PF,500V	52763	2RDPLZ007 5P60DC
C146	283-0177-00			CAP,FXD,CER DI:1UF,+80-20%,25V	04222	SR302E105ZAATR
C150	281-0114-00			CAP,VAR,AIR DI:1.3-5.4PF,425V	TK1036	189-0752-075
C164	281-0523-00			CAP,FXD,CER DI:100PF,20%,350V	52763	2RDPLZ007 100PMU
C176	281-0618-00			CAP,FXD,CER DI:4.7PF,+/-0.5PF,500V	52763	2RDPLZ007 4P70DC
C195	281-0518-00			CAP,FXD,CER DI:47PF,+/-9.4PF,500V	52763	2RDPLZ007 47P0MU
C207	283-0005-00			CAP,FXD,CER DI:0.01UF,+100-0%,250V	04222	SR303E103ZAA
C222	281-0093-00	B010100	B039999	CAP,VAR,CER DI:5.5-18PF,350V	52763	302322237
C222	281-0092-00	B040000		CAP,VAR,CER DI:9-35PF,200V	33095	53-717-001 D9-35
C231	281-0612-00			CAP,FXD,CER DI:5.6PF,+/-0.5PF,500V	52763	2RDPLZ007 5P60DC
C252	290-0512-00	B052350	B059999	CAP,FXD,ELCTLT:22UF,20%,15V	05397	T3688226M015AS
C252	290-0745-00	B060000		CAP,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
C264	281-0523-00			CAP,FXD,CER DI:100PF,20%,350V	52763	2RDPLZ007 100PMU
C276	281-0618-00			CAP,FXD,CER DI:4.7PF,+/-0.5PF,500V	52763	2RDPLZ007 4P70DC
C431	290-0527-00	B010100	B059999	CAP,FXD,ELCTLT:15UF,20%,20V	05397	T3688156M020AS
C431	290-0745-00	B060000		CAP,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
C433	290-0527-00	B010100	B059999	CAP,FXD,ELCTLT:15UF,20%,20V	05397	T3688156M020AS
C433	290-0745-00	B060000		CAP,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
C435	290-0527-00	B010100	B059999	CAP,FXD,ELCTLT:15UF,20%,20V	05397	T3688156M020AS
C435	290-0745-00	B060000		CAP,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
C438	283-0177-00			CAP,FXD,CER DI:1UF,+80-20%,25V	04222	SR302E105ZAATR
C443	290-0527-00	B010100	B059999	CAP,FXD,ELCTLT:15UF,20%,20V	05397	T3688156M020AS
C443	290-0745-00	B060000		CAP,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
C448	283-0177-00			CAP,FXD,CER DI:1UF,+80-20%,25V	04222	SR302E105ZAATR
C450	281-0613-00	B010100	B051720	CAP,FXD,CER DI:10PF,1%,500V	59660	374-018C0G0100F
C450	281-0629-00	B051721		CAP,FXD,CER DI:33PF,5%,600V	52763	2RDPLZ007 33P0JC
C470	283-0594-00			CAP,FXD,MICA DI:0.001UF,1%,100V	00853	D151F102F0
C471	283-0594-00			CAP,FXD,MICA DI:0.001UF,1%,100V	00853	D151F102F0
C472	285-0809-00			CAP,FXD,PLASTIC:1UF,10%,50V	56289	LP66A1A105K
C473	285-0809-00			CAP,FXD,PLASTIC:1UF,10%,50V	56289	LP66A1A105K
C490	281-0511-00			CAP,FXD,CER DI:22PF,+/-2.2PF,500V	52763	2RDPLZ007 22P0KC
C491	281-0721-00			CAP,FXD,CER DI:72PF,5%,500V	52763	2RDPLZ007 72P0JU
C493	283-0604-00			CAP,FXD,MICA DI:304PF,2%,500V	00853	D155F304060

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C494	283-0594-00			CAP,FXD,MICA DI:0.001UF,1%,100V	00853	0151F102F0
C495	285-0627-00			CAP,FXD,PLASTIC:0.0033UF,5%,100V	07716	TEK44-33251
C496	285-0598-00			CAP,FXD,PLASTIC:0.01UF,5%,100V	19396	0U490B103J
C497	285-0702-00			CAP,FXD,PLASTIC:0.033UF,5%,100V	19396	0U591/74-16903
C498	285-0703-00			CAP,FXD,PLASTIC:0.1UF,5%,100V	19396	104J01PT605
C499	285-0633-00			CAP,FXD,PLASTIC:0.22UF,10%,100V	84411	663UM-22491
C530	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
C536	290-0534-00			CAP,FXD,ELCTLT:1UF,20%,35V	05397	T368A105M035AZ
C552	291-0511-00			CAP,FXD,CER DI:22PF,+/-2.2PF,500V	52763	ZROPLZ007 22P0KC
C560	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
C570	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
C910	290-0512-00	B010100	B059999	CAP,FXD,ELCTLT:22UF,20%,15V	05397	T368B226M015AS
C910	290-0745-00	B060000		CAP,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
C922	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
C924	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
C926	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
C930	290-0527-00			CAP,FXD,ELCTLT:15UF,20%,20V	05397	T368B156M020AS
C942	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
C960	290-0527-00			CAP,FXD,ELCTLT:15UF,20%,20V	05397	T368B156M020AS
C964	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
C966	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
C968	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
CR108	152-0323-00			SEMICOND DVC,DI:SM,SI,35V,0.1A,DO-7	14433	MG1518
CR109	152-0323-00			SEMICOND DVC,DI:SM,SI,35V,0.1A,DO-7	14433	MG1518
CR131	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR150	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR181	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR208	152-0323-00			SEMICOND DVC,DI:SM,SI,35V,0.1A,DO-7	14433	MG1518
CR209	152-0323-00			SEMICOND DVC,DI:SM,SI,35V,0.1A,DO-7	14433	MG1518
CR231	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR250	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR281	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR438	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR441	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR448	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR531	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR555	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR558	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR560	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR561	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR570	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
CR571	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V	03508	DA2527 (1N4152)
DS50	150-0107-00	B010100	B052349	LAMP,INCAND:12V,0.04A,#227AS25,WIRE LD	87034	227AS25
DS50	150-0048-01	B052350		LAMP,INCAND:5V,0.06A,#683,AGED & SEL	58854	683AS15
DS900	150-0107-00	B010100	B052349	LAMP,INCAND:12V,0.04A,#227AS25,WIRE LD	87034	227AS25
DS900	150-0109-00	B052350		LAMP,INCAND:18V,0.026A,#CM7220,WIRE LD	71744	CM7220
F100	159-0024-00			FUSE,CARTRIDGE:3AG,0.062A,250V,0.3SEC	71400	MGB 1/16
F200	159-0024-00			FUSE,CARTRIDGE:3AG,0.062A,250V,0.3SEC	71400	MGB 1/16
J10	131-0955-00			CONN,RCPT,ELEC:BNC,FEMALE	13511	31-279
J15	129-0103-00			POST,BDG,ELEC:ASSEMBLY	80009	129-0103-00
J20	131-0955-00			CONN,RCPT,ELEC:BNC,FEMALE	13511	31-279
J550	131-0818-00			CONN,RCPT,ELEC:BNC,FEMALE	91836	KC-19-153
L164	108-0409-00			COIL,RF:FIXED,17.5UH	TK1345	108-0409-00
L264	108-0409-00			COIL,RF:FIXED,17.5UH	TK1345	108-0409-00
L416	276-0507-00			SHLD BEAD,ELEK:FERRITE	02114	56-590-65B/3B
L426	276-0507-00			SHLD BEAD,ELEK:FERRITE	02114	56-590-65B/3B
L445	276-0507-00			SHLD BEAD,ELEK:FERRITE	02114	56-590-65B/3B
Q121	151-1027-00			TRANSISTOR:FET,N-CHAN,SI,TO-71	80009	151-1027-00
Q131	151-0261-00			TRANSISTOR:PNP,SI,TO-77	04713	SD441

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Q136	151-1025-00	B010100	B059999	TRANSISTOR:FET,N-CHAN,SI,TO-92	04713	SPF3036
Q136	151-1042-00	B060000		SEMICOND DVC SE:FET,SI,TO-92	04713	SPF627M2
Q141	151-0176-00			TRANSISTOR:NPN,SI,TO-78	04713	SD555
Q145	151-0261-00			TRANSISTOR:PNP,SI,TO-77	04713	SD441
Q152	153-0586-00	B010100	B057429	SEMICOND DVC SE:MATCHED PAIR	80009	153-0586-00
Q152	151-0354-00	B057430		TRANSISTOR:PNP,SI,TO-78	32293	ITS-1200-A
Q162	151-1036-00			TRANSISTOR:FET,N-CHAN,SI,TO-71	80009	151-1036-00
Q164	153-0586-00	B010100	B057429	SEMICOND DVC SE:MATCHED PAIR	80009	153-0586-00
Q164	151-0354-00	B057430		TRANSISTOR:PNP,SI,TO-78	32293	ITS-1200-A
Q167	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
Q168	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q171	151-1029-00			TRANSISTOR:FET,N-CHAN,SI,TO-71	80009	151-1029-00
Q181	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
Q185	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
Q195	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q196	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q236	151-1025-00	B010100	B059999	TRANSISTOR:FET,N-CHAN,SI,TO-92 (PART OF Q136)	04713	SPF3036
Q267	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
Q268	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q269	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q281	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
Q285	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
Q410	153-0586-00	B010100	B071449	SEMICOND DVC SE:MATCHED PAIR	80009	153-0586-00
Q410	151-0354-00	B071450		TRANSISTOR:PNP,SI,TO-78	32293	ITS-1200-A
Q416	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q422	153-0587-00	B010100	B071449	SEMICOND DVC SE:MATCHED PAIR	80009	153-0587-00
Q422	151-0236-00	B071450		TRANSISTOR:NPN,SI,DUAL,TO-77	32293	ITS1074
Q426	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
Q431	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
Q443	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
Q445	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q451	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q501	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q511	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q521	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q532	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
Q540	151-0260-00			TRANSISTOR:NPN,SI,TO-39	04713	ST1083
Q541	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q555	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q558	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
Q561	151-0307-00			TRANSISTOR:PNP,SI,TO-78	04713	2N3726
Q571	151-0309-00			TRANSISTOR:NPN,SI,TO78	04713	SD3167
Q910	151-0301-00	B010100	B040389	TRANSISTOR:PNP,SI,TO-18	04713	ST898
Q910	151-0302-00	B040390		TRANSISTOR:NPN,SI,TO-18	04713	ST899
Q940	151-0334-00			TRANSISTOR:NPN,SI,TO-126,SEL	04713	SJE914
Q942	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
Q990	151-0302-00	B010100	B040389	TRANSISTOR:NPN,SI,TO-18	04713	ST899
Q990	151-0301-00	B040390		TRANSISTOR:PNP,SI,TO-18	04713	ST898
R10	315-0105-00			RES,FXD,FILM:1M OHM,5%,0.25M	19701	5043CX1M000J
R20	315-0105-00			RES,FXD,FILM:1M OHM,5%,0.25M	19701	5043CX1M000J
R30	322-0687-07			RES,FXD,FILM:1.005MEG OHM,0.1%,0.25M,TC=T9	19701	5043RE1M005B
R35	322-0624-07			RES,FXD,FILM:990K OHM,0.1%,0.25M,TC=T9	19701	5043RE990K0B
R38	321-0289-03			RES,FXD,FILM:10.0K OHM,0.25%,0.125M,TC=T2	07716	CEAC10001C
R40	311-1566-00	B010100	B052349	RES,VAR,NONWM:TRMR,200 OHM,0.5M	32997	3352T-1-201
R40	311-1568-00	B052350		RES,VAR,NONWM:TRMR,50 OHM,0.5M	32997	3352T-1-500
R50	322-0687-07			RES,FXD,FILM:1.005MEG OHM,0.1%,0.25M,TC=T9	19701	5043RE1M005B
R55	322-0624-07			RES,FXD,FILM:990K OHM,0.1%,0.25M,TC=T9	19701	5043RE990K0B

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R58	321-0289-03			RES,FXD,FILM:10.0K OHM,0.25%,0.125M,TC=T2	07716	CEAC10001C
R103	321-0281-00	B010100	B059999	RES,FXD,FILM:8.25K OHM,1%,0.125M,TC=T0	19701	5043ED8K250F
R103	321-0239-00	B060000		RES,FXD,FILM:3.01K OHM,1%,0.125M,TC=T0	19701	5043ED3K010F
R105	311-1559-00			RES,VAR,NONWM:TRMR,10K OHM,0.5M	32997	3352T-1-103
R106	315-0107-00			RES,FXD,FILM:100M OHM,5%,0.25M	01121	CB1075
R107	315-0107-00			RES,FXD,FILM:100M OHM,5%,0.25M	01121	CB1075
R120	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25M	57668	NTR25J-E 100E
R121	321-0222-00			RES,FXD,FILM:2.00K OHM,1%,0.125M,TC=T0	19701	5033ED2K00F
R122	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25M	57668	NTR25J-E05K1
R125	321-0114-00			RES,FXD,FILM:150 OHM,1%,0.125 M,TC=T0	19701	5033ED150R0F
R126	321-0927-07			RES,FXD,FILM:125 OHM,0.1%,0.125M,TC=T9	19701	5033RE125R0B
R131	321-0251-00			RES,FXD,FILM:4.02K OHM,1%,0.125M,TC=T0	19701	5033ED4K020F
R136	321-0199-06			RES,FXD,FILM:1.15K OHM,0.25%,0.125M,TC=T9	07716	CEAE11500C
R137	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25M	57668	NTR25J-E 100E
R141	321-0813-07			RES,FXD,FILM:495 OHM,0.1%,0.125M,TC=T9	19701	5033RE4950B
R145	321-0353-00			RES,FXD,FILM:46.4K OHM,1%,0.125M,TC=T0	07716	CEA046401F
R146	321-0272-00			RES,FXD,FILM:6.65K OHM,1%,0.125M,TC=T0	19701	5043ED6K650F
R152	321-0222-00			RES,FXD,FILM:2.00K OHM,1%,0.125M,TC=T0	19701	5033ED2K00F
R154	321-0225-06			RES,FXD,FILM:2.15K OHM,0.25%,0.125M,T=T9MI	07716	CEAE21500C
R155	321-0154-00	B010100	B039999	RES,FXD,FILM:392 OHM,1%,0.125M,TC=T0	07716	CEA0392R0F
R155	321-0150-00	B040000		RES,FXD,FILM:357 OHM,1%,0.125M,TC=T0	07716	CEA0357R0F
R157	315-0564-00	B010100	B059999	RES,FXD,FILM:560K OHM,5%,0.25M	19701	5043CX560K0J
R157	321-0457-00	B060000		RES,FXD,FILM:562K 1%,0.125 M,TC=T0	19701	5043ED562K0F
R158	311-0467-00			RES,VAR,NONWM:PNL,100K OHM,0.5M	01121	M77058
R159	311-1567-00	B010100	B039999	RES,VAR,NONWM:TRMR,100 OHM,0.5M	32997	3352T-1-101
R159	311-1566-00	B040000		RES,VAR,NONWM:TRMR,200 OHM,0.5M	32997	3352T-1-201
R160	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25M	57668	NTR25JE01K0
R161	311-1564-00	B010100	B059999	RES,VAR,NONWM:TRMR,500 OHM,0.5M	32997	3352T-CK5501
R161	311-1307-00	B060000		RES,VAR,NONWM:TRMR,500 OHM,0.5M	32997	3299M-R27-501
R162	321-0240-00			RES,FXD,FILM:3.09K OHM,1%,0.125M,TC=T0	07716	CEA030900F
R164	321-0309-00			RES,FXD,FILM:16.2K OHM,1%,0.125M,TC=T0	19701	5033ED16K20F
R166	321-0143-00			RES,FXD,FILM:301 OHM,1%,0.125M,TC=T0	07716	CEA0301R0F
R168	321-0224-00			RES,FXD,FILM:2.10K OHM,1%,0.125M,TC=T0	07716	CEA021000F
R170	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25M	57668	NTR25JE01K0
R171	321-0277-00			RES,FXD,FILM:7.50K OHM,1%,0.125M,TC=T0	24546	NA5507501F
R173	321-0239-07			RES,FXD,FILM:3.01K OHM,0.1%,0.125M,TC=T9MI	07716	CEAE301008
R175	321-0289-07			RES,FXD,FILM:10.0K OHM,0.1%,0.125M,TC=T9	19701	5033RE10K00B
R176	321-1267-03			RES,FXD,FILM:5.97K OHM,0.25%,0.125M,TC=T2	19701	5033RC5K971C
R177	321-0147-00			RES,FXD,FILM:332 OHM,1%,0.125M,TC=T0	07716	CEA0332R0F
R178	311-1494-00			RES,VAR,NONWM:PNL,2K OHM,1M,M/SM (PART OF S178)	01121	11M187
R181	321-0187-00			RES,FXD,FILM:866 OHM,1%,0.125M,TC=T0	07716	CEA0866R0F
R184	321-0297-00			RES,FXD,FILM:12.1K OHM,1%,0.125M,TC=T0	07716	CEA012101F
R185	321-0236-00			RES,FXD,FILM:2.80K OHM,1%,0.125M,TC=T0	07716	CEA028000F
R191	311-1555-00			RES,VAR,NONWM:TRMR,100K OHM,0.5M	32997	3352T-1-104
R193	315-0474-00			RES,FXD,FILM:470K OHM,5%,0.25M	19701	5043CX470K0J92U
R195	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25M	57668	NTR25J-E05K1
R196	315-0682-00			RES,FXD,FILM:6.8K OHM,5%,0.25M	57668	NTR25J-E06K8
R198	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25M	57668	NTR25J-E04K7
R205	311-1559-00			RES,VAR,NONWM:TRMR,10K OHM,0.5M	32997	3352T-1-103
R206	315-0107-00			RES,FXD,FILM:100M OHM,5%,0.25M	01121	CB1075
R207	315-0107-00			RES,FXD,FILM:100M OHM,5%,0.25M	01121	CB1075
R220	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25M	57668	NTR25J-E 100E
R221	321-0222-00			RES,FXD,FILM:2.00K OHM,1%,0.125M,TC=T0	19701	5033ED2K00F
R222	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25M	57668	NTR25J-E05K1
R225	321-0114-00			RES,FXD,FILM:150 OHM,1%,0.125 M,TC=T0	19701	5033ED150R0F
R226	321-0927-07			RES,FXD,FILM:125 OHM,0.1%,0.125M,TC=T9	19701	5033RE125R0B
R231	321-0251-00			RES,FXD,FILM:4.02K OHM,1%,0.125M,TC=T0	19701	5033ED4K020F

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
R236	321-0199-06			RES,FXD,FILM:1.15K OHM,0.25%,0.125M,TC=T9	07716	CEAE11500C
R237	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25M	57668	NTR25J-E 100E
R241	321-0813-07			RES,FXD,FILM:495 OHM,0.1%,0.125M,TC=T9	19701	5033RE4950B
R245	321-0353-00			RES,FXD,FILM:46.4K OHM,1%,0.125M,TC=T0	07716	CEA046401F
R246	321-0272-00			RES,FXD,FILM:6.65K OHM,1%,0.125M,TC=T0	19701	5043ED6K650F
R252	321-0222-00			RES,FXD,FILM:2.00K OHM,1%,0.125M,TC=T0	19701	5033ED2K00F
R254	321-0225-06			RES,FXD,FILM:2.15K OHM,0.25%,0.125M,T=T9MI	07716	CEAE21500C
R255	321-0154-00	B010100	B039999	RES,FXD,FILM:392 OHM,1%,0.125M,TC=T0	07716	CEA0392R0F
R255	321-0150-00	B040000		RES,FXD,FILM:357 OHM,1%,0.125M,TC=T0	07716	CEA0357R0F
R260	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25M	57668	NTR25JE01K0
R261	321-0239-00			RES,FXD,FILM:3.01K OHM,1%,0.125M,TC=T0	19701	5043ED3K010F
R262	321-0240-00			RES,FXD,FILM:3.09K OHM,1%,0.125M,TC=T0	07716	CEA030900F
R264	321-0309-00			RES,FXD,FILM:16.2K OHM,1%,0.125M,TC=T0	19701	5033ED16K20F
R266	321-0143-00			RES,FXD,FILM:301 OHM,1%,0.125M,TC=T0	07716	CEA0301R0F
R268	321-0224-00			RES,FXD,FILM:2.10K OHM,1%,0.125M,TC=T0	07716	CEA021000F
R269	311-1564-00	B010100	B059999	RES,VAR,NONWM:TRMR,500 OHM,0.5M	32997	3352T-CK5501
R269	311-1307-00	B060000		RES,VAR,NONWM:TRMR,500 OHM,0.5M	32997	3299W-R27-501
R270	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25M	57668	NTR25JE01K0
R271	321-0277-00			RES,FXD,FILM:7.50K OHM,1%,0.125M,TC=T0	24546	NA55D7501F
R273	321-0239-07			RES,FXD,FILM:3.01K OHM,0.1%,0.125M,TC=T9MI	07716	CEAE30100B
R275	321-0289-07			RES,FXD,FILM:10.0K OHM,0.1%,0.125M,TC=T9	19701	5033RE10K00B
R276	321-1267-03			RES,FXD,FILM:5.97K OHM,0.25%,0.125M,TC=T2	19701	5033RC5K971C
R277	321-0147-00			RES,FXD,FILM:332 OHM,1%,0.125M,TC=T0	07716	CEA0332R0F
R284	321-0314-00			RES,FXD,FILM:18.2K OHM,1%,0.125M,TC=T0	19701	5043ED18K20F
R285	321-0236-00			RES,FXD,FILM:2.80K OHM,1%,0.125M,TC=T0	07716	CEA028000F
R410	321-0068-00			RES,FXD,FILM:49.9 OHM,0.5%,0.125M,TC=T0	91637	CMF55116G49R90F
R411	321-0068-00			RES,FXD,FILM:49.9 OHM,0.5%,0.125M,TC=T0	91637	CMF55116G49R90F
R414	315-0680-00	B010100	B071936	RES,FXD,FILM:68 OHM,5%,0.25M	57668	NTR25J-E68E0
R414	315-0470-00	B071937		RES,FXD,FILM:47 OHM,5%,0.25M	57668	NTR25J-E47E0
R420	322-0238-00			RES,FXD,FILM:2.94K OHM,1%,0.25M,TC=T0	19701	5043RD2K940F
R421	321-0274-00			RES,FXD,FILM:6.98K OHM,1%,0.125M,TC=T0	19701	5043ED6K980F
R422	315-0470-00			RES,FXD,FILM:47 OHM,5%,0.25M	57668	NTR25J-E47E0
R423	321-0068-00			RES,FXD,FILM:49.9 OHM,0.5%,0.125M,TC=T0	91637	CMF55116G49R90F
R424	321-0068-00			RES,FXD,FILM:49.9 OHM,0.5%,0.125M,TC=T0	91637	CMF55116G49R90F
R431	321-0182-00			RES,FXD,FILM:768 OHM,1%,0.125M,TC=T0	07716	CEA0768R0F
R433	321-0179-00			RES,FXD,FILM:715 OHM,1%,0.125M,TC=T0	07716	CEA0715R0F
R435	321-0233-00			RES,FXD,FILM:2.61K OHM,1%,0.125M,TC=T0	07716	CEA026100F
R436	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25M	57668	NTR25J-E04K7
R438	315-0222-00			RES,FXD,FILM:2.2K OHM,5%,0.25M	57668	NTR25J-E02K2
R440	321-0268-00			RES,FXD,FILM:6.04K OHM,1%,0.125M,TC=T0	19701	5043ED6K040F
R441	321-0247-00			RES,FXD,FILM:3.65K OHM,1%,0.125M,TC=T0	19701	5043ED3K650F
R442	321-0400-00			RES,FXD,FILM:143K OHM,1%,0.125M,TC=T0	19701	5043ED143K0F
R443	315-0471-00			RES,FXD,FILM:470 OHM,5%,0.25M	57668	NTR25J-E470E
R445	321-0218-00			RES,FXD,FILM:1.82K OHM,1%,0.125M,TC=T0	19701	5033ED1K82F
R446	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25M	57668	NTR25J-E04K7
R448	315-0222-00			RES,FXD,FILM:2.2K OHM,5%,0.25M	57668	NTR25J-E02K2
R450	315-0222-00			RES,FXD,FILM:2.2K OHM,5%,0.25M	57668	NTR25J-E02K2
R451	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25M	57668	NTR25J-E 100E
R460	321-0229-00			RES,FXD,FILM:2.37K OHM,1%,0.125M,TC=T0	19701	5043ED2K37F
R461	311-1566-00	B010100	B059999	RES,VAR,NONWM:TRMR,200 OHM,0.5M	32997	3352T-1-201
R461	311-1036-00	B060000		RES,VAR,NONWM:TRMR,200 OHM,0.5M	32997	3299W-R27-201
R462	321-0229-00			RES,FXD,FILM:2.37K OHM,1%,0.125M,TC=T0	19701	5043ED2K37F
R464	321-0204-00			RES,FXD,FILM:1.30K OHM,1%,0.125M,TC=T0	19701	5033ED1K30F
R466	315-0105-00			RES,FXD,FILM:1M OHM,5%,0.25M	19701	5043CX1M000J
R467	311-1057-00			RES,VAR,MM:PNL,5K OHM,2M	73138	7266-371-1
R468	311-0887-00			RES,VAR,NONWM:PNL,50K OHM,10%,0.5M	71590	B002520017
R470	316-0155-00			RES,FXD,CMPSN:1.5M OHM,10%,0.25M	01121	CB1551
R471	316-0155-00			RES,FXD,CMPSN:1.5M OHM,10%,0.25M	01121	CB1551
R474	321-0408-00			RES,FXD,FILM:174K OHM,1%,0.125M,TC=T0	07716	CEA017402F

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
R475	321-0408-00			RES,FXD,FILM:174K OHM,1%,0.125M,TC=T0	07716	CEA017402F
R478	321-0303-00			RES,FXD,FILM:14.0K OHM,1%,0.125M,TC=T0	07716	CEA0 14001F
R479	321-0303-00			RES,FXD,FILM:14.0K OHM,1%,0.125M,TC=T0	07716	CEA0 14001F
R480	321-0289-03			RES,FXD,FILM:10.0K OHM,0.25%,0.125M,TC=T2	07716	CEAC10001C
R481	321-0816-07			RES,FXD,FILM:5K OHM,0.1%,0.125M,TC=T9	19701	5033RE5K000B
R482	321-0222-03			RES,FXD,FILM:2.0K OHM,0.25%,0.125M,TC=T2	19701	5033RC2K000C
R483	321-0193-03			RES,FXD,FILM:1K OHM,0.25%,0.125M,TC=T2	07716	CEAC10000C
R484	321-0612-03			RES,FXD,FILM:500 OHM,0.25%,0.125M,TC=T2	19701	5033RC500R0C
R485	321-0126-03			RES,FXD,FILM:200 OHM,0.25%,0.125M	19701	5033RC200R0C
R486	321-0097-03			RES,FXD,FILM:100 OHM,0.25%,0.125M,TC=T0	91637	CMF55116D100R0C
R487	321-0751-06			RES,FXD,FILM:50 OHM,0.25%,0.125M,TC=T9	91637	CMF55116C50R00C
R488	321-0030-02			RES,FXD,FILM:20.0 OHM,0.5%,0.125M,TC=T2	91637	CMF55116D20R000
R489	321-0001-01			RES,FXD,FILM:10.0 OHM,0.5%,0.125M,TC=T0	19701	5033R010R000
R501	316-0225-00			RES,FXD,CMPSN:2.2M OHM,10%,0.25M	01121	CB2251
R503	321-0452-00			RES,FXD,FILM:499K OHM,1%,0.125M,TC=T0	19701	5043ED499K0F
R504	321-0423-00			RES,FXD,FILM:249K OHM,1%,0.125M,TC=T0	19701	5043ED249K0F
R507	315-0473-00			RES,FXD,FILM:47K OHM,5%,0.25M	57668	NTR25J-E47K0
R510	315-0104-00			RES,FXD,FILM:100K OHM,5%,0.25M	57668	NTR25J-E100K
R511	315-0104-00			RES,FXD,FILM:100K OHM,5%,0.25M	57668	NTR25J-E100K
R513	315-0104-00			RES,FXD,FILM:100K OHM,5%,0.25M	57668	NTR25J-E100K
R521	316-0276-00			RES,FXD,CMPSN:27M OHM,10%,0.25M	01121	CB2761
R523	321-0423-00			RES,FXD,FILM:249K OHM,1%,0.125M,TC=T0	19701	5043ED249K0F
R524	321-0452-00			RES,FXD,FILM:499K OHM,1%,0.125M,TC=T0	19701	5043ED499K0F
R527	315-0104-00			RES,FXD,FILM:100K OHM,5%,0.25M	57668	NTR25J-E100K
R531	315-0224-00			RES,FXD,FILM:220K OHM,5%,0.25M	57668	NTR25J-E220K
R532	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25M	19701	5043CX10K00J
R533	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25M	19701	5043CX10K00J
R536	315-0104-00			RES,FXD,FILM:100K OHM,5%,0.25M	57668	NTR25J-E100K
R541	315-0681-00			RES,FXD,FILM:680 OHM,5%,0.25M	57668	NTR25J-E680E
R542	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25M	19701	5043CX10K00J
R550	315-0682-00			RES,FXD,FILM:6.8K OHM,5%,0.25M	57668	NTR25J-E06K8
R551	315-0153-00			RES,FXD,FILM:15K OHM,5%,0.25M	19701	5043CX15K00J
R552	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25M	57668	NTR25JE01K0
R553	315-0682-00			RES,FXD,FILM:6.8K OHM,5%,0.25M	57668	NTR25J-E06K8
R555	315-0302-00			RES,FXD,FILM:3K OHM,5%,0.25M	57668	NTR25J-E03K0
R558	315-0302-00			RES,FXD,FILM:3K OHM,5%,0.25M	57668	NTR25J-E03K0
R559	315-0202-00			RES,FXD,FILM:2K OHM,5%,0.25M	57668	NTR25J-E 2K
R560	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25M	57668	NTR25J-E 100E
R561	315-0181-00			RES,FXD,FILM:180 OHM,5%,0.25M	57668	NTR25J-E180E
R562	307-0104-00			RES,FXD,CMPSN:3.3 OHM,5%,0.25M	01121	CB33G5
R570	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25M	57668	NTR25J-E 100E
R571	315-0181-00			RES,FXD,FILM:180 OHM,5%,0.25M	57668	NTR25J-E180E
R572	307-0104-00			RES,FXD,CMPSN:3.3 OHM,5%,0.25M	01121	CB33G5
R900	304-0102-00	B010100	B029999	RES,FXD,CMPSN:1K OHM,10%,1M	01121	GB1021
R900	303-0511-00	B030000	B052349	RES,FXD,CMPSN:510 OHM,5%,1M	01121	GB5115
R900	303-0751-00	B052350		RES,FXD,CMPSN:750 OHM,5%,1M	01121	GB7515
R910	315-0821-00			RES,FXD,FILM:820 OHM,5%,0.25M	19701	5043CX820R0J
R915	321-0285-00			RES,FXD,FILM:9.09K OHM,1%,0.125M,TC=T0	07716	CEA090900F
R916	321-0268-00			RES,FXD,FILM:6.04K OHM,1%,0.125M,TC=T0	19701	5043ED6K040F
R920	307-0105-00			RES,FXD,CMPSN:3.9 OHM,5%,0.25M	01121	CB 3905
R922	315-0100-00			RES,FXD,FILM:10 OHM,5%,0.25M	19701	5043CX10RR00J
R924	315-0100-00			RES,FXD,FILM:10 OHM,5%,0.25M	19701	5043CX10RR00J
R926	315-0100-00			RES,FXD,FILM:10 OHM,5%,0.25M	19701	5043CX10RR00J
R940	307-0106-00			RES,FXD,CMPSN:4.7 OHM,5%,0.25M	01121	CB 47G5
R942	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25M	57668	NTR25JE01K0
R945	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25M	57668	NTR25J-E09K1
R946	315-0622-00			RES,FXD,FILM:6.2K OHM,5%,0.25M	19701	5043CX6K200J
R964	315-0100-00			RES,FXD,FILM:10 OHM,5%,0.25M	19701	5043CX10RR00J
R966	315-0100-00			RES,FXD,FILM:10 OHM,5%,0.25M	19701	5043CX10RR00J

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
R968	315-0100-00			RES,FXD,FILM:10 OHM,5%,0.25W	19701	5043CX10RR00J
R970	307-0105-00			RES,FXD,CMPSN:3.9 OHM,5%,0.25W	01121	CB 39G5
R989	315-0561-00			RES,FXD,FILM:560 OHM,5%,0.25W	19701	5043CX560R0J
R990	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
R994	321-0306-00			RES,FXD,FILM:15.0K OHM,1%,0.125W,TC=TO	19701	5033ED15J00F
R995	321-0306-00			RES,FXD,FILM:15.0K OHM,1%,0.125W,TC=TO	19701	5033ED15J00F
RT104	307-0181-00			RES,THERMAL:100K OHM,10%,NTC	14193	K10-10002K
RT203	307-0181-00			RES,THERMAL:100K OHM,10%,NTC	14193	K10-10002K
S10	260-1207-00			SWITCH,PUSH:DPDT,28VDC,PUSH-PUSH	59821	ORDER BY DESCR
S20	260-1207-00			SWITCH,PUSH:DPDT,28VDC,PUSH-PUSH	59821	ORDER BY DESCR
S30	260-1209-00			SWITCH,PUSH:18UTTON,4 POLE,DISPLAY	31918	601347
S178	----- -----			(PART OF R178)		
S470	263-1004-00			SW CAM ACTR AS:LF-3DB POINT	80009	263-1004-00
S480	263-1005-00			SW CAM ACTR AS:GAIN	80009	263-1005-00
S490	263-1003-00			SW CAM ACTR AS:HF-3DB POINT	80009	263-1003-00
U910	156-0067-00			MICROCKT,LINEAR:OPNL AMPL,SEL	04713	MC1741CP1
U990	156-0067-00			MICROCKT,LINEAR:OPNL AMPL,SEL	04713	MC1741CP1
VR252	152-0168-00			SEMICOND DVC,DI:ZEN,SI,12V,5%,0.4W,DO-763B	14552	TD331689
VR438	152-0243-00			SEMICOND DVC,DI:ZEN,SI,15V,5%,0.4W,DO-7	04713	SZ13203 (1N9658)
VR448	152-0243-00			SEMICOND DVC,DI:ZEN,SI,15V,5%,0.4W,DO-7	04713	SZ13203 (1N9658)
VR910	152-0123-00			SEMICOND DVC,DI:ZEN,SI,9V,5%,0.5W,DO-7	04713	SZ11530RL

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols and Reference Designators

Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors = Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).

Resistors = Ohms (Ω).

Graphic symbols and class designation letters are based on ANSI Standard Y32.2-1975.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The overline on a signal name indicates that the signal performs its intended function when it goes to the low state.

Abbreviations are based on ANSI Y1.1-1972.

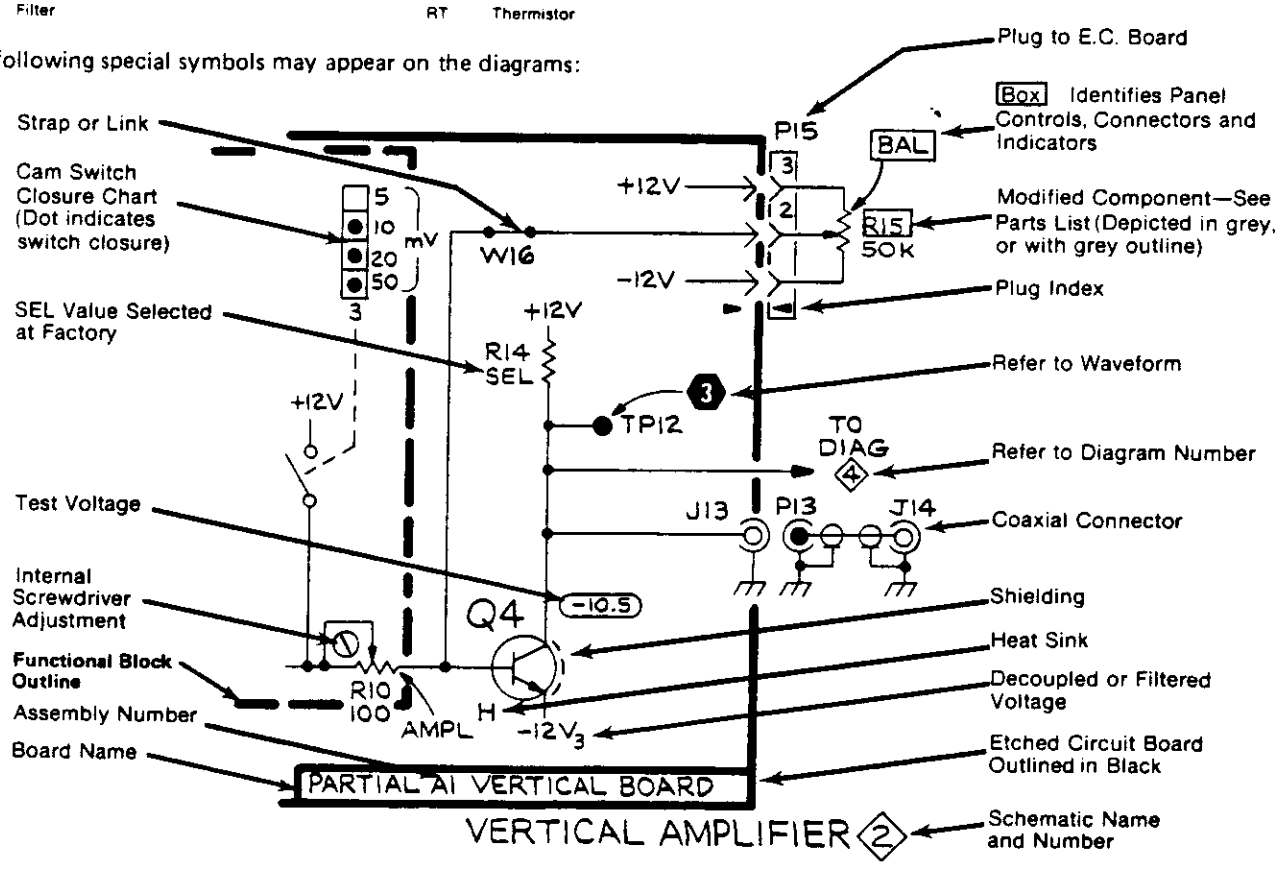
Other ANSI standards that are used in the preparation of diagrams by Tektronix, Inc. are:

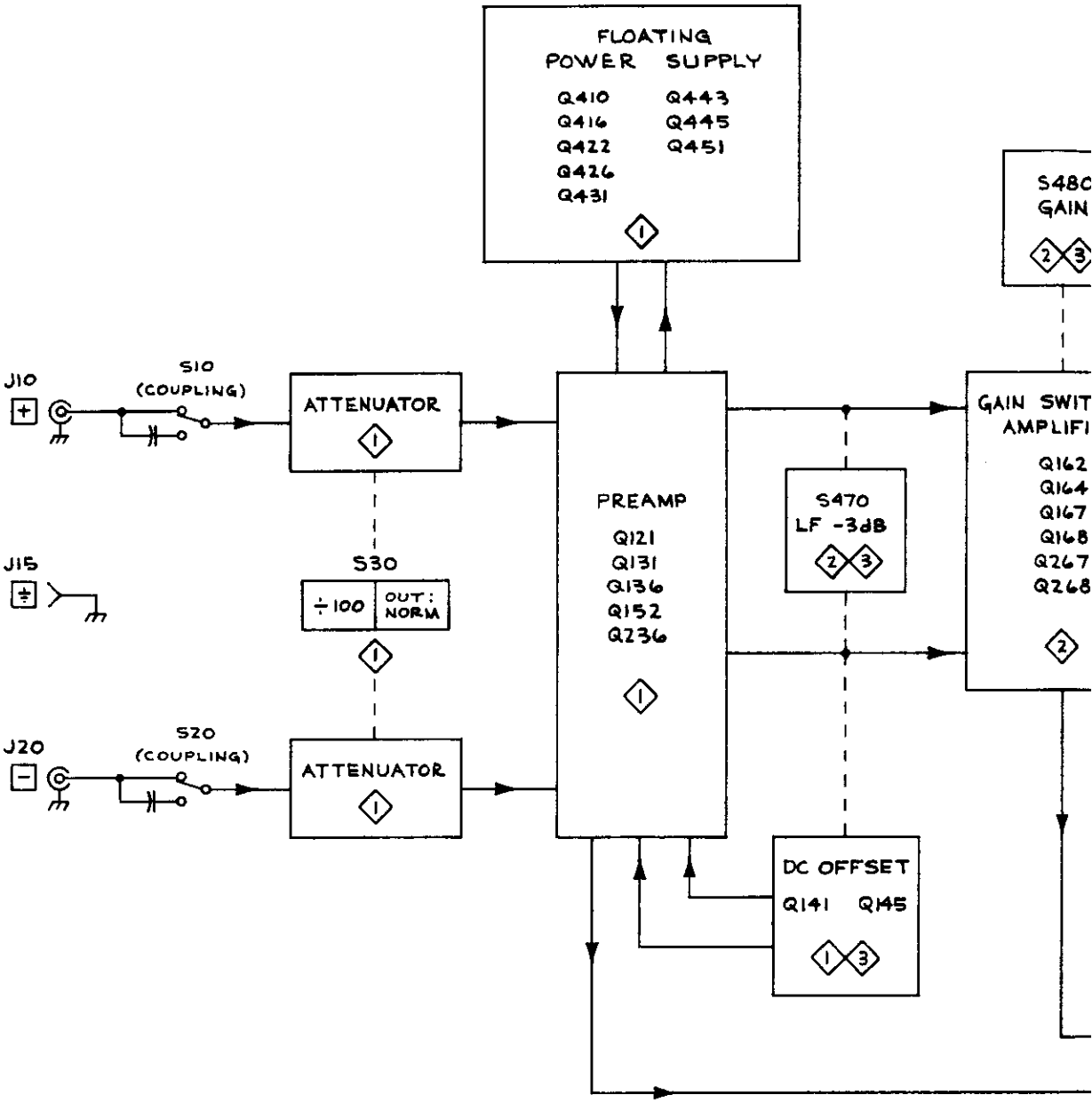
Y14.15, 1966	Drafting Practices.
Y14.2, 1973	Line Conventions and Lettering.
Y10.5, 1968	Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

A	Assembly, separable or repairable (circuit board, etc)	H	Heat dissipating device (heat sink, heat radiator, etc)	S	Switch or contactor
AT	Attenuator, fixed or variable	HR	Heater	T	Transformer
B	Motor	HY	Hybrid circuit	TC	Thermocouple
BT	Battery	J	Connector, stationary portion	TP	Test point
C	Capacitor, fixed or variable	K	Relay	U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
CB	Circuit breaker	L	Inductor, fixed or variable	V	Electron tube
CR	Diode, signal or rectifier	M	Meter	VR	Voltage regulator (zener diode, etc.)
DL	Delay line	P	Connector, movable portion	W	Wirestrap or cable
DS	Indicating device (lamp)	Q	Transistor or silicon-controlled rectifier	Y	Crystal
E	Spark Gap, Ferrite bead	R	Resistor, fixed or variable	Z	Phase shifter
F	Fuse	RT	Thermistor		
FL	Filter				

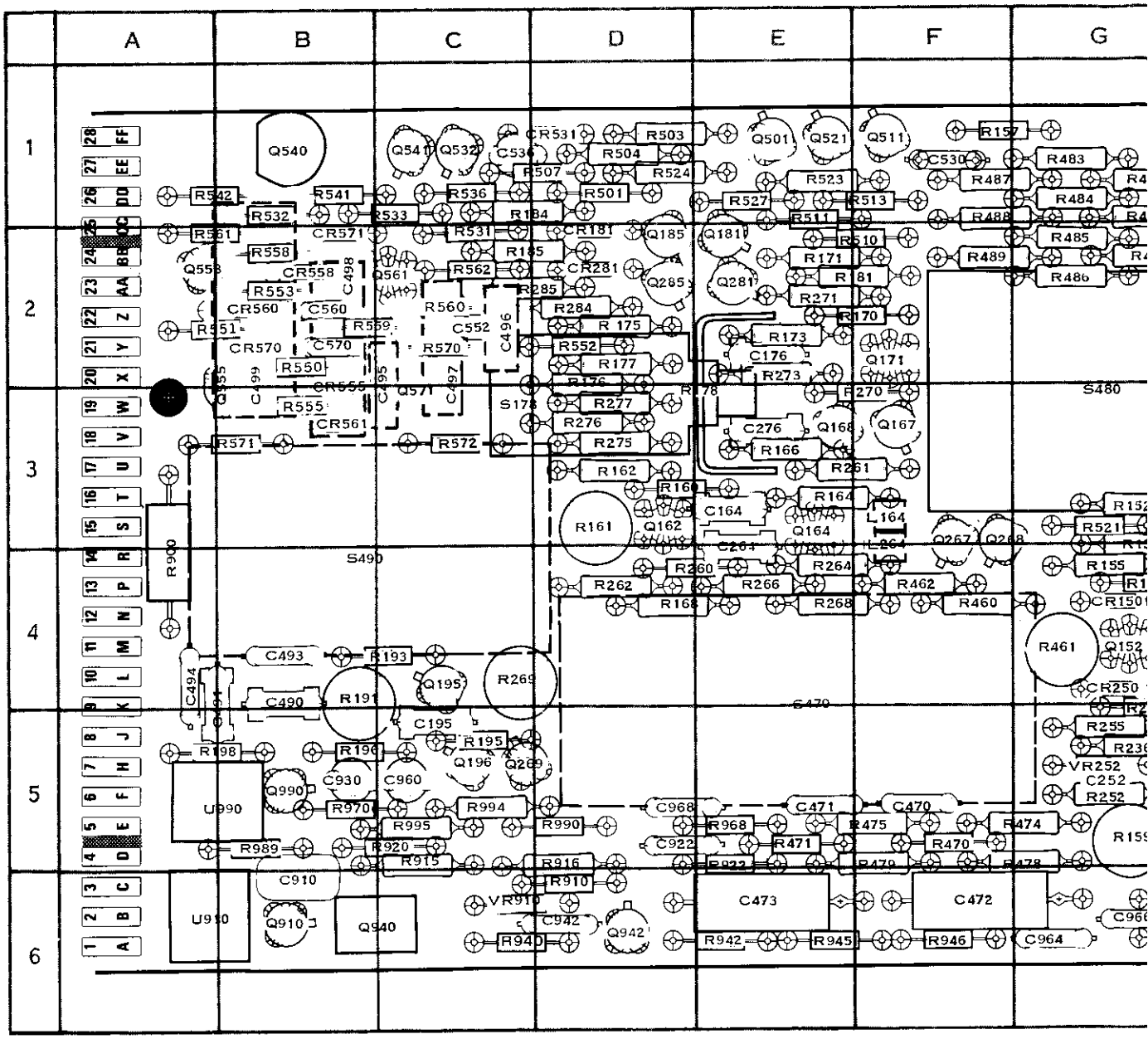
The following special symbols may appear on the diagrams:




FLOATING
POWER SUPPLY
Q410
Q416
Q422
Q426
Q431
Q443
Q445
Q451
1
S480
GAIN
2
3
J10
S10
(COUPLING)
ATTENUATOR
1
PREAMP
Q121
Q131
Q136
Q152
Q236
1
S470
LF -3dB
2
3
GAIN SWIT
AMPLIFI
Q162
Q164
Q167
Q168
Q267
Q268
2
J15
S30
÷100
OUT:
NORM
1
J20
S20
(COUPLING)
ATTENUATOR
1
DC OFFSET
Q141 Q145
1
3

PARTS LOCATION GRID

AM 502



A1 Main Circuit Board

Component Reference Chart

CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC
C28	K3	CR108	I2	Q501	E1	R185	C2	R451	J4	R926	H6
C30	K3	CR109	J3	Q511	F1	R191	B4	R460	F4	R940	C6
C32	K2	CR141	H4	Q521	E1	R193	C4	R461	G4	R942	E6
C34	K2	CR150	G4	Q532	C1	R195	C5	R462	F4	R945	E6
C35	L2	CR181	D2	Q540	B1	R196	B5	R464	H1	R946	F6
C38	K1	CR208	I3	Q541	C1	R198	A5	R466	H1	R964	H6
C48	L3	CR209	J3	Q555	B3	R205	I2	R470	F5	R966	H6
C50	L3	CR231	H4	Q558	A2	R206	I3	R471	E5	R968	E5
C54	M2	CR250	G4	Q561	C2	R207	I3	R474	G5	R970	B5
C55	L3	CR281	D2	Q571	C3	R220	I4	R475	F5	R989	B5
C58	L1	CR438	J2	Q910	B6	R221	I4	R478	G6	R990	D5
C107	I2	CR441	K4	Q940	B6	R222	H5	R479	F6	R994	C5
C122	I3	CR448	K3	Q942	D6	R225	H5	R480	G2	R995	C5
C131	H4	CR531	D1	Q990	B5	R226	I5	R481	G1	RT104	H2
C146	I6	CR555	B3			R231	I5	R482	G1	RT203	H2
C150	H5	CR558	B2	R10	K4	R236	G5	R483	G1		
C164	E3	CR560	B2	R20	K5	R237	G5	R484	G1	S10A	L4
C176	E2	CR561	B3	R30	K3	R241	J6	R485	G2	S10B	L4
C195	C5	CR570	B2	R35	K2	R245	J6	R486	G2	S20A	L5
C207	I2	CR571	B2	R38	K2	R246	H6	R487	F1	S20B	L6
C222	I5			R40	L2	R252	G5	R488	F1	S30	L1
C231	H5	F100	J3	R50	L2	R254	H5	R489	F2	S178	C3
C252	G5	F200	I3	R55	L2	R255	G5			S470 †	E5
C264	E4			R58	L2	R260	D4	R501	D1	S480	G3
C276	E3	L164	F3	R103	H1	R261	E3	R503	D1	S490 †	B4
C431	J4	L264	F4	R105	I2	R262	D4	R504	D1		
C433	J4	L416	J5	R106	I2	R264	E4	R507	D1	U910	A6
C435	K4	L426	K5	R107	I3	R266	E4	R510	F2	U990	A5
C438	J2	L445	K3	R120	I4	R268	E4	R511	E1		
C443	L4	P40	K3	R121	I4	R269	C4	R513	F1	VR252	G5
C448	K3	Q121	I4	R122	H4	R270	F3	R521	G3	VR438	J2
C450	K4	Q131	H4	R125	H4	R271	E2	R523	E1	VR448	J3
C470	F5	Q136	H4	R126	I4	R273	E2	R524	D1	VR910	C6
C471	E5	Q141	I5	R131	I3	R275	D3	R527	E1		
C472	F6	Q145	I6	R136	G4	R276	D3	R532	B1		
C473	E6	Q152	G4	R137	G4	R277	D3	R533	C1		
C490	B4	Q162	D3	R141	J6	R284	D2	R536	C1		
C491	A4	Q164	E3	R145	J5	R285	C2	R541	B1		
C493	B4	Q167	F3	R146	H6	R410	J5	R542	A1		
C494	A4	Q168	E3	R152	G3	R411	J6	R550	B2		
C495 †	C2	Q171	F2	R154	H3	R414*	J5	R551	A2		
C496 †	C2	Q181	E2	R155	G4	R420	K5	R552	D2		
C497 †	C2	Q185	D2	R157	F1	R421	K5	R553	B2		
C498 †	B2	Q195	C4	R159	G5	R422	K5	R555	B3		
C499 †	B2	Q196	C5	R160	D3	R423	K5	R558	B2		
C530	F1	Q236	H4	R161	D3	R424	K6	R559	B2		
C536	C1	Q267	F3	R162	D3	R431	J4	R560	C2		
C552	C2	Q268	F3	R164	E3	R433	J4	R561	A2		
C560	B2	Q269	C5	R166	E3	R435	J4	R562	C2		
C570	B2	Q281	E2	R168	D4	R436	J3	R570	C2		
C910	B6	Q285	D2	R170	F2	R438	J2	R571	B3		
C922	D5	Q410*	J5	R171	E2	R440	K4	R572	C3		
C924	H6	Q416	J4	R173	E2	R441	K4	R900	A4		
C926	H6	Q422*	J5	R175	D2	R442	K4	R910	D6		
C930	B5	Q426	K5	R176	D3	R443	K4	R915	C5		
C942	D6	Q431	J4	R177	D2	R445	K3	R916	D6		
C960	C5	Q443	L4	R178	E3	R446	J3	R920	C5		
C964	G6	Q445	K4	R181	E2	R448	J2	R922	E5		
C966	G6	Q451	J4	R184	C1	R450	J4	R924	H6		
C968	D5										

Turn page for Voltage and Waveform Conditions

***See Parts List for serial number ranges.**

VOLTAGE AND WAVEFORM CONDITIONS

WARNING

Dangerous potentials exist at several points throughout this instrument. When the instrument is operated with the covers removed, do not touch exposed connections or components. Some transistors have voltages present on their cases. Disconnect the power source before replacing parts.

The voltages and waveforms shown on the diagram 1 and 2 were taken with the AM 502 front panel controls set as follows:

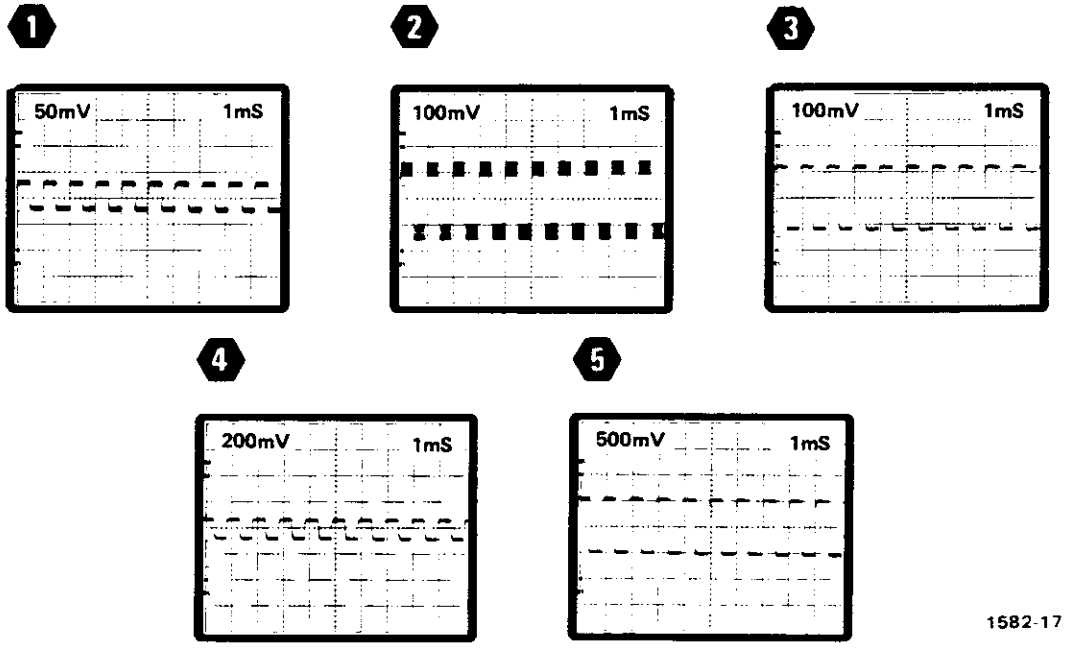
VOLTAGES		WAVEFORMS[1]	
GAIN	100	GAIN	100
÷100	pushbutton out	÷100	pushbutton out
HF −3 dB switch	1 MHz	HF −3 dB switch	1 MHz
LF −3 dB switch	DC	LF −3 dB switch	DC
+ input AC	pushbutton out	+ input AC	pushbutton out
GND	pushbutton in	GND	pushbutton out
− input AC	pushbutton out	− input AC	pushbutton out
GND	pushbutton in	GND	pushbutton in
STEP GAIN	centered	STEP GAIN	centered
DC BAL		DC BAL	
DC OFFSET (COURSE - FINE)	centered	DC OFFSET (COURSE- FINE)	centered

[1]**Ground reference: center horizontal graticule line**

The waveforms shown were taken with a 50 mV square-wave input signal applied to the + input connector of the AM 502.

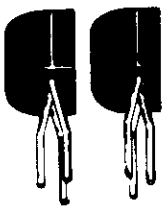
Voltage Conditions. The voltages shown on the diagram were obtained using a digital multimeter with a 10 megohm input impedance (TEKTRONIX DM 501 Digital Multimeter or TEKTRONIX 7D13 Digital Multimeter used with readout equipped, 7000-series oscilloscope).

Waveform Conditions. The waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule. Vertical deflection factor shown on the waveform is the actual deflection factor from the probe tip. Voltages and waveforms on the diagrams are not absolute and may vary between instruments because of component tolerances, internal calibration, or front-panel settings. Readouts are simulated in larger-than-normal type.



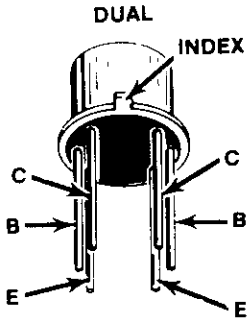
1582-17

Voltage and Waveform Conditions



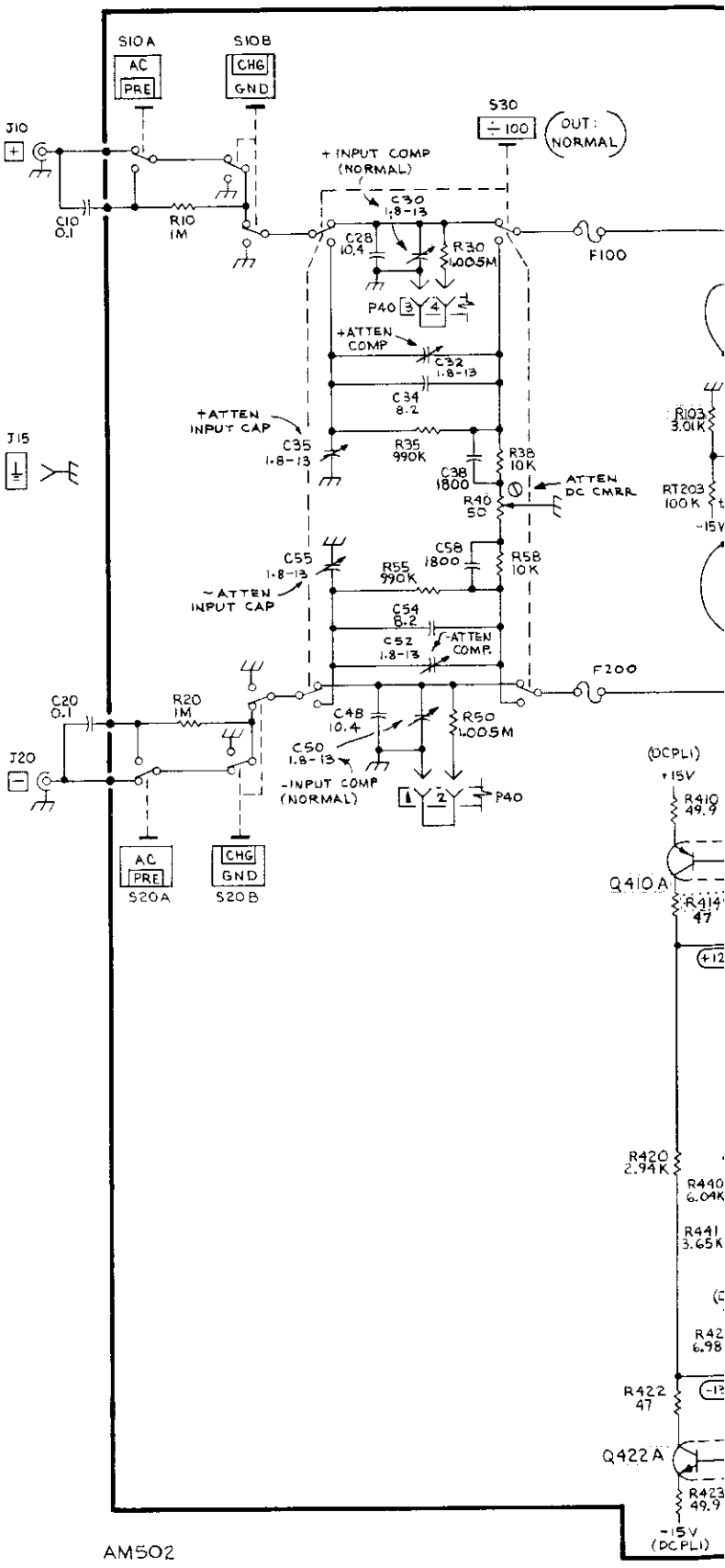
Q152 (SN B057429 & BELOW), Q410, Q422

Q416, Q426, Q431 Q443, Q445, Q451

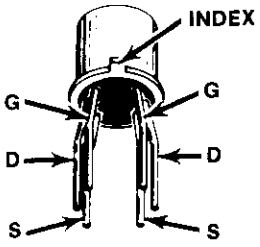


Q121, Q131, Q141, Q145, Q152, Q410, Q422

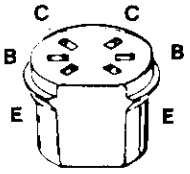
Q136, Q236



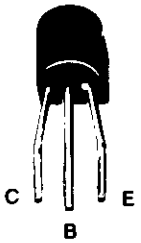
AM502



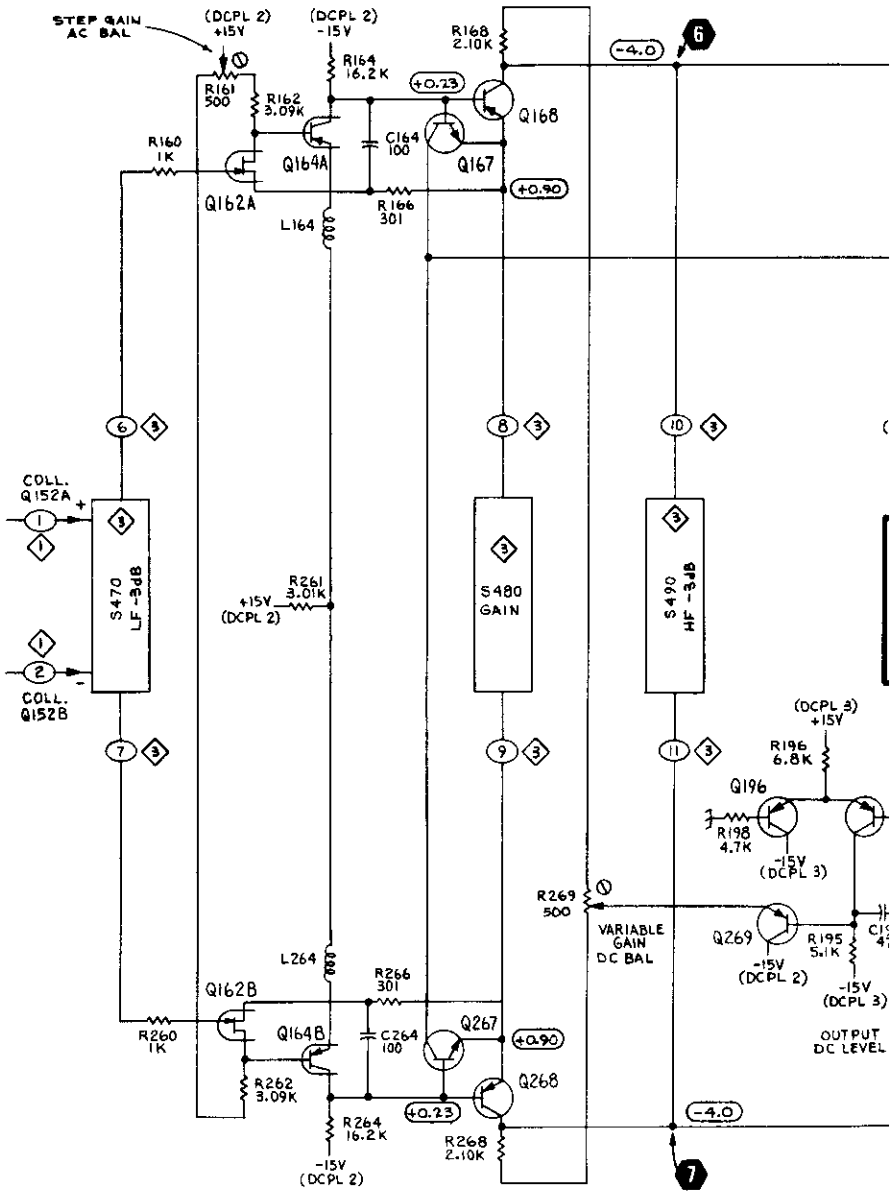
Q162, Q171

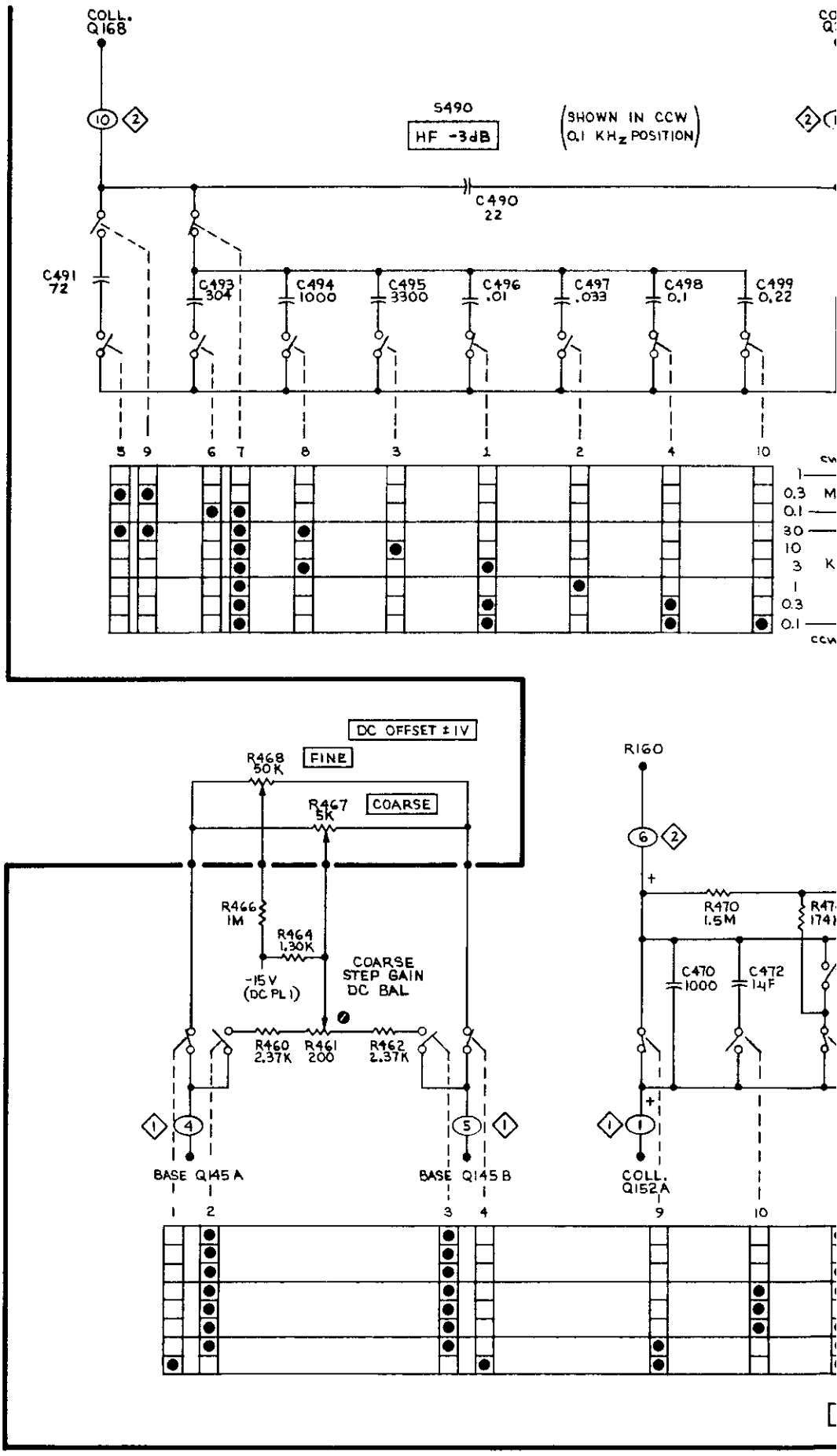


Q164 (SN B057429 & BELOW)

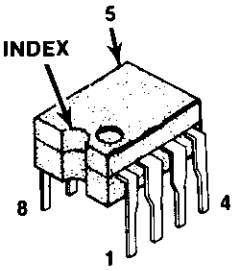


Q167, Q168, Q181, Q185
Q195, Q196, Q267, Q268
Q269, Q281, Q285



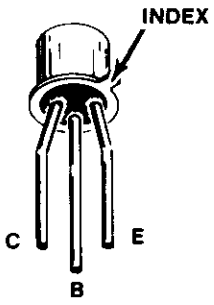

COLL. Q168
S490
HF -3dB
(SHOWN IN CCW 0.1 KHz POSITION)
C490 22
C491 72
C493 304
C494 1000
C495 3300
C496 .01
C497 .033
C498 0.1
C499 0.22
5 9 6 7 8 3 1 2 4 10
CW
0.3 M
0.1
30
10
3 K
1
0.3
0.1
CCW
DC OFFSET ± 1V
R468 50K FINE
R467 5K COARSE
R466 1M
R464 1.30K
-15 V (DC PL 1)
COARSE STEP GAIN DC BAL
R460 2.37K
R461 200
R462 2.37K
BASE Q145 A
BASE Q145 B
1 2 3 4
R160
R470 1.5M
C470 1000
C472 1μF
COLL. Q152A
9 10

Voltage Conditions

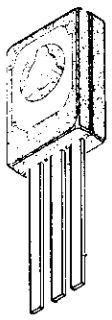


U910, U990

SINGLE

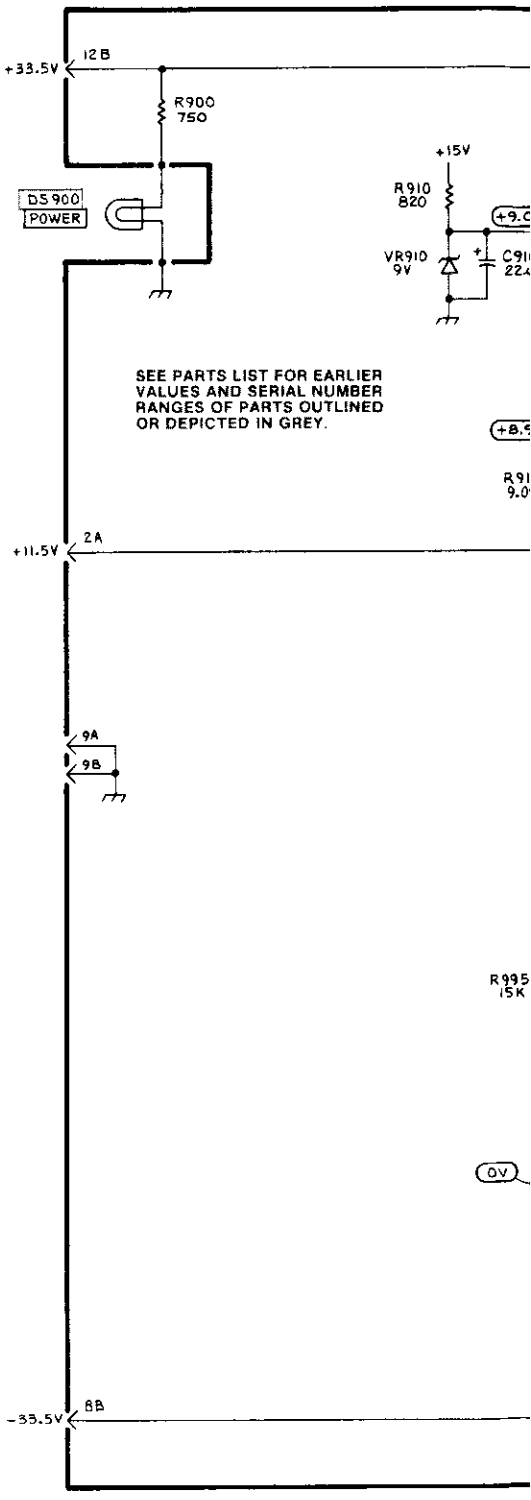


Q910, Q990



Q940

Q942



REPLACEABLE MECHANICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

```
1 2 3 4 5                    Name & Description

Assembly and/or Component
Attaching parts for Assembly and/or Component
                - - - * - - -
  Detail Part of Assembly and/or Component
  Attaching parts for Detail Part
                - - - * - - -
    Parts of Detail Part
    Attaching parts for Parts of Detail Part
                - - - * - - -
```

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol - - - * - - - indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

"	INCH
#	NUMBER SIZE
ACTR	ACTUATOR
ADPTR	ADAPTER
ALIGN	ALIGNMENT
AL	ALUMINUM
ASSEM	ASSEMBLED
ASSY	ASSEMBLY
ATTEN	ATTENUATOR
AWG	AMERICAN WIRE GAGE
BD	BOARD
BRKT	BRACKET
BRS	BRASS
BRZ	BRONZE
BSHG	BUSHING
CAB	CABINET
CAP	CAPACITOR
CER	CERAMIC
CHAS	CHASSIS
CKT	CIRCUIT
COMP	COMPOSITION
CONN	CONNECTOR
COV	COVER
CPLG	COUPLING
CRT	CATHODE RAY TUBE
DEG	DEGREE
DWR	DRAWER
ELCTRN	ELECTRON
ELEC	ELECTRICAL
ELCTLT	ELECTROLYTIC
ELEM	ELEMENT
EPL	ELECTRICAL PARTS LIST
EQPT	EQUIPMENT
EXT	EXTERNAL
FIL	FILLISTER HEAD
FLEX	FLEXIBLE
FLH	FLAT HEAD
FLTR	FILTER
FR	FRAME or FRONT
FSTNR	FASTENER
FT	FOOT
FXD	FIXED
GSKT	GASKET
HDL	HANDLE
HEX	HEXAGON
HEX HD	HEXAGONAL HEAD
HEX SOC	HEXAGONAL SOCKET
HLCPS	HELICAL COMPRESSION
HLEXT	HELICAL EXTENSION
HV	HIGH VOLTAGE
IC	INTEGRATED CIRCUIT
ID	INSIDE DIAMETER
IDENT	IDENTIFICATION
IMPLR	IMPELLER
IN	INCH
INCAND	INCANDESCENT
INSUL	INSULATOR
INTL	INTERNAL
LPHLDR	LAMPHOLDER
MACH	MACHINE
MECH	MECHANICAL
MTG	MOUNTING
NIP	NIPPLE
NON WIRE	NOT WIRE WOUND
OBD	ORDER BY DESCRIPTION
OD	OUTSIDE DIAMETER
OVH	OVAL HEAD
PH BRZ	PHOSPHOR BRONZE
PL	PLAIN or PLATE
PLSTC	PLASTIC
PN	PART NUMBER
PNH	PAN HEAD
PWR	POWER
RCPT	RECEPTACLE
RES	RESISTOR
RGD	RIGID
RLF	RELIEF
RTNR	RETAINER
SCH	SOCKET HEAD
SCOPE	OSCILLOSCOPE
SCR	SCREW
SE	SINGLE END
SECT	SECTION
SEMICOND	SEMICONDUCTOR
SHLD	SHIELD
SHLDR	SHOULDERED
SKT	SOCKET
SL	SLIDE
SLFLKG	SELF-LOCKING
SLVG	SLEEVING
SPR	SPRING
SQ	SQUARE
SST	STAINLESS STEEL
STL	STEEL
SW	SWITCH
T	TUBE
TERM	TERMINAL
THD	THREAD
THK	THICK
TNSN	TENSION
TPG	TAPPING
TRH	TRUSS HEAD
V	VOLTAGE
VAR	VARIABLE
W/	WITH
WSHR	WASHER
XFMR	TRANSFORMER
XSTR	TRANSISTOR

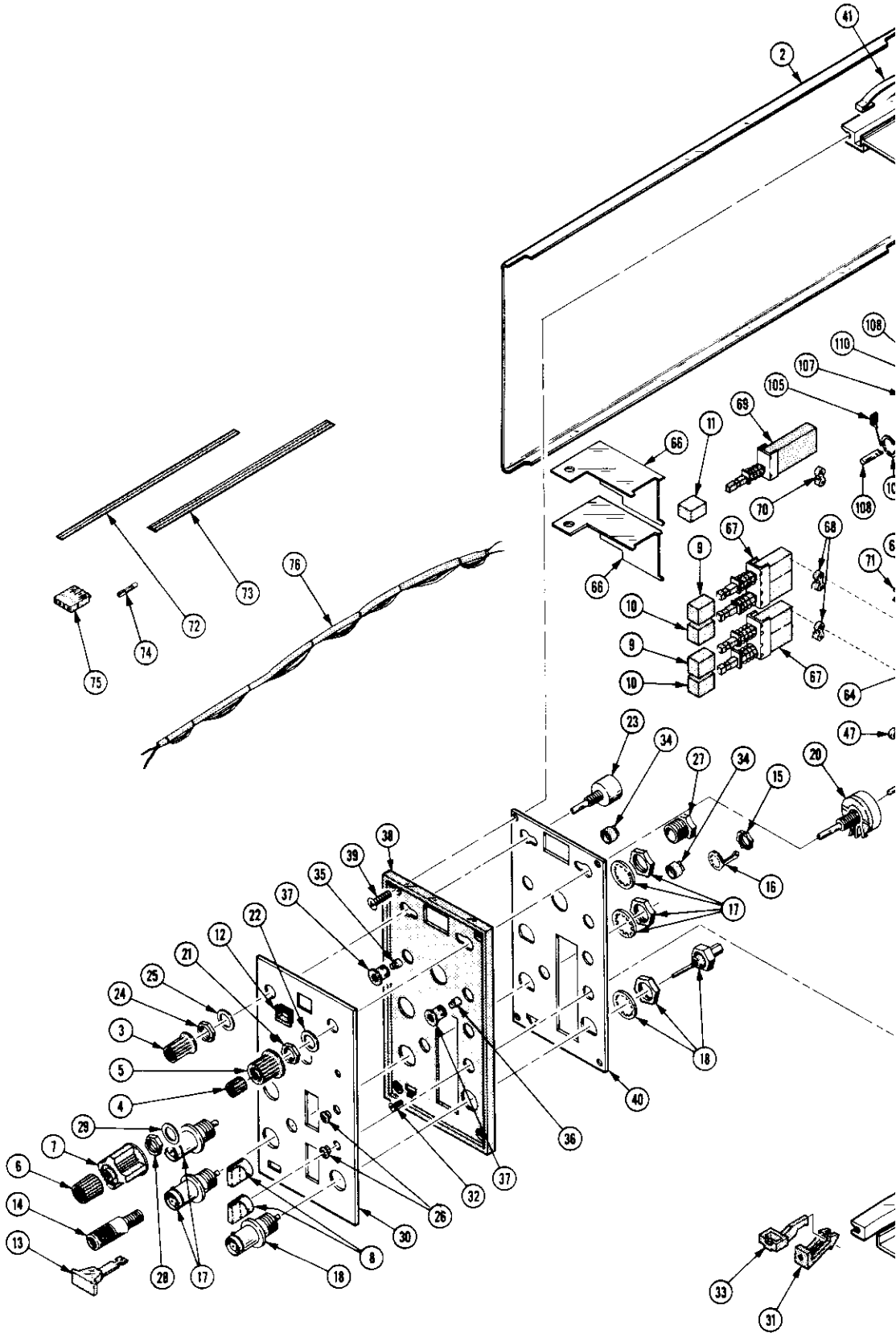
CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
02107	SPARTA MFG CO	5200 N MOOSTER RD P O BOX 449	DOVER OH 44622
09922	BURNDY CORP	RICHARDS AVE	NORWALK CT 06852
12327	FREEWAY CORP	9301 ALLEN DR	CLEVELAND OH 44125
13511	AMPHENOL CADRE DIV BUNKER RAMO CORP		LOS GATOS CA
22526	DU PONT E I DE NEMOURS AND CO INC DU PONT CONNECTOR SYSTEMS	30 HUNTER LANE	CAMP HILL PA 17011
28520	HEYCO MOLDED PRODUCTS	147 MICHIGAN AVE P O BOX 160	KENILWORTH NJ 07033
45722	USM CORP., PARKER-KALON FASTENER DIV .		CAMPBELLSVILLE, KY 42718
56878	SPS TECHNOLOGIES INC	HIGHLAND AVE	JENKINTOWN PA 19046
71159	BRISTOL SOCKET SCREW CO		WATERBURY CT
71785	TRW INC TRW CINCH CONNECTORS	1501 MORSE AVE	ELK GROVE VILLAGE IL 60007
73743	FISCHER SPECIAL MFG CO	446 MORGAN ST	CINCINNATI OH 45206
74445	HOLO-KROME CO	31 BROOK ST	WEST HARTFORD CT 06110
77900	SHAKEPROOF DIV OF ILLINOIS TOOL WORKS	SAINT CHARLES RD	ELGIN IL 60120
78189	ILLINOIS TOOL WORKS INC SHAKEPROOF DIVISION	ST CHARLES ROAD	ELGIN IL 60120
79136	WALDES KOHINOOR INC	47-16 AUSTEL PLACE	LONG ISLAND CITY NY 11101
80009	TEKTRONIX INC	4900 S W GRIFFITH DR P O BOX 500	BEAVERTON OR 97077
83385	MICRODOT MANUFACTURING INC GREER-CENTRAL DIV	3221 W BIG BEAVER RD	TROY MI 48098
86928	SEASTROM MFG CO INC	701 SONORA AVE	GLENDALE CA 91201
91836	KINGS ELECTRONICS CO INC	40 MARBLEDALE ROAD	TUCKAHOE NY 10707
93907	TEXTRON INC CAMCAR DIV	600 18TH AVE	ROCKFORD IL 61101
TK0392	NORTHWEST FASTENER SALES INC	7923 SW CIRRUS DRIVE	BEAVERTON OR 97005
TK0435	LENIS SCREW CO	4114 S PEORIA	CHICAGO IL 60609
TK0507	O HARA METAL PRODUCTS CO	542 BRANNAN ST	SAN FRANCISCO CA 94107

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-1	337-1399-01	B010100	B130524	2	SHIELD,ELEC:SIDE	80009	337-1399-01
	337-1399-01	B130525		1	SHIELD,ELEC:SIDE	80009	337-1399-01
-2	337-1399-00	B130525		1	SHIELD,ELEC:SIDE	80009	337-1399-00
-3	366-0494-00			1	KNOB:GRAY WITH SETSCREW	80009	366-0494-00
	213-0153-00			1	.SETSCREW:5-40 X 0.125,STL	TK0392	ORDER BY DESCR
-4	366-1518-00	B010100	B040799	1	KNOB:GY,0.083 ID X 0.392 OD X 0.4 H	80009	366-1518-00
	213-0153-00	B010100	B040799	1	.SETSCREW:5-40 X 0.125,STL	TK0392	ORDER BY DESCR
	366-1084-00	B040800	B049999	1	KNOB:GY,0.08 ID X 0.392 OD X 0.4 H	80009	366-1084-00
	213-0725-00	B040800	B049999	1	.SETSCREW:3-48 X 0.094,STL	56878	ORDER BY DESCR
	366-1023-00	B050000		1	KNOB:GY,0.127 ID X 0.392 OD X 0.531 H	80009	366-1023-00
	213-0246-00	B050000		1	.SETSCREW:5-40 X 0.094,STL	71159	ORDER BY DESCR
-5	366-1101-00			1	KNOB:GY,0.127 ID X 0.706 OD X 0.6 H	80009	366-1101-00
	213-0153-00			1	.SETSCREW:5-40 X 0.125,STL	TK0392	ORDER BY DESCR
-6	366-1317-00			1	KNOB:RED,CAL,0.127 ID X 0.5 OD X 0.531 H	80009	366-1317-00
	213-0153-00			1	.SETSCREW:5-40 X 0.125,STL	TK0392	ORDER BY DESCR
-7	366-1001-00			1	KNOB:GY,0.252 ID X 0.925 OD X 0.67	80009	366-1001-00
	213-0153-00			2	.SETSCREW:5-40 X 0.125,STL	TK0392	ORDER BY DESCR
-8	366-1163-00			2	KNOB:GY,0.127 ID X 0.392 OD X 0.466 H	80009	366-1163-00
	213-0153-00			1	.SETSCREW:5-40 X 0.125,STL	TK0392	ORDER BY DESCR
-9	366-1257-11			2	PUSH BUTTON:SIL GY,AC PRE	80009	366-1257-11
-10	366-1257-12			2	PUSH BUTTON:SIL GY,CHG GND	80009	366-1257-12
-11	366-1489-31			1	PUSH BUTTON:SIL GY,DIVIDE BY 10	80009	366-1489-31
-12	426-0681-00			5	FRAME,PUSH BTN:	80009	426-0681-00
	214-1840-00	B010100	B053579	1	PIN,KNOB SECRG:0.12 L X 0.094-0.1 OD,ACETAL	80009	214-1840-00
-13	366-1422-01	B010100	B053579	1	KNOB:LATCH	80009	366-1422-01
	366-1690-00	B053580		1	KNOB,LATCH:SIL GY,0.53 X 0.23 X 1.059	80009	366-1690-00
-14	129-0103-00			1	POST,BDG,ELEC:ASSEMBLY	80009	129-0103-00
					(ATTACHING PARTS)		
-15	210-0455-00			1	NUT,PLAIN,HEX:0.25-28 X 0.375,BRS NP	73743	3089-402
-16	210-0223-00			1	TERMINAL,LUG:0.26 ID,LOCKING,BRZ TIN PL	86928	5441-37
					(END ATTACHING PARTS)		
	200-0103-00			1	.NUT,PLAIN,KNURL:0.25-28 X 0.375"OD BRASS	80009	200-0103-00
	129-0077-00			1	.STUD,SHOULDERED:0.938 L X 0.375,0.250-28	80009	129-0077-00
-17	131-0955-00			2	CONN,RCPT,ELEC:BNC,FEMALE	13511	31-279
-18	131-0818-00			1	CONN,RCPT,ELEC:BNC,FEMALE	91836	KC-19-153
-19	384-1221-00	B010100	B049999	1	EXTENSION SHAFT:3.0 L X 0.081 OD,SST	80009	384-1221-00
	384-0415-01	B050000		1	EXTENSION SHAFT:3.18 L X 0.081 OD,STEEL	80009	384-0415-01
-20	----- -----			1	RESISTOR,VARIABLE:(SEE R468 REPL)		
					(ATTACHING PARTS)		
-21	210-0583-00			1	NUT,PLAIN,HEX:0.25-32 X 0.312,BRS CD PL	73743	2X-20319-402
-22	210-0940-00			1	WASHER,FLAT:0.25 ID X 0.375 OD X 0.02,STL	12327	ORDER BY DESCR
					(END ATTACHING PARTS)		
-23	----- -----			1	RESISTOR,VARIABLE:(SEE R158 REPL)		
					(ATTACHING PARTS)		
-24	210-0583-00			1	NUT,PLAIN,HEX:0.25-32 X 0.312,BRS CD PL	73743	2X-20319-402
-25	210-0940-00			1	WASHER,FLAT:0.25 ID X 0.375 OD X 0.02,STL	12327	ORDER BY DESCR
					(END ATTACHING PARTS)		
-26	358-0378-00	B010100	B054649	2	BUSHING,SLEEVE:0.131 ID X 0.18 OD X 0.125 L	80009	358-0378-00
	358-0599-00	B054650		2	BUSHING,SLEEVE:0.125 ID X 0.25 OD X 0.234	28520	B-187-125
-27	358-0029-00			1	BSHG,MACH THD:0.375-32 X 0.5 HEX,BRS NP	80009	358-0029-00
					(ATTACHING PARTS)		
-28	210-0590-00			1	NUT,PLAIN,HEX:0.375-32 X 0.438 BRS CD PL	73743	28269-402
-29	210-0978-00			1	WASHER,FLAT:0.375 ID X 0.5 OD X 0.024,STL	12327	ORDER BY DESCR
					(END ATTACHING PARTS)		
-30	333-1711-00			1	PANEL,FRONT:	80009	333-1711-00
-31	214-1513-01	B010100	B053579	1	LCH,PL-IN RTNG:PLASTIC	80009	214-1513-01
	105-0719-00	B053580		1	LATCH,RETAINING:PLUG-IN	80009	105-0719-00
					(ATTACHING PARTS)		
-32	213-0254-00			1	SCREW,TPG,TF:2-32 X 0.25,TYPE B,FLH,100 DEG	45722	ORDER BY DESCR
-33	105-0718-00	B053580	B054529	1	BAR,LATCH RLSE:	80009	105-0718-00
	105-0718-01	B054530		1	BAR,LATCH RLSE:	80009	105-0718-01
					(END ATTACHING PARTS)		
-34	200-0935-00			2	BASE,LAMPHOLDER:0.29 OD X 0.19 L,BK PLSTC	80009	200-0935-00
-35	378-0602-01			1	LENS,LIGHT:AMBER	80009	378-0602-01
-36	378-0602-00			1	LENS,LIGHT:GREEN	80009	378-0602-00
-37	352-0157-00			2	LAMPHOLDER:(1)T-2 UNBASED,WHITE	80009	352-0157-00
-38	386-2529-00	B010100	B049999	1	SUBPANEL,FRONT:	80009	386-2529-00

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345	Name & Description	Mfr. Code	Mfr. Part No.
1-	386-2529-01	B050000		1		SUBPANEL,FRONT:	80009	386-2529-01
						(ATTACHING PARTS)		
-39	213-0229-00	B010100	B054759	4		SCREW,TPG,TF:6-20 X 0.375,TYPE B,FLH,STL	93907	ORDER BY DESCR
	213-0123-00	B054760		4		SCREW,TPG,TF:6-32 X 0.375,SPCL TYPE,FLH	93907	234-21940-026
						(END ATTACHING PARTS)		
-40	337-1782-00	B010100	B049999	1		SHIELD,ELEC:REAR PANEL	80009	337-1782-00
	337-1782-01	B050000		1		SHIELD,ELEC:REAR	80009	337-1782-01
-41	214-1061-00			1		CONTACT,ELEC:GROUNDING,CU BE	80009	214-1061-00
-42	426-0725-00			1		FR SECT,PLUG-IN:TOP	80009	426-0725-00
						(ATTACHING PARTS)		
-43	213-0146-00			2		SCREW,TPG,TF:6-20 X 0.312,TYPE B,PNH,STL	83385	ORDER BY DESCR
						(END ATTACHING PARTS)		
-44	386-3657-00	B053580	B055259	2		SUPPORT,PLUG-IN:	80009	386-3657-00
	386-3657-01	B055260		2		SUPPORT,PLUG-IN:	93907	ORDER BY DESCR
-45	210-1270-00	B053580		2		WASHER,FLAT:0.141 ID X 0.219 OD X 0.04,AL	80009	210-1270-00
-46	426-0724-00			1		FR SECT,PLUG-IN:BOTTOM	80009	426-0724-00
						(ATTACHING PARTS)		
-47	213-0146-00			1		SCREW,TPG,TF:6-20 X 0.312,TYPE B,PNH,STL	83385	ORDER BY DESCR
-48	211-0012-00			1		SCREW,MACHINE:4-40 X 0.375,PNH,STL	TK0435	ORDER BY DESCR
-49	210-0406-00			1		NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
						(END ATTACHING PARTS)		
-50	376-0039-00			1		CPLG,SHAFT,RGD:0.082 & 0.128 ID,AL	80009	376-0039-00
	213-0075-00			2		.SETSCREW:4-40 X 0.094,STL	74445	ORDER BY DESCR
-51	----- -----			1		CKT BOARD ASSY:MAIN(SEE A1 REPL)		
-52	----- -----			1		.TRANSISTOR:(SEE A1Q940 REPL)		
-53	210-1122-00			1		..WASHER,LOCK:0.12 ID,DISHED,0.025 THK,STL	86928	ORDER BY DESCR
-54	210-0910-00			1		..WASHER,FLAT:0.19 OD X 0.281 OD X 0.046	02107	S-47-11
-55	131-0604-00			36		.CONTACT,ELEC:CKT BD SM,SPR,CU BE	80009	131-0604-00
-56	136-0252-04	B010100	B030294	72		.SOCKET,PIN TERM:U/M 0.016-0.018 DIA PINS	22526	75060-007
	136-0252-04	B030295		56		.SOCKET,PIN TERM:U/M 0.016-0.018 DIA PINS	22526	75060-007
	136-0514-00	B030295	B058919	2		.SKT,PL-IN ELEK:MICROCIRCUIT,8 DIP	09922	DILB8P-108
-57	200-0687-01			1		.COVER,XSTR:TO-5,ACETAL	80009	200-0687-01
	131-0608-00			4		.TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
-58	136-0235-00			1		.SKT,PL-IN ELEK:TRANSISTOR,6 CONTACT	71785	133-96-12-062
-59	----- -----			1		.RESISTOR,VARIABLE:(SEE A1R467 REPL)		
						.(ATTACHING PARTS)		
-60	210-0583-00			1		.NUT,PLAIN,HEX:0.25-32 X 0.312,BRS CD PL	73743	2X-20319-402
-61	210-0046-00			1		.WASHER,LOCK:0.261 ID,INTL,0.018 THK,STL	77900	1214-05-00-0541C
-62	210-1025-00	B010100	B059999	2		.WASHER,FLAT:0.312 ID X 0.469 OD X 0.031,BR	12327	ORDER BY DESCR
						.S		
	210-0465-00	B060000		1		.NUT,PLAIN,HEX:0.25-32 X 0.375,BRS CD PL	73743	3095-402
						.(END ATTACHING PARTS)		
-63	407-1337-00			1		.BRACKET,VAR RES:STEEL	80009	407-1337-00
						.(ATTACHING PARTS)		
-64	211-0008-00			2		.SCREW,MACHINE:4-40 X 0.25,PNH,STL	93907	ORDER BY DESCR
-65	210-0551-00			2		.NUT,PLAIN,HEX:4-40 X 0.25,ST CD PL	TK0435	ORDER BY DESCR
						.(END ATTACHING PARTS)		
-66	337-1883-00			2		.SHIELD,ELEC:PUSHBUTTON,CTR	80009	337-1883-00
-67	----- -----			2		.SWITCH,PUSH:(SEE A1S10 AND A1S20 REPL)		
-68	361-0385-00	B010100	B052349	8		.SPACER,PB SW:0.164 L,GREEN POLYCARBONATE	80009	361-0385-00
	361-0384-00	B052350		8		.SPACER,PB SW:0.133 L,RED POLYCARBONATE	80009	361-0384-00
-69	----- -----			1		.SWITCH,PUSH:(SEE A1S30 REPL)		
-70	361-0383-00			2		.SPCR,PB SW:0.33 L,CHARCOAL,POLYCARBONATE	80009	361-0383-00
-71	344-0154-00			4		.CLIP,ELECTRICAL:FUSE,CKT BD MT	80009	344-0154-00
	198-2155-00			1		.WIRE SET,ELEC:	80009	198-2155-00
-72	175-0825-00			1		..CABLE,SP,ELEC:2,26 AWG,STRD,PVC JKT,RBN	80009	175-0825-00
-73	175-0826-00			1		..CABLE,SP,ELEC:3,26 AWG,STRD,PVC JKT,RBN	80009	175-0826-00
-74	131-0707-00			4		..CONTACT,ELEC:22-26 AWG,BRS,CU BE GLD PL	22526	47439-000
-75	352-0162-02			1		..HLDR,TERM CONN:4 WIRE,RED	80009	352-0162-02
-76	179-2028-00			1		.WIRING HARNESS:MAIN	80009	179-2028-00
	175-3112-00			1		.CABLE ASSY,RF:50 OHM COAX,0.958 L	80009	175-3112-00
-77	384-0173-00			1		EXTENSION SHAFT:6.438 L X 0.125 STEP OD,STL	80009	384-0173-00
-78	384-0348-01			1		EXTENSION SHAFT:9.161 L X 0.125 STEP OD	80009	384-0348-01
	263-1004-00			1		SW CAM ACTR AS:LF-30B POINT	80009	263-1004-00
						(ATTACHING PARTS)		
-79	211-0116-00	B010100	B057469	4		SCR,ASSEM WSHR:4-40 X 0.312,PNH,BRS,NP	77900	ORDER BY DESCR
	211-0292-00	B057470		4		SCR,ASSEM WSHR:4-40 X 0.29,PNH,BRS NI PL	78189	51-040445-01

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-					(END ATTACHING PARTS)		
-80	200-1598-00			1	.COVER,CAM SM:16 ELEMENTS	80009	200-1598-00
-81	354-0219-00			1	.RING,RETAINING:EXT,CRESCENT,U/O 0.25 DIA	79136	5103-25-S-ZO-R
-82	401-0155-00			1	.BEARING,CAM SM:FRONT,0.454 DIA CAM	80009	401-0155-00
-83	131-0840-00			1	.CONTACT,ELEC:GROUNDING,NI BE	80009	131-0840-00
-84	214-1704-01			2	.SPRING,FLAT:0.52 X 0.125 X 0.008,CU BE	80009	214-1704-01
-85	214-1127-00			2	.ROLLER,DETENT:0.125 DIA X 0.125,SST	80009	214-1127-00
-86	105-0498-00			1	.ACTUATOR,CAM SM:LF-3DB	80009	105-0498-00
-87	401-0156-00			1	.BEARING,CAM SM:REAR,0.454 DIA CAM	80009	401-0156-00
-88	210-0406-00			4	.NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
	213-0075-00			2	.SETSCREW:4-40 X 0.094,STL	74445	ORDER BY DESCR
	263-1003-00			1	SM CAM ACTR AS:HF-3DB POINT	80009	263-1003-00
					(ATTACHING PARTS)		
-89	211-0116-00			4	SCR,ASSEM WSHR:4-40 X 0.312,PNH,BRS,NP	77900	ORDER BY DESCR
					(END ATTACHING PARTS)		
-90	200-1597-00			1	.COVER,CAM SM:10 ELEMENTS	80009	200-1597-00
-91	354-0219-00			1	.RING,RETAINING:EXT,CRESCENT,U/O 0.25 DIA	79136	5103-25-S-ZO-R
-92	401-0155-00			1	.BEARING,CAM SM:FRONT,0.454 DIA CAM	80009	401-0155-00
-93	131-1248-00			1	.CONTACT,ELEC:SHAFT GND,NI BE	80009	131-1248-00
-94	214-1704-00			1	.SPRING,FLAT:0.52 X 0.125 X 0.006,CU BE	80009	214-1704-00
-95	214-1704-01			1	.SPRING,FLAT:0.52 X 0.125 X 0.008,CU BE	80009	214-1704-01
-96	214-1127-00			2	.ROLLER,DETENT:0.125 DIA X 0.125,SST	80009	214-1127-00
-97	105-0502-00			1	.ACTUATOR,CAM SM:HF-3DB	80009	105-0502-00
-98	401-0156-00			1	.BEARING,CAM SM:REAR,0.454 DIA CAM	80009	401-0156-00
-99	210-0406-00			4	.NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
	213-0075-00			2	.SETSCREW:4-40 X 0.094,STL	74445	ORDER BY DESCR
	263-1005-00			1	SM CAM ACTR AS:GAIN	80009	263-1005-00
					(ATTACHING PARTS)		
-100	211-0116-00			4	SCR,ASSEM WSHR:4-40 X 0.312,PNH,BRS,NP	77900	ORDER BY DESCR
					(END ATTACHING PARTS)		
-101	200-1596-00			1	.COVER,CAM SM:10 ELEMENTS	80009	200-1596-00
					.(ATTACHING PARTS)		
-102	211-0008-00			4	.SCREW,MACHINE:4-40 X 0.25,PNH,STL	93907	ORDER BY DESCR
-103	210-0004-00			4	.WASHER,LOCK:#4 INTL,0.015 THK,STL	77900	1204-00-00-0541C
-104	210-0406-00			3	.NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
-105	131-0963-00			1	.CONTACT,ELEC:GROUNDING,PH BRZ,W/BRACKET	TK0507	ORDER BY DESCR
					.(END ATTACHING PARTS)		
-106	354-0391-00			1	.RING,RETAINING:EXT,U/O 0.438 DIA SFT	80009	354-0391-00
-107	401-0081-02			1	.BEARING,CAM SM:FRONT W/O MOUNTING BOSSES	80009	401-0081-02
-108	214-1139-03			1	.SPRING,FLAT:0.885 X 0.156 CU BE RED CLR	80009	214-1139-03
-109	214-1139-02			1	.SPRING,FLAT:0.885 X 0.156 CU BE GRN CLR	80009	214-1139-02
-110	214-1127-00			2	.ROLLER,DETENT:0.125 DIA X 0.125,SST	80009	214-1127-00
-111	105-0503-00			1	.ACTUATOR,CAM SM:GAIN	80009	105-0503-00
-112	401-0115-00			1	.BEARING,CAM SM:CNTR,0.83 DIA CAM,08L BD	80009	401-0115-00
	210-0406-00			3	.NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
	131-0963-00			1	.CONTACT,ELEC:GROUNDING,PH BRZ,W/BRACKET	TK0507	ORDER BY DESCR
-113	384-1220-00			1	EXTENSION SHAFT:8.038 L X 0.125 OD,AL	80009	384-1220-00
-114	376-0029-00	B010100	B059999	1	CPLG,SHAFT,RGD:0.128 ID X 0.312 OD,AL	80009	376-0029-00
	376-0051-00	B060000	B070609	1	CPLG,SHAFT,FLEX:0.127 ID X 0.375 OD	80009	376-0051-00
	376-0051-01	B070610		1	CPLG,SHAFT,FLEX:0.127 ID X 0.375 OD	80009	376-0051-01
	213-0075-00			2	.SETSCREW:4-40 X 0.094,STL	74445	ORDER BY DESCR
-115	----- -----			1	RESISTOR,VARIABLE:(SEE R178/S178 REPL)		
					(ATTACHING PARTS)		
-116	210-0583-00			1	NUT,PLAIN,HEX:0.25-32 X 0.312,BRS CD PL	73743	2X-20319-402
-117	210-0046-00			2	WASHER,LOCK:0.261 ID,INTL,0.018 THK,STL	77900	1214-05-00-0541C
-118	407-0803-00			1	BRACKET,ELEC SM:BRASS	80009	407-0803-00
					(END ATTACHING PARTS)		
					STANDARD ACCESSORIES		
	070-1582-01			1	MANUAL,TECH:INSTRUCTION	80009	070-1582-01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RE

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.

Tektronix
COMMITTED TO EXCELLENCE

MANUAL CHANGE INFORMATION

Date: Feb 23, 1989 Change Reference: M68883

Product: AM 502 Differential Amplifier Manual Part No: 070-1582-01

DESCRIPTION

For Serial Numbers B073418 and above, please make the following changes:

Section 7

REPLACEABLE ELECTRICAL PARTS

Change:

Page 7-3

A1	670-2733-09	Circuit Bd Assy:Main

Page 7-5

Q152	151-0261-00	Transistor:PNP,SI TO-77
Q164	151-0261-00	Transistor:PNP,SI TO-77
Q410	151-0261-00	Transistor:PNP,SI TO-77