BOONTON

BOONTON ELECTRONICS CORPORATION

TM-09464A-14 & P

MODEL 8210-01-S/3

NSN 6625-01-284-5256

TAM # A7054

CONTRACT: N00104-88-D-D056

INSTRUCTION MANUAL

MODEL 8210-01-S/3

F.M.-A.M. MODULATION METER

N00104-88-D-D058

N00104-91-D-M090

7Z 6625-01-284-8256

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Part No. 984003-1
Printed In U.S.A.

SAFETY SUMMARY

The following general safety prccilutirms must be observed during all phases of operation and maintenance of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Boonton Electronics assumes no liability for the customer's failure to comply with these requirements.

THE INSTRUMENT MUST BE GROUNDED

To minimize shock hazard the instrument chasis and cabinet must be connected to an electrical ground. The instrument is quipped with a three conductor, three prong a.c. power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to a two-contact adapter with the (green) grounding wire firmly connected to an electrical ground at the power outlet.

DO NOT OPERATE THE INSTRUMENT IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with the power cable connected. Under certain conditions dangerous voltage may exist even though the power cable was removed, therefore; always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitiation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Do not install substitute parts or perform any unauthorized modification of the instrument. Return the instrument to Boonton Electronics for repair to ensure the safety features are maintained.

SAFETY SYMBOLS.

This safety requirements symbol (located on the rear panel) has been adopted by the International Elcctrotechnical Commission. Document 66 (Central Office) 3. Paragraph 5.3. which directs that and instrumnet be so labeled if for the correct use of the instrument. it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source. Verify that the correct fuse is installed for the power available, and that the switch on the rear panel is set to the applicable operating voltage.

The CAUTION sign denotes a hazard. It calls attention to an operatition procedure. practice, or the like, which, it not correctly performed or adhered to could result in damage to or destruction of part or all of the equipment. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

The WARNING sign denotes a hazard. It calls attention to an operation procedures. practice, or the like, which, if not correctly performed or adhered to could result in injury or loss of life. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

Indicates dangerous voltages.

BOONTON ELECTRONICS CORPORATION

Instruction-Manual SUPPLEMENT: MODEL 8210-01-S/3

Instruction -manual supplements are issued as required to correct errors in a manual, and to adapt the manual to changes made after its printing.

Page 1-1, Para. 1-2. b.
replace "Each time it is turned on, . . ."with

"When the LEVEL key is depressed at power on, . .."

Page 1-4, Para. 1-6 continued.
add after the WEIGHT specification,

"Recommended Calibration Internal: 12 Months."

Page 2-4, Para. 2-3. a.
before the period after "position"

add "and depress the LEVEL key"

Page 2-8, Para. 2-5. a. (1)
after the word "measured"

add "Note: If a calibration cycle is desired, depress the LEVEL key while the firmware date is displayed."

Page 2-8, Para. 2-5. a. (2)
delete the text, "After the 8210 has completed its calibration cycle," and Capitalize the word "select".

Page 2-5, Para. 2-5 c.
after 'The LEVEL pushbutton serves another purpose."

add "If a calibration operation is desired, depress the LEVEL key while the firmware date is displayed at power on."

Page 3-2, Para. 3-2 c.
delete the words "which are activated when the 8210 is turned on"

Page 3-10, Para. 3-3 e.
before the word "RAM" add "non-volatile"

Page 3-13, Para. 3-3 e
add sub-paragraph (8)

"Non-volatile operation of A4U13 is controlled byU31. This circuit switches the Vcc connection of A4U13 from the + 5L supply to the battery supply, BT1 and BT2, when the + 5L supply falls below the battery voltage. Additionally, U31 inhibits the chip enable signal at pin 18 of A4U13 when the + 5L supply drops below 4.75 volts. This action insures that the RAM contents will not change when power is removed."

Page 4-20, Table 4-9
before step 1) add,

Procedure	Indication	Indication is abnormal
Connect 'scope to Pin 16 of A4U8.	TTL high	Replace A4U13.
Connect 'scope to pin 2 of U31.	Voltage greater than 2.2 volts dc.	Replace BT1 and Bt2.
Compare signals on pins 5 and 6 of U31.	Same signal.	Replace U31.

Page 5-9, Table 5-2
Before Item Cl

add Item BT1-Battery, alkaline, 1.5 volts-54473;P146ND-55601100A

add Item BT2-Battery, alkaline, 1.5 volts-54473;P146ND-55601100A

Page 5-11, Table 5-2
after Item U29

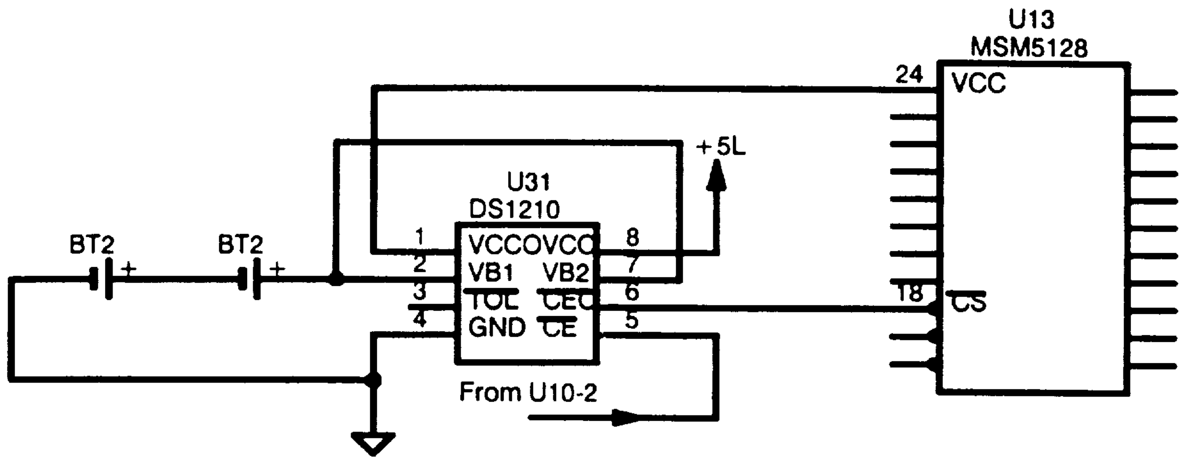
add Item U31-IC DS1210 controller-0B0A9;DS1210-53514300A

change Item U11-IC EProm PROG.-04901-53444300B

add Item XBTl,2-Socket Battery-FSCN-BH2AAA-W-48331700A

Page 5-12, Table 5-2
Change Item T1 from part number 446093 to 446101

Page 6-9,10, Figure 6-5
modify schematic as follows:



Page 6-13,14 Figure 6-7
modify schematic as follows:

change voltage at C26 from 8.7V to 9.7V

change voltage at C27 from 20V to 22V

change voltage at C25 from -20V to -22V

Figure 1-1. Model 8210 F.M.-A.M. Modulation Meter

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SECTION I

GENERAL INFORMATION

1-1. SAFETY NOTICE

The Model 8210 is furnished with a three-conductor power cable and three-prong plug so that, when the plug is inserted in a properly polarized a.c. power receptacle, the instrument is grounded. The instrument depends upon such connection to ground for equipment and operator safety.

***** WARNING *****

> To avoid the possibility of electrical shock, before anything is connected to this instrument, and before you use this instrument, make certain that its power cable is plugged into a mating a.c. receptacle that has a grounded ("earthed") contact.

Never defeat the instrument's protective grounding. For example: Do not use an extension power cable if it is not equipped with a ground conductor; do not plug the instrument into an a.c. receptacle that does not provide a high-quality earth ground. If only a two-terminal a.c. power receptacle is available, use a three-prong-to-two-prong adapter and connect the ground wire of the adapter to the power-receptacle ground. Do not use such an adapter if the ground wire cannot be grounded.

1-2. DESCRIPTION

The Model 8210 Modulation Meter, manufactured by Boonton Electronics Corp., is a versatile, solid-state instrument that measures and displays the deviation of frequency-modulated signals or the percentage modulation of amplitude-modulated signals over a carrier range of 2 MHz to 1.5 GHz. Both the a.m. and f.m. detectors of the 8210 are true peak-responding at all levels. Thus they conform to the basic definition of modulation depth or deviation. In addition, because the detectors are true peak-responding, the effect of any system noise will be accurately included in the measured value. Among the features of the Model 8210 are:

a. Fully Automatic Tuning and Leveling. The Model 8210 will automatically acquire the largest signal present at the input connector and adjust its local oscillator, and the gain of its measurement channel, to provide a fully calibrated display of amplitude modulation or frequency modulation.

b. Internal Calibration. Each time it is turned on, the 8210 calibrates both its a.m. and its f.m. detector.

c. Digital Display. The 8210 presents recovered modulation on a 3-1/2 digit. display, providing exceptional resolution and accuracy for modulation measurements.

d. Pushbutton operation. Selection of all operational parameters is made by means of pushbuttons, thus allowing fast measurement setup.

e. Low Residual Modulation. The 8210's exceptionally low residual modulation permits accurate measurements of low-noise sources. Direct residual measurements are possible if an external r.m.s. detector is used.

The Model 8210 is intended for both laboratory and field application. It will also be especially useful in the design of, and for production-line and field-testing of, f.m. and a.m. transmitters and signal generators.

1-3. ITEMS FURNISHED

The instrument is supplied complete with power cord. For making measurements the connection of various cables will be called for, depending upon the operating mode of the 8210. Required cable connections are discussed in paragraph 2.1d.

1-4. OPTIONS AND ACCESSORIES

Option -01: with this option, the 15 kHz low-pass filter is replaced by a 30 kHz low-pass filter. See Specifications, below, for details.

Accessory 950027: This is a rack-mounting kit (not supplied as standard), for mounting a single 8210 to left or right of center.

1-5. ENVIRONMENTAL DATA, OPERATING AND STORAGE

Temperature: Operating, 0 to +55°C
Storage, -55°C to +75°C

1-6. SPECIFICATIONS

R.F. INPUT:

Carrier-Frequency Range	2 MHz to 1.5 GHz
Tuning	Automatic
Sensitivity	10 mV, r.m.s., 2 MHz to 520 MHz 30 mV, r.m.s., 520 MHz to 1.5 GHz
Level Set	Automatic for levels up to 1 V
Maximum Safe Input	7 v, r.m.s.
Input Impedance	50 ohms, nominal

FREQUENCY MODULATION:

Maximum Deviation	150 kHz, peak
Deviation Ranges	10 and 100 kHz, full scale
Deviation Accuracy	1% of reading for modulation frequencies between 50 Hz and 5 kHz. 2% of reading, 5 kHz to 7.5 kHz. NOTE: Peak residuals must be accounted for to obtain the above accuracies.
Modulation Bandwidth	<30 Hz to 15 kHz
Residual F.M. (R.F. Level >100 mV)	with 3 kHz low-pass filter: <150 Hz, r.m.s., at 1.5 GHz, decreasing linearly to a floor of <5 Hz, r.m.s. With 15 kHz low-pass filter: <200 Hz, r.m.s., at 1.5 GHz, decreasing linearly to a floor of <15 Hz, r.m.s.
A.M. Rejection	<100 Hz deviation at 50% a.m. (modulation frequency < 1 kHz) 3 kHz low-pass filter.

S1-6, Continued.

AMPLITUDE MODULATION

Modulation-Depth Ranges: 10% and 100%, full scale

Depth Accuracy:

Modulation Frequency	Accuracy	
	10% to 90% A.M.	<10% & >90% A.M.
50 Hz to 5 kHz	1% of reading	3% of reading
5 kHz to 7.5 kHz	2% of reading	6% of reading

NOTE: Peak residuals must be accounted for to obtain the above accuracies. Carrier frequency <520 MHz; r.f. level between -10 and +10 dBm.

Modulation Bandwidth: <30 Hz to 15 kHz.

Residual A.M.: With 3 kHz low-pass filter: Less than 0.15% a.m., r.m.s., for input levels above 100 mV, r.m.s.

With 15 kHz low-pass filter: Less than 0.25% a.m., r.m.s., for input levels above 100 mV, r.m.s.

NOTE: Carrier frequency <520 MHz; above 520 MHz residuals increase linearly with frequency.

F.M. Rejection: Less than 1.0% a.m. ,peak, at 100 kHz peak modulation.

AUDIO-FREQUENCY RESPONSE

Filters: 3 kHz low-pass, 15 kHz low-pass, & 750 us de-emphasis; corner accuracy is ± 4%. Jumper selects de-emphasis either before or after the display.

Audio Distortion: Less than 0.25% t.h.d., for 75 kHz peak deviation. <0.5% t.h.d., for 90% a.m.

Output Level: F.M.: 1 v, r.m.s., approx. , into 600 ohms at 1000 counts on the display.

A.M.: 1 V to 1.2 V, r.m.s.

DISPLAY

Modulation: LED display; 1000 counts plus 50% over-range; true peak, positive peak, negative peak, or peak-average indications.

Annunciators: Display of settings of mode switch and of filter. Digital display indicates level-high, level-low and unlocked conditions.

I.F. OUTPUT

Frequency: 400 kHz, nominal.

Level: 300 to 360 mV, approx. , into 600 ohm load

POWER REQUIREMENTS

100, 120, 220, or 240 volts, a.c., 50 to 400 Hz; 24 VA.

DIMENSIONS — 103 mm high x 218 wide x 278 deep (4.1 in. x 8.6 x 11.0)

WEIGHT — 3.18 kg (7.0 lbs.), approximately.

OPTIONAL MODEL 8210-01

This model is the same as the standard Model 8210 except as follows:

AUDIO-FREQUENCY RESPONSE

Filters — The 15 kHz low-pass filter is replaced by a 30 kHz low-pass filter; corner accuracy is ± 4%.

FREQUENCY MODULATION

Deviation Accuracy — 1% of reading for modulation frequencies between 50 Hz and 10 kHz.

2% of reading, 10 kHz to 15 kHz.

Modulation Bandwidth — <30 Hz to 30 kHz

Residual F.M. (R.F. Level >100 mV) — with 30 kHz low-pass filter: <400 Hz, r.m.s., at 1.5 GHz, decreasing linearly to a floor of <25 Hz, r.m.s.

With 3 kHz low-pass filter: <150 Hz, r.m.s,, at 1.5 GHz, decreasing linearly to a floor of <5 Hz, r.m.s.

AMPLITUDE MODULATION

Depth Accuracy

Modulation Frequency	Accuracy: 10% to 90% A.M.	Accuracy: <10% & >90% A.M.
50 Hz to 10 kHz	1% of reading	3% of reading
10 kHz to 15 kHz	2% of reading	6% of reading

NOTE: Peak residuals must be accounted for to obtain the above accuracies.

Carrier frequency <520 MHz; r.f. level between -10 and +10 dBm.

Modulation Bandwidth — <30 Hz to 30 kHz.

Residual A.M. — With 30 kHz low-pass filter: Less than 0.35% a.m., r.m.s., for input levels above 100 mV, r.m.s.

With 3 kHz low-pass filter: Less than 0.15% a.m., r.m.s., for input levels above 100 mV, r.m.s.

NOTE : Carrier frequency <520 MHz; above 520 MHz residuals increase linearly with frequency.

SECTION II

INSTALLATION & OPERATION

2-1. INSTALLATION

a. Unpacking. The 8210 is shipped complete and ready for use. Unpack the equipment from the shipping container and inspect it for any damage that may have occured during shipment. Check that all connectors and switches operate without binding.

NOTE: Save the packing material and container for possible use in reshipment of the 8210. See Figure 2-10 (p. 2-14) for the repacking method.

b. Mounting. For bench mounting, choose a clean, sturdy and uncluttered mounting surface. For rack mounting, an accessory package (Model Number 950027) is available; it consists of two angle-mounting brackets, two flat plates, four binder-head screws, and four lockwashers. To rack mount an 8210, proceed as follows:

(1) The 8210 has one extrusion at each end of the front panel. On the outside surfaces of these extrusions, where they join the cabinet, are two strips of green pressure-sensitive tape. Remove or perforate these tape strips to expose the tapped mounting holes for the rack-mounting brackets.

(2) Refer to the drawing in the accessory's package for the proper orientation of the two mounting brackets.

(3) Mount the 8210 in the rack with standard rack-mounting screws through the slotted holes in the angle brackets.

NOTE: If necessary, the feet and tilt bail may be removed from the cover in order to clear any adjacent rack-mounted units.

c. Power Requirements. The 8210 can be operated on a.c. power sources of 100, 120, 220 or 240 volts, 50 to 400 Hz, single phase. The power required is 24 VA at 120 or 240 volts, a.c.

CAUTION

Before connecting the 8210 to an a.c. power source, see that the voltage-selector switches on the rear panel are set for the available line voltage and that a fuse of the proper rating is in the instrument's fuse holder: 0.25 A for 100 or 120 V; 0.125 A for 220 or 240 V -- either fuse to he type MDL Slo-Blo.

d. Cable Connecting. Depending on the operating mode of the 8210,various cables will have to be connected to it; these cables are not supplied with the instrument. Connections that may be required are:

(1) R.F. Input. The RF IN connector of the 8210 is a type BNC. The input impedance is 50 ohms, nominal.

(2) I.F. Output. The 8210's if. output is available at the front-panel BNC marked IF OUT. The level varies between 300 and 360 mV, r.m.s.; the source impedance is 600 ohms, nominal.

(3) A.F. Output. The recovered audio signal appears at the front-panel BNC connector labeled AF OUT. For f.m., the level is approximately 1 volt, r.m.s., into 600 ohms at 1000 counts on the digital display. For a.m., the level is 1 to 1.2 volts.

2-2. OPERATING CONTROLS, INDICATORS AND CONNECTORS

All controls, indicators and connectors used during operation of the 8210 are shown in Figures 2-1 and 2-2. They are described in Table 2-1, below.

Table 2-1. operating Controls, Indicators, and Connectors

ITEM	FIGURE	INDEX NO.	FUNCTION
FILTER switches	2-1	1	Select low-pass or de-emphasis filters.
PEAK switches	"	2	Select display of + peak, - peak or peak average.
FUNCTION switches	"	3	Select AM, FM or LEVEL display functions.
RANGE switches	"	4	Select desired full-scale modulation range.
LED display	"	5	Indicates modulation or i.f. level--as determined by the FUNCTION switch setting.
LINE switch	"	6	Turns line power on and off.
RF IN connector	"	7	Input signal connection point.
IF OUT connector	"	8	Allows connection of 8210's i.f. signal to external circuits.
AF OUT connector	"	9	Allows connection of 8210's recovered audio signal to external circuits.
Power connector	2-2	1	Input connector for a.c. power cable.
Line-voltage switches	"	2	Permit selection of appropriate a.c. operating voltage.
Fuse holder	"	3	Contains replaceable line fuse.

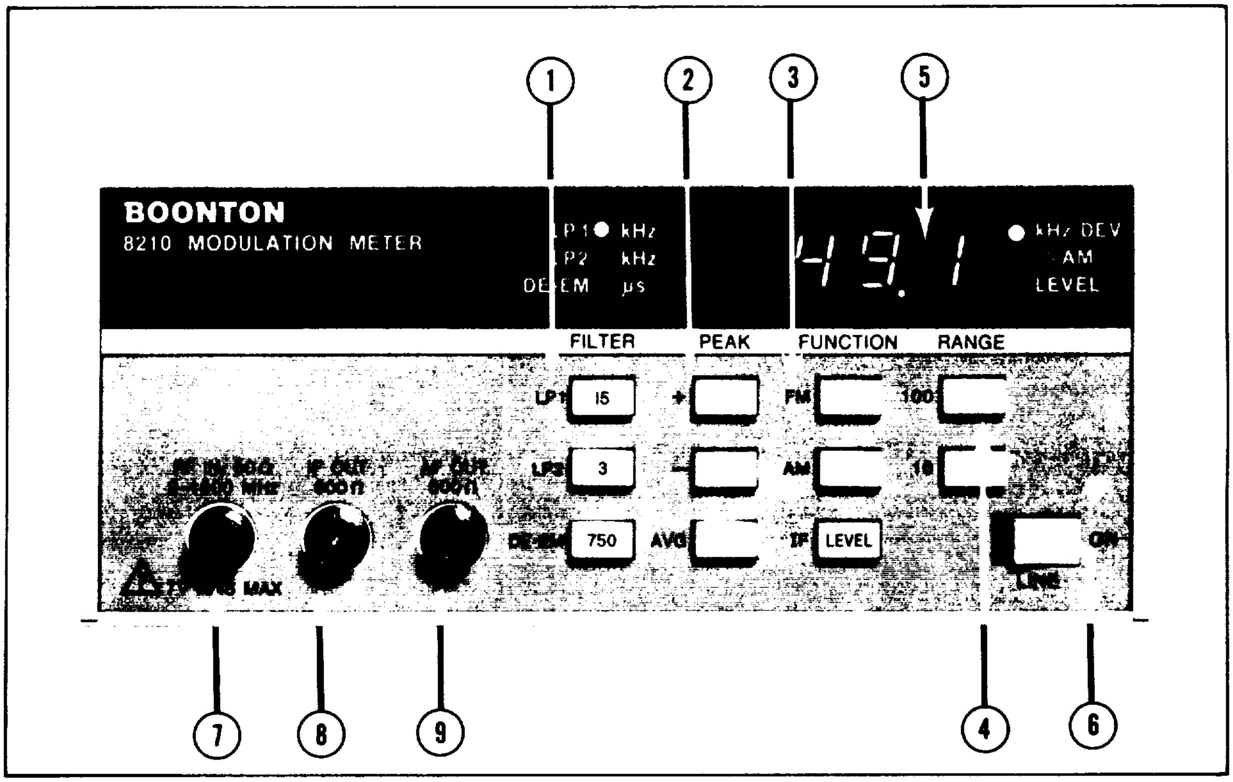


Figure 2-1. Model 8210, Front View

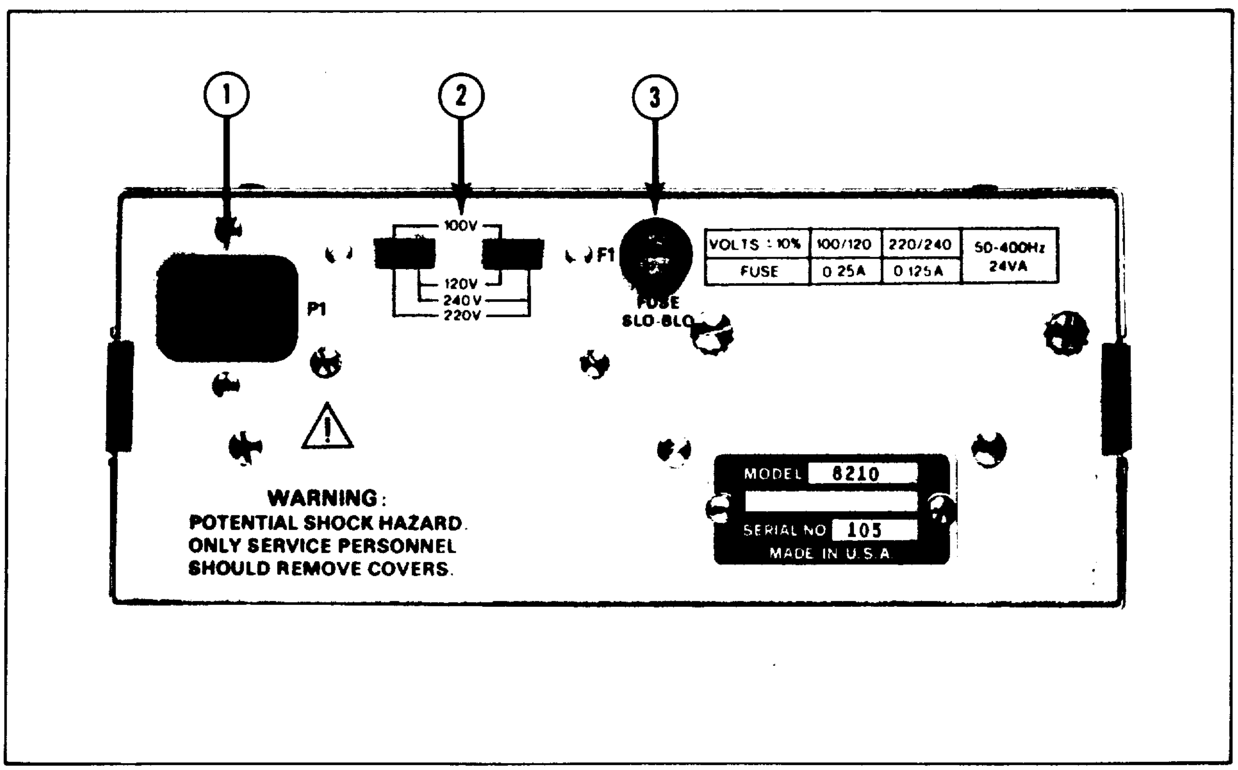


Figure 2-2. Model 8210, Rear View

2-3. PRELIMINARY CHECK

NOTE: The following preliminary check procedure is intended only to ensure that all circuits are operating. If a detailed performance check against specifications is desired, refer to subsection 2-6.

Before using the Model 8210, perform a preliminary check as follows:

a. Set the LINE switch to the "on" position. The LED display should indicate "CAL," which means that the calibration sequence has begun. After about 30 seconds, a series of dashes should appear on the LED display, indicating an unlocked condition.

b. Apply a 100 mV (r.m.s.) unmodulated test signal, at a frequency between 2 and 520 MHz, to the RF IN connector of the 8210. The LED display on the 8210 should now indicate residual modulation. Note that two dashes on the LED indicate that the 8210 is executing an a.g.c. cycle.

c. Reduce the test signal to 5 mV. The display should indicate "IFLO."

d. Increase the test signal to 1.5 V. The display now should read "IFHI."

e. Decrease the test signal to approximately 0 dBm. The display should read as in Step (b).

f. In turn, depress the three FILTER switches, and see that the associated annunciators indicate the switch selection correctly.

g. Repeat Step (f) for the FUNCTION switches.

h. Depress in turn the three PEAK switches. A plus sign (+) will be shown for the + PEAK switch, a minus sign (-) for the - PEAK, and no sign when the AVG switch is depressed.

i. Depress in turn the RANGE switches. The decimal-point indication of the display should move to left or right as each switch is depressed.

j. Connect an oscilloscope to the 8210's IF OUT connector. Set the scope so that it displays the 400 kHz if. signal of the 8210.

k. Modulate the test signal with approximately 50% a.m. Depress the AM FUNCTION switch, the 100 RANGE switch, and the 15 kHz FILTER switch. The display should indicate approximately 50% a.m.

l. Remove the amplitude modulation, and frequency-modulate the test signal with approximately 50 kHz peak deviation. Depress the FM FUNCTION switch. The display should indicate approximately 50 kHz deviation.

2-4. APPLICATION NOTES

The following paragraphs describe some typical applications for the Model 8210. The use of the 8210 is not restricted to these applications, however.

a. <u>F.M. Measurements</u> . High-accuracy f.m. measurements are possible with the 8210 for modulating frequencies from less than 30 Hz to 15 kHz, and deviations up to 300 kHz p-p. To achieve maximum accuracy, the signal level applied to the RF IN connector should be greater than 100 mV, r.m.s. Such signal levels reduce residual f.m. in the 8210 to a minimum value. To further reduce residuals, the minimum measurement-bandwidth consistent with the modulation frequency should be used. For instance: for measurements at a 400 Hz modulation rate, the 3 kHz low-pass filter should be used.

Typical residuals for the 8210 are plotted in Figures 2-3 and 2-4; audio response curves are plotted in Figure 2-5. Because the audio detectors in the 8210 are true peak-responding, the residual noise is added to the recovered signal being measured. Peak-detector response to a signal plus

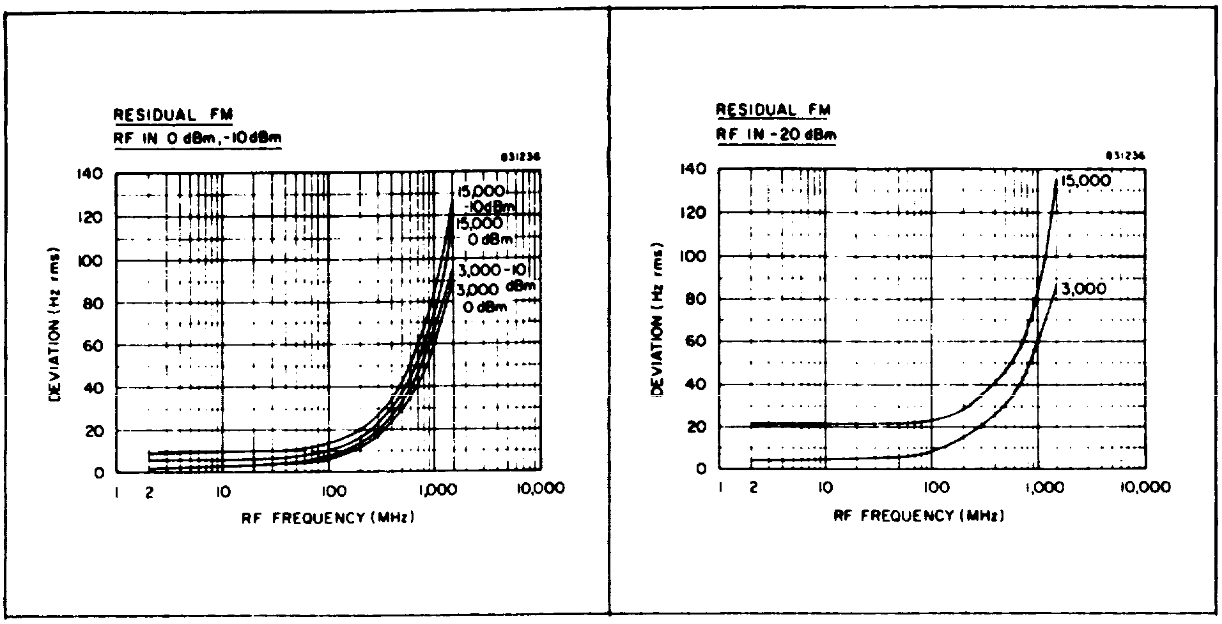


Figure 2-3. Residual P. M., Typical

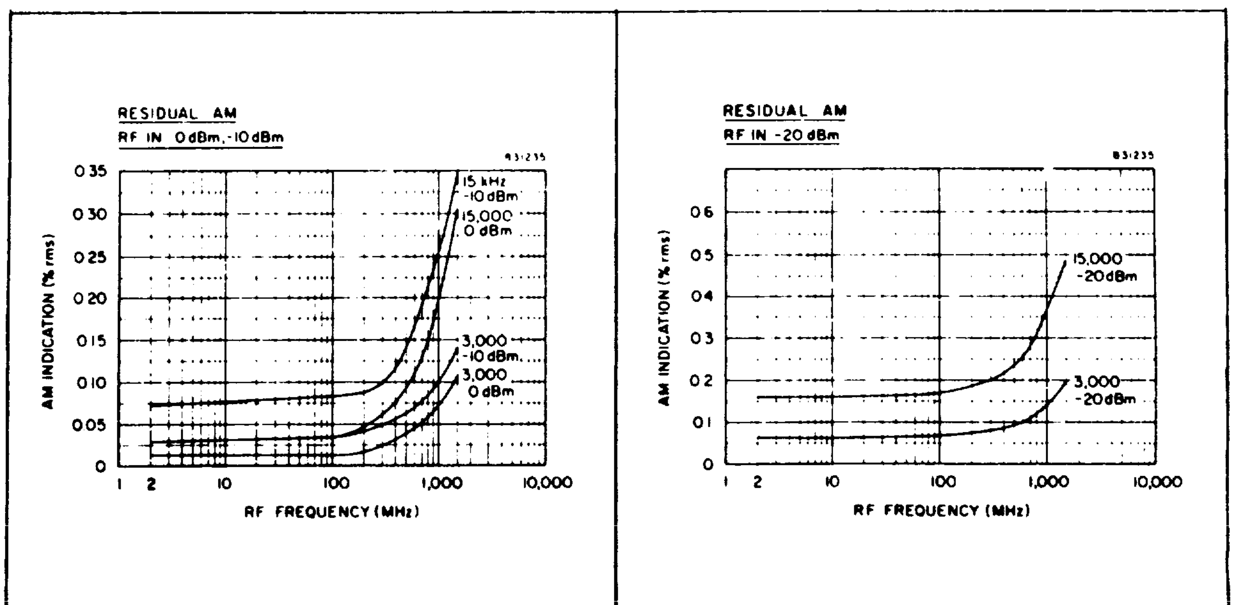


Figure 2-4. Residual A. M., Typical

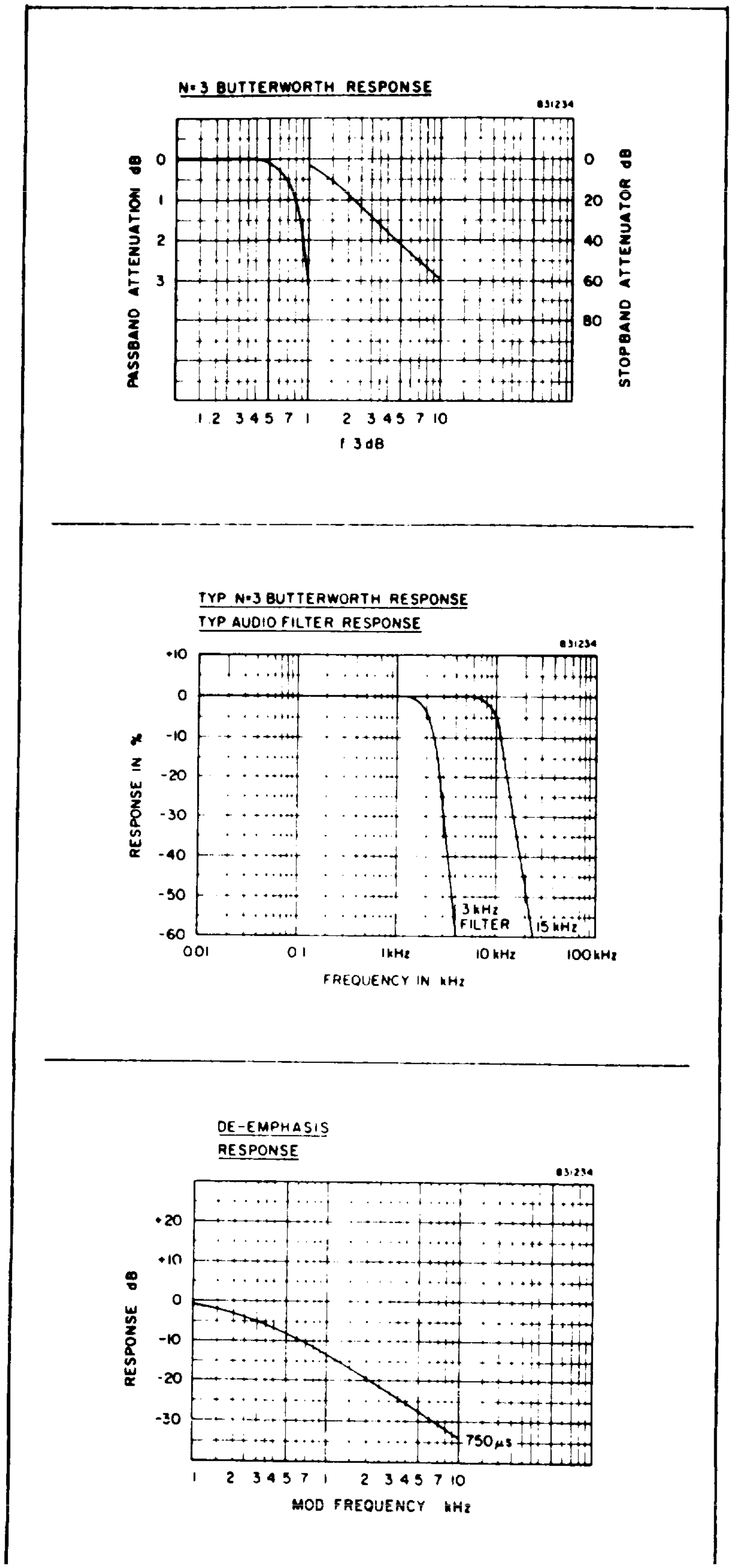


Figure **2-5**. Audio Response, Typical

noise is not linear, and is a function of the carrier-to-noise ratio and the modulation waveshape. In most measurement situations involving sinusoidal modulation, noise suppression is approximately 30%.

For example, if the peak residual indicated without modulation is 100 Hz, and 10 kHz deviation is added, the resulting display would be 10.07. (Since the 0.7 multiplier is an approximate value, there will be variation. However, the use of that figure guarantees that the resulting display will always be within specification.) The assumption made is that the noise is gaussian and that the carrier-to-noise ratio exceeds 20 dB.

True r.m.s. measurements of the recovered audio signal will provide a more precise indication of modulation in the presence of large amounts of noise.

b. A.M. Measurements. The 8210 makes possible fast, accurate indications of amplitude modulation. Optimum accuracy is achieved with input signal levels between -10 and +10 dBm (for lowest residuals), and the minimum bandwidth consistent with the modulation frequency. As discussed above for f.m., noise suppression does occur, and the 0.7 multiplier is used to subtract added noise.

c. Spurious Responses. Most frequency- translating devices rely on a non-linear circuit element to produce the multiplication required for frequency translation. This non-linearity produces spurious mixing products, which tend to “cross over” the desired if. and change its character. In contrast, the 8210 converts frequency by using a sampler, which is very linear and which produces few spurious responses in the usual sense.

There are, however, a few points to remember when applying a sampling instrument like the 8210. If the input signal contains significant harmonic power above the third harmonic, an if. beat can occur and thus produce unwanted a.m. and f.m. indications.

Signals that are not harmonically related can interfere if, when they are mixed with any local-oscillator harmonic, the resulting sum frequency or difference frequency appears near the 8210’s intermediate frequency.

EXAMPLE: Assume two input signals--the larger at 100 MHz, the smaller at 501.6 MHz. The local oscillator might be at 2.51 MHz so that its 40th harmonic (100.4 MHz), when mixed with the 100 MHz signal, produces a 400 kHz if. However, the 200th harmonic of 2.51 MHz is 502 MHz--which converts the 501.6 MHz carrier to 400 kHz also. Since the two signals are not phase coherent, a low-frequency beat will occur at the i.f. and produce spurious a.m. and f.m. indications. The offending input signal should be filtered in order to eliminate this interference.

d. Additional Applications. Information relevant to further applications of the 8210 will be found in Boonton Electronics’ Application Note $19:

High Accuracy AM-FM Measurements

with the Boonton 82AD Modulation Meter.

The Application Note is available free upon request to Boonton Electronics.

inquiries regarding application of the 8210 to specific customer requirements are invited. Please direct any such inquiries to the Applications Engineering Department of Boonton Electronics Corporation.

2-5. OPERATING INSTRUCTIONS

The operation of The Model 8210 is essentially automatic, requiring only that the operator select the proper display function and baseband filter. Paragraphs 2-5a and 2-5b summarize operating steps for a.m. and f.m. measurements, respectively.

a. A.M. Measurements.

(11 Set the LINE switch to ON, and connect to the RF IN connector the r.f. signal that is to be measured.

(2) After the 8210 has completed its calibration cycle, select the desired measurement bandwith. Use the minimum bandwidth consistent with the modulation frequency.

(3) Depress the appropriate PEAK switch, as determined by the amplitude modulation measurement to be made.

(4) Depress the AM FUNCTION switch and the 100 RANGE switch.

(5) Read the percentage of a.m. modulation from the LED display. The 10 RANGE may be selected if the modulation is less than 15%.

b. F.M. Measurements. Operation of the Model 8210 for f.m. measurements is basically the same as for a.m., except for the selection of Function and Filter. For f.m. measurements, depress the FM FUNCTION switch and the appropriate RANGE and PEAK switches.

Either a low-pass filter or the 750 µs de-emphasis filter may be selected for the measurement. The de-emphasis filter may be placed before or after the modulation display, according to an internal jumper selection. Units shipped from the factory are normally wired for de-emphasis before the display.

c. Level Function. The “Level” function is included in the Model 8210 to indicate the relatlve a.m.-detector operating point; it is required only when an external indicator is used for making an a.m. measurement. When the 8210 is operating properly, depressing LEVEL should always result in a number between 0.95 and 11.5 on its digital display. If the reading on the external indicator is now multiplied by 10.00, then divided by the Level indication, the external indicator will be properly scaled.

The LEVEL pushbuton serves another purpose. If a malfunction occurs during calibration, a condition code (the letters cc, followed by a number), will appear on the digital display. It means that proper calibration could not be accomplished. (Refer to Section IV for the meaning of each condition code.) Depressing the LEVEL pushbutton releases the error condition, and measurements can be made. Note, however, that the detector that malfunctioned will not be properly calibrated.

In addition, the LEVEL button is utilized in several of the test routines provided for troubleshooting the 8210. These routines are described in detail in Section IV.

2-6. PERFORMANCE VERIFICATION

The following tests may be performed when the Model 8200 is first received. Thereafter, performance verification should be needed only after repair to the instrument.

NOTE: In these verification procedures, some settings or results are followed by data in parentheses. These parenthetical entries apply to instruments with the -01 Option installed

a. Test Equipment Required. Table 2-2 lists all test equipment required for verification of performance of the 8210. Other models of test equipment that meet or exceed the Critical Specifications may be used instead.

Table 2-2. Recommended Test Equipment for Performance Verification

EQUIPMENT	CRITICAL SPECIFICATIONS	SUGGESTED MODEL
Signal Generator	A.M.-F.M., 0.01 to 520 MHz, -30 to +10 dBm level. T.H.D. <0.05% at 75 kHz deviation at 100 MHz	Boonton Electronics 102E-19
Signal Generator	C.W., 1.5 GHz, -30 to +7 dBm	Hewlett-Packard 8660C & 86603A
Crystal-Controlled Source or Synthesizer	< 3 Hz residual f.m. at 500 MHz in 15 kHz bandwidth	Ailtech 460
Voltmeter	True r.m.s., 10 mV full-scale sensitivity, 100 kHz bandwidth	Boonton Electronics 93AD
Double-Balanced Mixer	+7 dBm, l.o. Range of l.o. & r.f.: 0.5 - 500 MHz	Mini-Circuits ZAD-1
Audio Oscillator	Range: 20 Hz - 20 kHz < 0.1% t.h.d.	Hewlett-Packard 204C
Resistor	10 kΩ, 1/4 W, 5%	Allen Bradley AB-EB
Resistor	620 Ω, 1/4 W, 5%	
Power Supply	+10 V, d.c.	Power Designs 5015T
Capacitor	1000 μF, 6 w.v.d.c.	-----
Distortion Analyzer	Range: 20 Hz - 20 kHz Resolution: 0.1% t.h.d.	Radiometer BKF10

S2-6, Continued.

b. <u>R.F. Input Sensitivity.</u>

(1) Connect the 8210 and test equipment as shown in Figure 2-6.

(2) Depress the switches of the 8210 as indicated in Figure 2-6.

(3) Apply a 10 MHz, 10 mV r.m.s. signal from the Model 102E-19 signal generator to the RF IN connector of the 8210. The 8210 should indicate "lock" and adequate signal level for a measurement.

(4) Change the r.f. input to 500 MHz. Indications should be the same as in Step (3).

(5) Connect the Model 8660C signal generator to the RF IN connector of the 8210. Set the signal generator's controls to provide an r.f. input of 30 mV, r.m.s., at 1500 MHz. Indications as in Step (3).

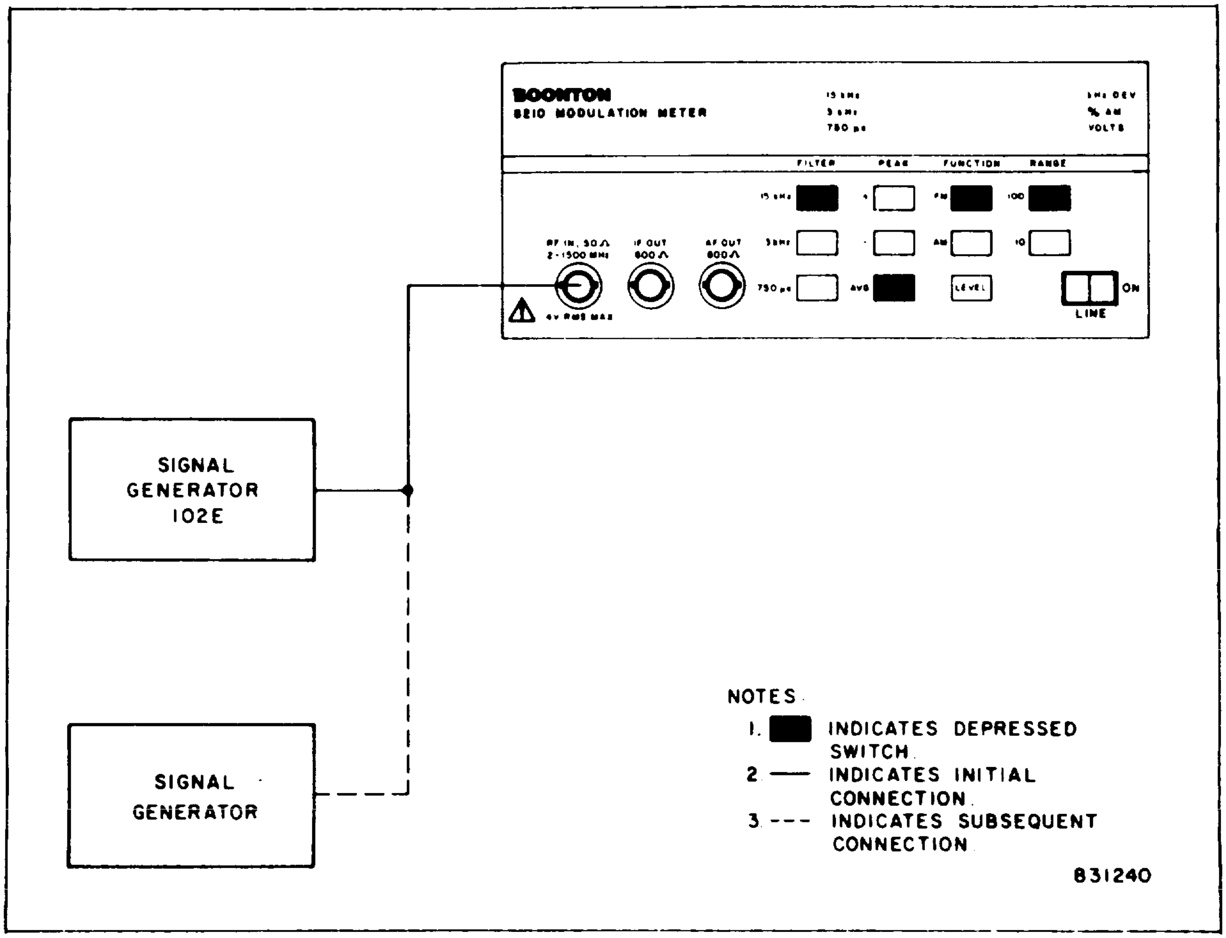


Figure 2-6. Test Setup: R.F. Input Sensitivity

c. <u>Deviation Accuracy.</u> Verification of the deviation accuracy of the 8210 is not usually required. If there is any doubt as to the operation of the internal calibrators, refer to Section IV for maintenance instructions, or to Appendix A for operation of the calibrators.

d. Residual F.M.

(1) Connect the 8210 and test equipment as shown in Figure 2-7.

(2) Apply the 500 MHz signal, at 0 dBm, from the test source to the RF IN connector of the 8210.

(3) Depress the switches of the 8210 as indicated in Figure 2-7.

(4) Connect the r.m.s. voltmeter (without 600 Ω termination) to the AF OUT connector on the 8210.

(5) Set the voltmeter for 100 kHz bandwidth and 30 mV full-scale sensitivity. The voltmeter should indicate less than 13.3 mV (26.6 mV).

(6) Depress the 8210's 3 kHz FILTER switch. The voltmeter should read less than 10 mV.

NOTE: The display of the 8210 indicates true peak deviation; therefore the display's readings will always be two to three times higher **than the r.m.s. readings of the voltmeter.**

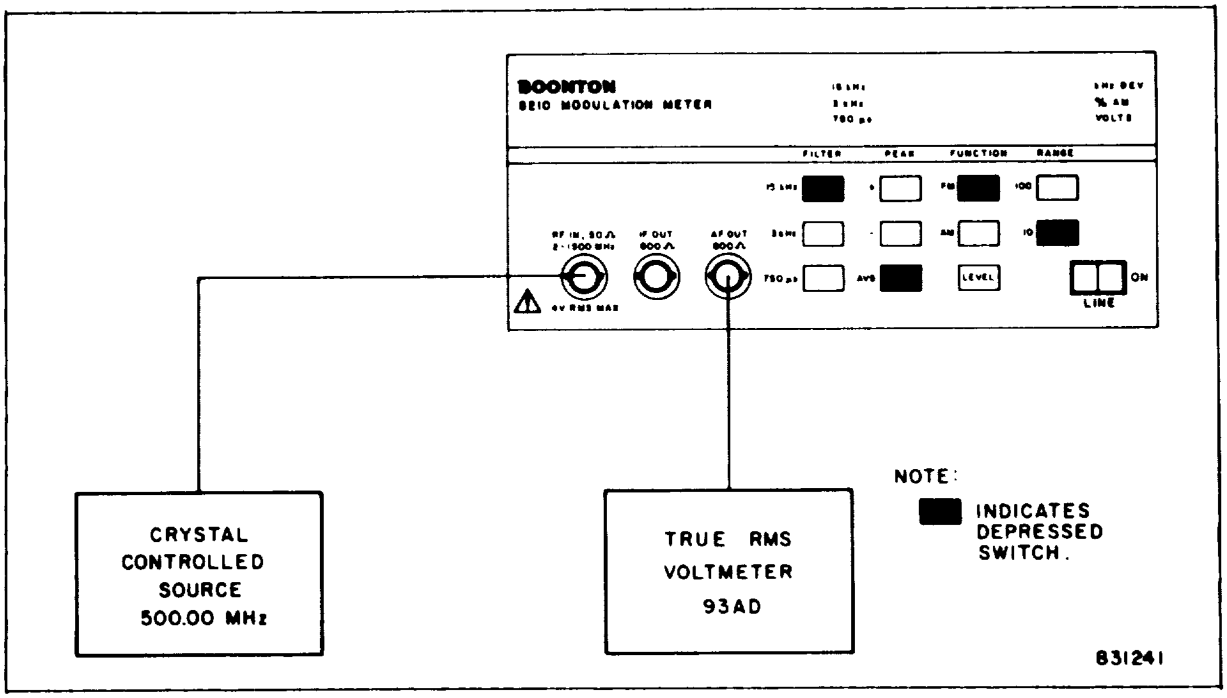


Figure 2-7. Test Setup: Residual F.M. and Residual A.M.

e. Residual A.M.

(1) Connect the equipment as shown in Figure 2-7.

(2) Set the 8210's controls as indicated, but select the AM FUNCTION.

(3) Set the voltmeter to 100 kHz bandwidth and 100 mV sensitivity.

(4) The voltmeter should indicate less than 50 mV (70 mV).

(5) Set the 8210's FILTER to 3 kHz, and voltmeter sensitivity to 30 mV.

(6) The voltmeter should indicate less than 30 mV.

S2-6, Continued.

f. A.M. Rejection.

(1) Connect the 8210 and test equipment as shown in Figure 2-8.

(2) Set the 8210's controls as shown in Figure 2-8.

(3) Apply a 30 MHz signal, at 0 dBm, from the generator to the mixer.

(4) Adjust the power-supply output voltage to +10 V d.c. Adjust the audio source for approximately 50% indicated a.m. at a 1 kHz rate.

(5) Change the 8210's FUNCTION to FM.

(6) Vary the r.f. level between 0 and +10 dBm for a deviation null. The display should indicate less than 100 Hz peak f.m. (Residual noise-modulation must be subtracted.)

g. A.M. Audio Distortion. NOTE: Step 2-6f, the A.M. Rejection check, should be completed before performing this verification. Leave the equipment set up as in Figure 2-8.

(1) Adjust the audio oscillator for 90% a.m. at a 1 kHz rate.

(2) The distortion analyzer should indicate less than 0.5%.

(3) Vary the audio oscillator frequency from 50 Hz to 10 kHz.

(4) The distortion should be less than 0.5% at all frequencies.

h. Audio-Frequency Response, 15 kHz. NOTE of Step 2-6g applies here also.

(1) Depress the AM FUNCTION button.

(2) Adjust the frequency of the audio oscillator to 1 kHz; adjust its amplitude for an indication of 60.0% a.m.

(3) While maintaining a constant audio-oscillator amplitude, vary the modulation frequency between 50 Hz and 5 kHz (10 kHz).

(4) The indicated a.m. should be between 59.4% and 60.6% for all modulation frequencies.

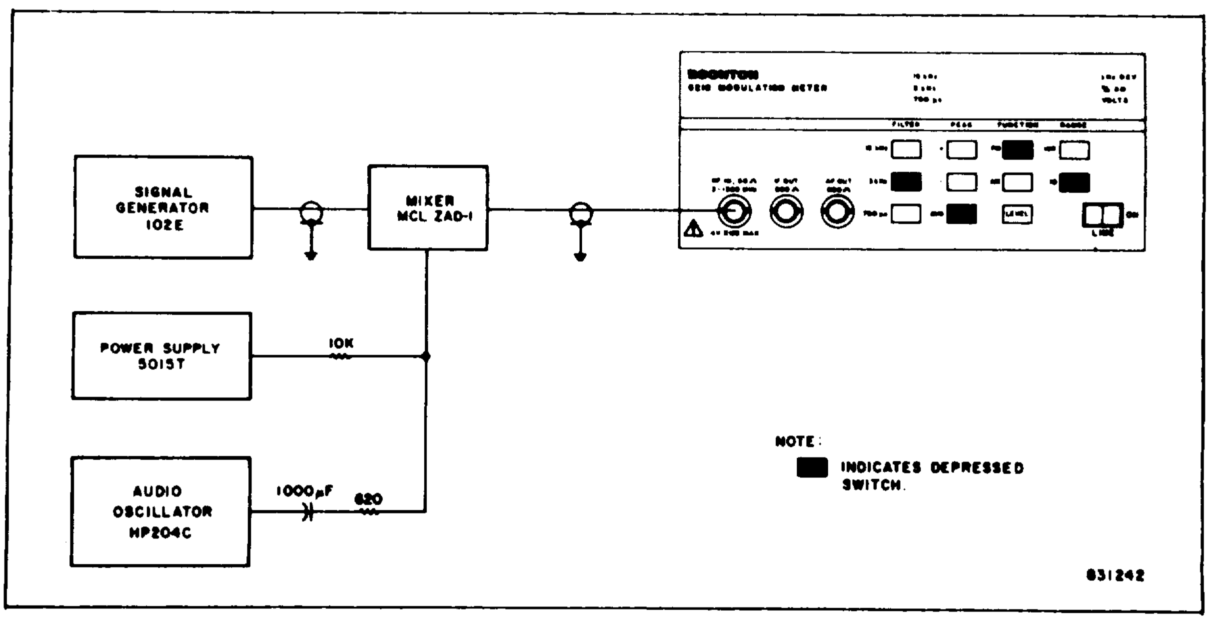


Figure 2-8. Test Setup: A.M. Rejection, A.M. Frequency Response, and A.M. Audio Distortion

S2-6h, Continued.

(5) Increase the frequency to 7.5 kHz (15 kHz). The indicated a.m. should be between 58.8% and 61.2%.

(6) Increase the frequency to 15.0 kHz (30 kHz). The indicated a.m. should be between 40.4% and 44.38.

i. F.M. Audio Distortion.

(1) Connect the 8210 and test equipment as shown in Figure 2-9.

(2) Set the controls of the 8210 as shown.

(3) Set the signal generator to 100 MHz, 0 dBm, and external f.m.

(4) Adjust the level of the audio oscillator for 75 kHz peak deviation at a 1 kHz rate.

(5) The indicated distortion should be less than 0.25%.

(6) Repeat **Step** (4) for modulation rates of 50 **Hz** and 10 kHz.

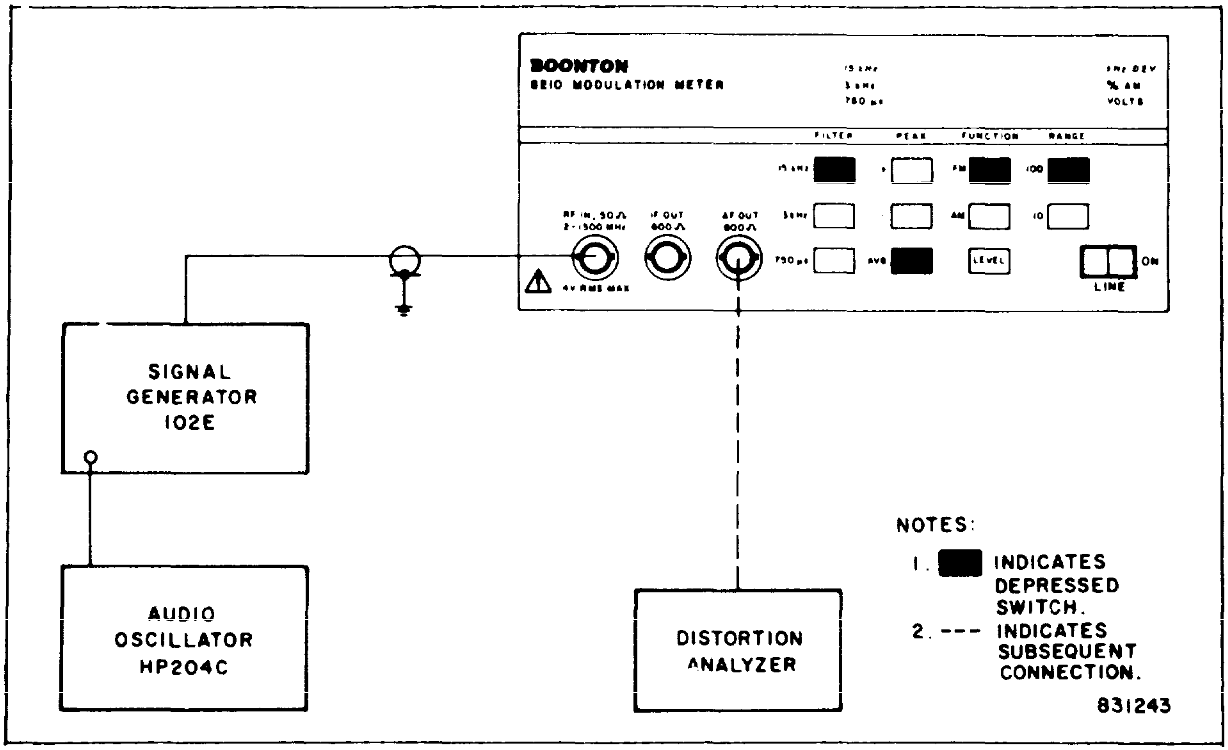


Figure 2-9. Test Setup: F.M. Audio Distortion and P.M. Rejection

j. F.M. Rejection.

(1) Connect the equipment as shown in Figure 2-9.

(2) Set the controls of the 8210 as indicated.

(3) Adjust the audio oscillator's frequency to 1 kHz; adjust its amplitude for a 100 kHz peak deviation.

(4) Change the 8210's FUNCTION to AM and its RANGE **to 10.**

(5) The display should indicate less than 1.0%, peak.

S2-6, Continued.

k. Audio-Frequency Response, 3 kHz.

(1) Connect the equipment as in Figure 2-9.

(2) Set the 8210's controls as shown.

(3) Adjust the audio oscillator's frequency to 300 Hz, then adjust its amplitude until the 8210 reads 100.0 kHz.

(4) Without changing the audio oscillator's level, adjust its frequency to exactly 3.00 kHz.

(5) The Model 8210 display should indicate between 67.5 and 73.8 kHz.

l. Audio-Frequency Response, 750 µs De-emphasis.

(1) Connect the equipment as in Figure 2-9.

(2) Set the 8210's controls as shown.

(3) Adjust the audio oscillator's frequency to 212.2 Hz, then adjust its amplitude until the 8210's display indicates 100.0 kHz.

(4) Change the 8210's FILTER to 750 us.

(5) The display should read between 68.0 and 73.5 kHz deviation.

m. A.M. Depth Accuracy. Verification of the a.m. depth accuracy of the 8210 is not required. If there is any doubt as to the operation of the internal calibrators, refer to Section IV for maintenance instructions, or to Appendix A for operation of the calibrators.

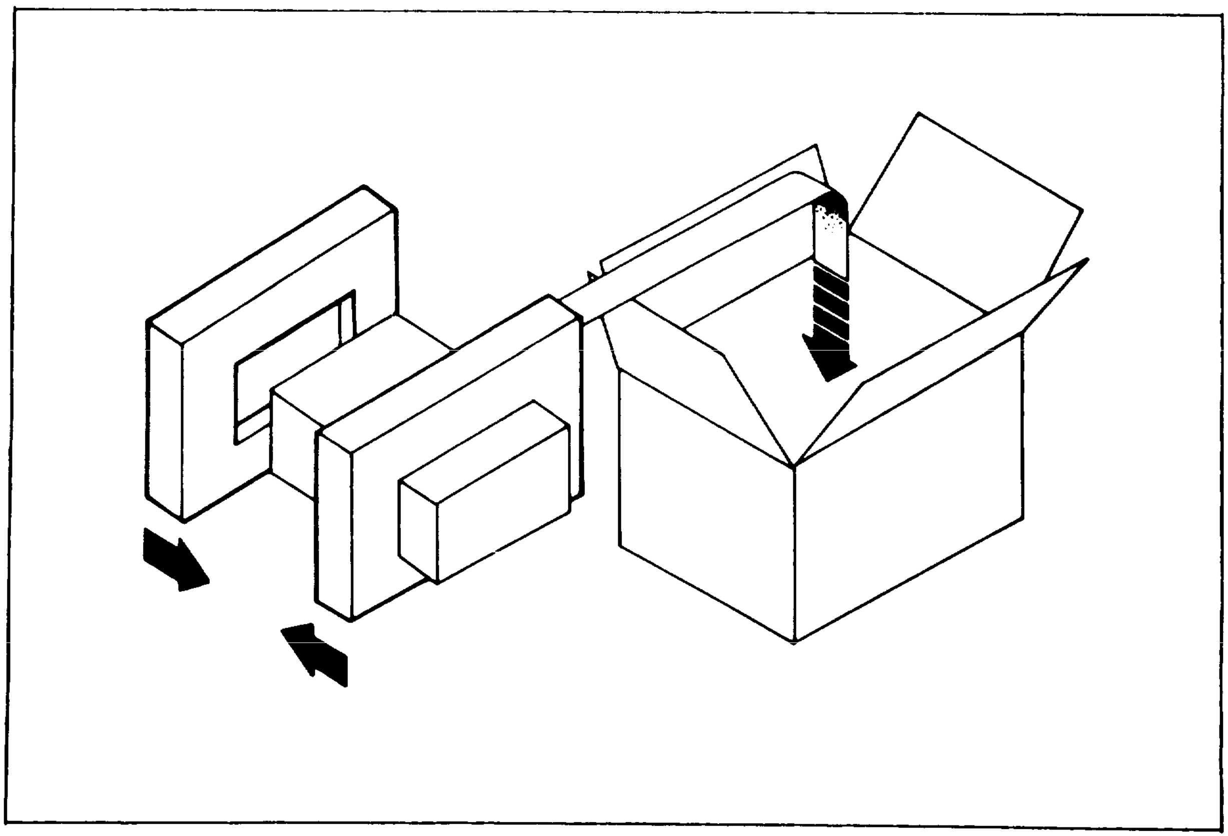


Figure 2-10. Packaging Diagram

SECTION III

THEORY OF OPERATION

3-1. 1NTRODUCTION

The 8210 is a compact, microprocessor-controlled, internally calibrated, a.m.-f.m. modulation meter that covers the carrier-frequency range of 2 MHz to 1.5 GHz. Amplitude modulation or frequency modulation is displayed on a four-digit LED display that provides a maximum resolution of 0.01% a.m. or 10 Hz deviation. Signal acquisition, display operation, calibration, and instrument control is accomplished using a microprocessor.

Operation of the 8210 is fully automatic. The largest signal present at the RF IN connector is converted to a 400 kHz intermediate frequency, which is adjusted to a convenient level for a.m. measurements. The modulation depth of a.m. signals is equal to the peak amplitude of the recovered audio signal divided by the d.c. level of the a.m. detector. The deviation of an f.m. signal is equal to the peak amplitude of the recovered signal. The recovered modulation is converted into a proportional d.c. level, then into a digital display, by microprocessor-controlled detectors and an analog-digital (A-D) converter.

3-2. CIRCUITS: GENERAL DISCUSSION

For this discussion the circuits of the 8210 are grouped by function, as follows: r.f., if., calibrator, a.f., logic, and power-supply circuits. Refer to Figure 3-1, a simplified block diagram of the 8210.

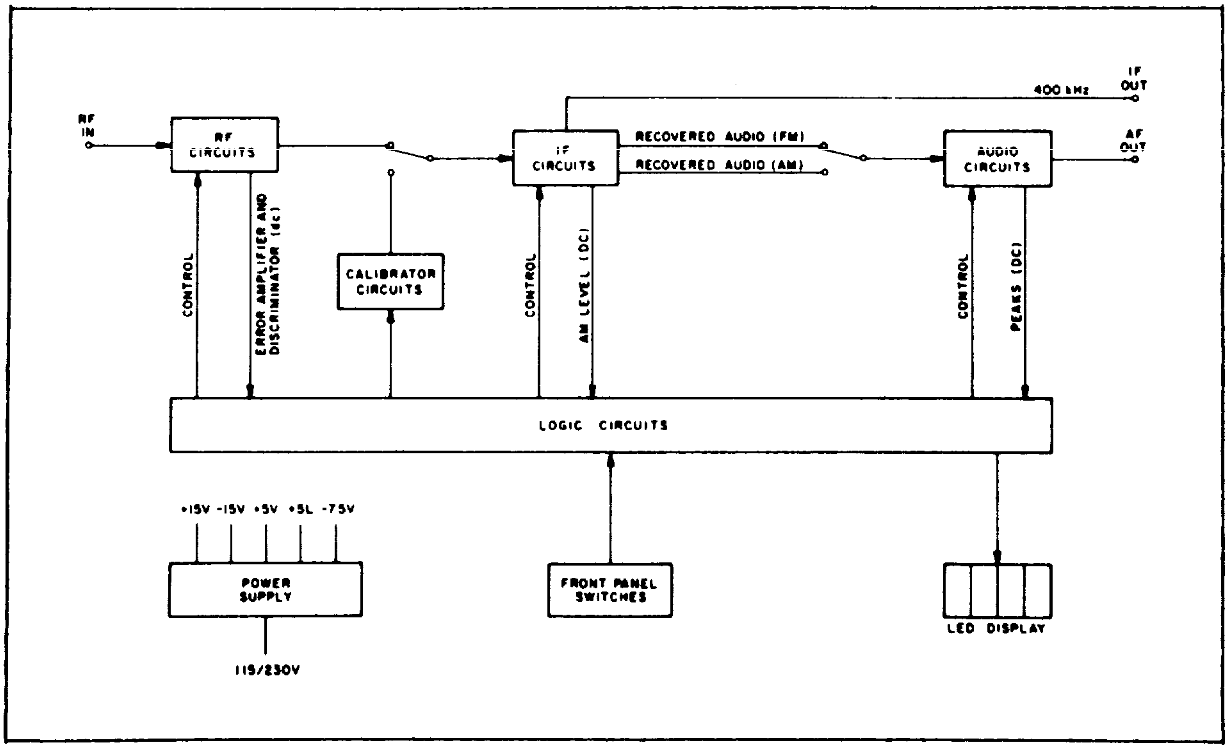


Figure 3-1. Simplified Block Diagram

a. <u>R.F. Circuits.</u> The r.f. input signal to be measured is applied to the r.f. circuits through the front-panel RF IN connector. This signal passes through a fixed 3 dB pad to a zero-order hold sampler. The sampler is fully bootstrapped to accept signals as large as 1 V, r.m.s., without overload.

3-2a, Continued.

A sampling pulse, generated from a tunable local oscillator, converts the r.f. signal into an if. signal at approximately 400 kHz. The if. signal is passed to the if. circuits and also through a filter to a limiter, a discriminator, and an error amplifier. Automatic frequency control is accomplished by these circuits in conjunction with the microprocessor.

b. I.F. Circuits. The if. signal from the sampler is filtered and amplified, then coupled to a.m. and f.m. detectors through a digital-to-analog (D-A) converter configured as a variable-gain element. The logic circuitry adjusts the converter so as to maintain a convenient d.c level at the output of the a.m. detector. The last-mentioned is a linear active detector, which recovers the amplitude modulation of the if. and provides a d.c. signal proportional to the if. level. A portion of the a.m. detector output signal is used to drive a monostable multivibrator, which detects the f.m. modulation of the if. signal. Both a.m. and f.m. signals are amplified and applied to the a.f. circuits through a switch. During calibration, the signal from the r.f. circuits is disconnected from, and the calibrator signal is connected to, the if. circuits.

c. Calibrator Circuits. The calibrator circuits, which are activated when the 8210 is turned on, consist of a variable-modulus counter circuit and a precision attenuator. The variable-modulus counter is alternately programmed to divide the output of a 3.579 MHz crystal-controlled oscillator by eight or by ten. The resulting signal has an average frequency of 402 kHz, approximately, and a peak deviation of 44.74 kHz. This signal is used to calibrate the f.m. detector. In addition, a fixed-frequency signal is applied to a switchable attenuator, which is alternately programmed to attenuate by two-thirds and by one-third. The signal from the attenuator has an amplitude variation of two to one, and therefore is equivalent to a signal with 33.33% a.m.

d. A.F. Circuits. The recovered audio signal from the a.m. or the f.m. detector (as determined by the FUNCTION switch), is filtered by an active-filter circuit to remove if. components. Baseband processing circuitry, in the form of selectable low-pass filters, additional gain, and precision peak detectors--all under the control of the logic circuity--convert the recovered signal into a digital display.

e. Logic Circuits. The logic circuits consist of a central processing unit (CPU), read-only memory (ROM), random-access memory (RAM), peripheral interface adapters (PIA), and a digital-to-analog converter (DAC). The CPU operates under control of a microprogram, stored in ROM, to monitor the frequency control, level control, peak-detector circuits, and the front-panel switches. In addition, the CPU controls and updates the front-panel displays, and operates all internal control circuits.

f. Power-Supply Circuits. The power-supply circuits convert the a.c. line voltage into well regulated d.c. voltages. Five power-supply voltages are used to operate the circuits in the 8210: +15, -15, -7.5, and separate +5 supplies for the analog and for the digital circuits.

3-3. CIRCUITS: DETAILED DISCUSSION

a. R.F. Circuits. The r.f. circuits convert the r.f. input signal that is to be measured into a 400 kHz if. signal. With the assistance of a microprocessor, a local-oscillator signal is generated and controlled so as to maintain this intermediate frequency. (Refer to Figure 3-2, a detailed block diagram of the r.f. circuits.)

(1) The input signal applied to the front-panel RF IN connector, J1, is passed through connectors J2 and P1 to a fixed 3 dB pad, which consists of R2-R4. This pad reduces the r.f. level, and improves the impedance match to the incoming signal. The output of the pad is connected to a sampling gate consisting of diodes CR2a-CR2d. The sampling gate and sampler amplifier, consisting of transistors Q2

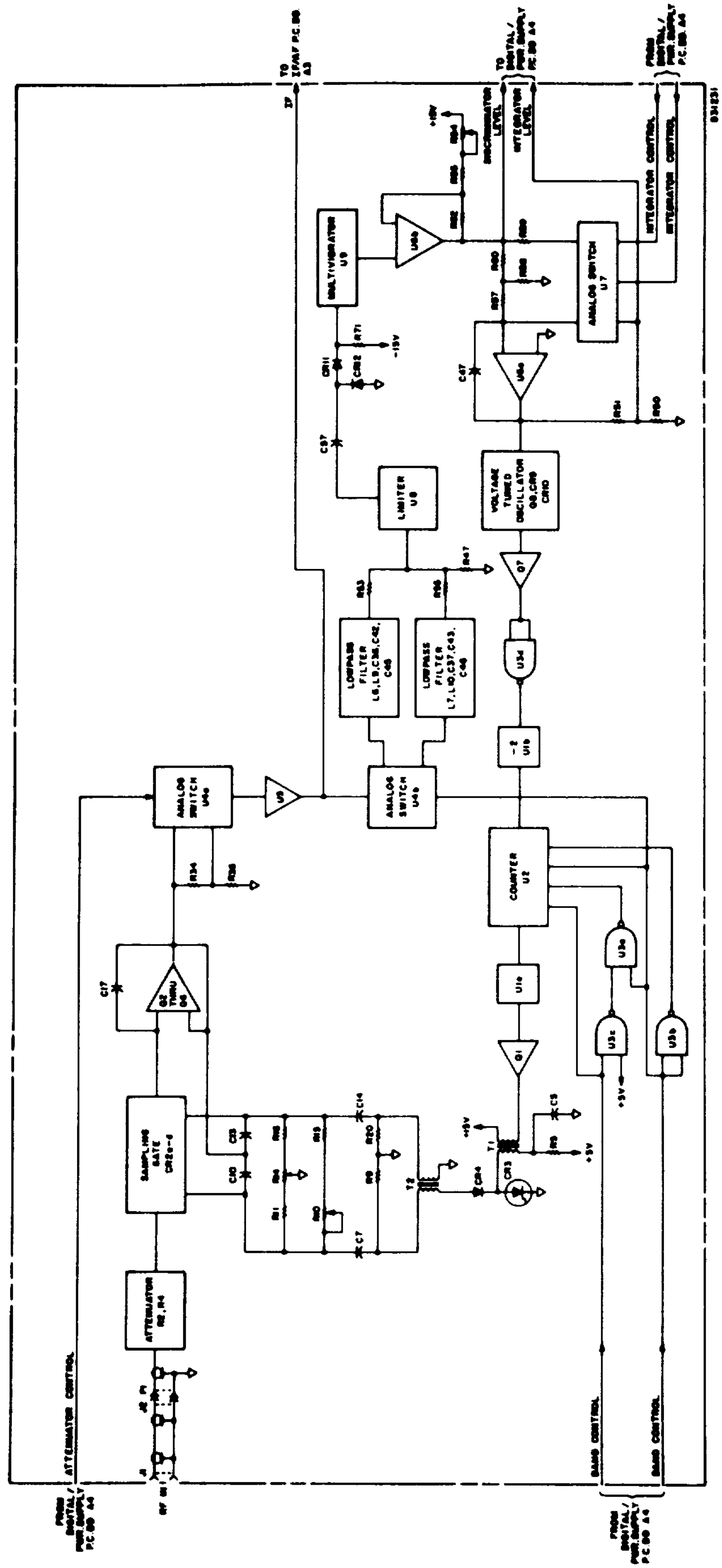


Figure 3-2. R.F. Circuits: Detailed Block Diagram

through Q6 and associated components, constitute a zero-order hold sampler.

(2) The operation of the sampling gate is shown in simplified form in Figure 3-3. Each time the sampling gate is closed, by a short-duration pulse, the input capacitance of the sampler amplifier plus any stray capacitance is charged to a voltage that is less than the instantaneous r.f. input voltage. Before the next sample is taken, positive feedback from the sampler amplifier causes additional charge to be placed on this capacitance. Charge is added until the output voltage of the sampler amplifier is equal to the r. f. input at the time the sample was taken. This output voltage is held constant until the next sample is taken. Sucessive samples are taken until the r.f. waveform is reconstructed at 400 kHz. Additional feedback from the sampler amplifier maintains symmetrical reverse bias on the sampling gate. R10 adjusts the bias magnitude, and R14 adjusts the bridge balance.

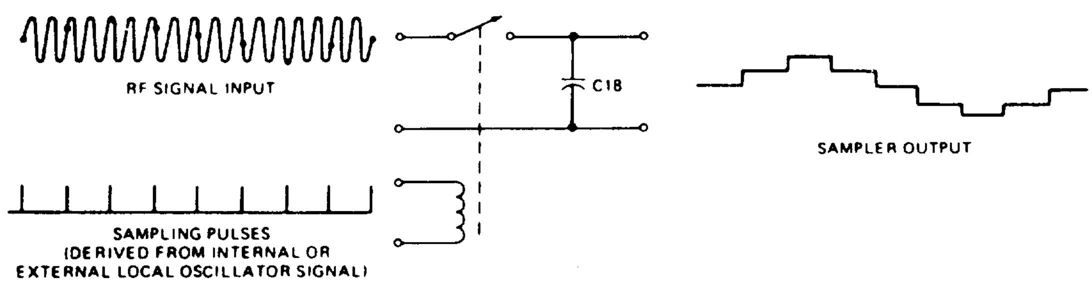


Figure 3-3. Sampling Gate: Simplified Operation

(3) The output of the sampler amplifier is connected to a switchable 20 dB attenuator, consisting of R34, R35, and U4a. The attenuation is selected by the control program whenever the r.f. input level exceeds approximately 100 mV. Amplifier U5 increases the signal level about four times before it is coupled to the if. circuits. The output of U5 is connected also to a switchable low-pass filter composed of U5b, L6, L7, L9, L10, C36, C37, C42, C43, C45 and C46. This filter eliminates most of the local-oscillator signal at the input of the limiting amplifier U8. A level-shift circuit, which consists of CR11, CR12, C57 and R71, translates the limited if. signal to TTL levels in order to operate U9--a monostable multi-vibrator. The duty cycle, and thus the average value, is proportional to frequency. R64 sets the operating level of U6b to zero volts, d.c., when the intermediate frequency is 400 kHz.

(4) The output of U6b is connected to integrating amplifier U6a through a voltage divider formed by R58, R60. This attenuation is needed to preserve low-frequency f.m. response at high carrier frequencies. CMOS switch U7 can be programmed to “dump” the integrator or to bypass the input voltage divider on command from the logic circuits. The output of the integrator is resistively coupled to the varactor diodes CR9 and CR10.

(5) The local oscillator, composed of FET 08 and associated components, is voltage-tuned. The frequency is determined by a tuned circuit consisting of L2 and varactor diodes CR9 and CR10. As the voltage at the ouput of U6a varies from +11 to -11 volts, the oscillator’s

frequency changes from less than 30 MHz to approximately 40 MHz. Level shifter Q7 increases the signal to TTL-compatible levels to drive both U3d (a buffer), and U1b (a divide-by-two stage). U2 and U3a-c are configured as a programmable counter, able to divide by four, by five, or by six, as controlled by the logic circuitry. By successively changing the divide modulus, three overlapping bands (extending together over one octave), are generated.

(6) The sampling pulses are generated by the step-recovery diode CR3, amplifier Q1, and transformer T1. Initially, diode CR3 is forward biased from the +5 volt supply through R5. Ula generates a narrow pulse from the output of the counter. This pulse, amplified by Q1, drives the step-recovery diode into reverse conduction; however,CR3 does not "open" until all of its stored charge is depleted. At that time the diode recovers and produces a large narrow pulse, which is coupled to the sampling bridge through T2, a balun transformer. The output of T2 is two nearly equal opposite-polarity pulses. If the two pulses were exactly equal and opposite, they would cancel one another at the input and output of the sampling bridge. Since such equality is never the case, however, R14 is adjusted to null the bridge-input signal--and thereby the signal fed out of the RF IN connector.

(7) Frequency acquisition occurs in the following manner: If no carrier is present at the input (RF IN), the discriminator level indicates that the frequency is high. The integrator ramps toward the negative supply rail until it has exceeded 11 volts. At that time the integrator is reset to 0 volts, the integrator attenuator is by-passed, and the count-modulus of the band counter is changed. This process continues until a carrier signal is applied to the RF IN connector.

(8) When a carrier is applied, an if. signal will be produced at a frequency that is between zero and one-half of the sampling rate. This signal is hard-limited, then applied to a discriminator which, in turn, causes the integrator to move toward one or the other of the supply rails--depending on whether the i. f. is high or is low. If a valid 400 khz i.f. is produced the inteqrator stops, and the by-pass of the integrator attenuator is removed. If no valid if. occurs, the integrator output. will eventually exceed either +11 or -11 volts. Then the integrator will be reset, and the band-counter modulus will be either increases or decreased. In this way, all. possible input frequencies can be made to produce a valid if.

(9) The capture performance of the system is determined principally by the limiter's gain and the bandwith of the sampler. Weaker signals at the r.f. input (non-harmonically related to the signal of interest) will be supressed, since the largest signal present will drive the limiter to a low–gain state. These weaker signals will appear as f.m. sidebands at the output of the limiter.

b. <u>I.F Circuits.</u> The if. circuits recover the a.m. and f.m. signals from the frequency-shifted input signal. These circuits also provide a sample if. kignal to the front-panel IF OUT connector; in addition, for a.m. measurements, they provide a d.c. signal proportional to the if. level . (Refer to Figure 3-4, a detailed block diagram of the if. circuits.)

(1) The 400 kHz if. signal from the r.f. circuits is connected to amplifier U2 through a low-pass filter that consists of inductors L1 through L3, capacitors C1-C2, and resistors R3, R5 and R6. Variable resistor R5 reduces the filter's amplitude-response variations, which are due to component tolerances. It is adjusted so as to give minimum a.m. indication when an F.m. siqnal is applied. Amplifier U2 has a closed-loop gain of four (approximately), as determined by

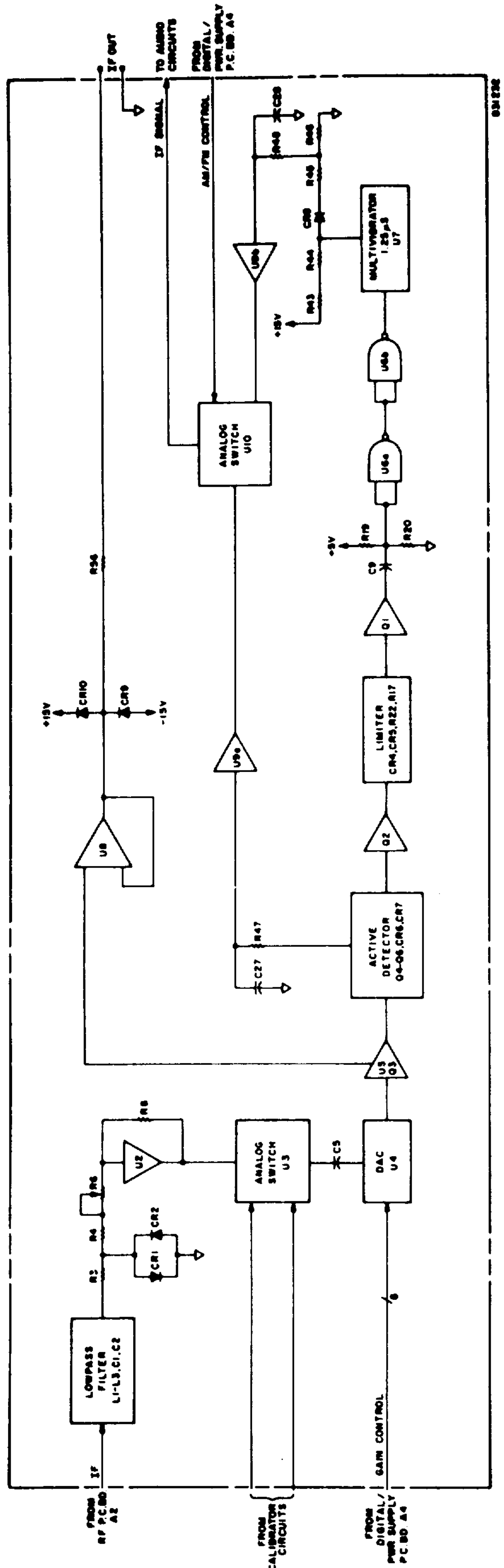


Figure 3-4. I.F. Circuits: Detailed Block Diagram

R3, R5, R6 & R8. The signal is then connected to calibrator switch U3, and a.c. -coupled to DAC U4. The gain of the DAC is determined by the digital byte appearing at inputs B1-B8. The logic circuitry varies this byte in order to maintain the d.c. output of the a.m. detector between 0.5 and 0.6 volts. The amplifier that consists of us, Q3, and associated components, increases the if. level and provides the high output impedance necessary for driving the linear active detector circuit. The signal at the emitter of Q3 is buffered by U8 and routed to the IF OUT connector.

(2) The active detector circuit, which comprises transistors Q4 through Q6, diodes CR6-CR7, and associated components, converts the input current into two half-wave-rectified signals. The circuitry of Q4-Q6 yields maximum gain and a high output impedance for driving the feedback network. The two half-wave-rectified signals at the outputs of CR6 and CR7 are added to complete the feedback path.

(3) The output at detector diode CR7 is a signal that contains a d.c. component proportional to if. level, and an a.c. component proportional to modulation depth. This signal is lightly filtered by R47 and C27, and amplified by U9a. The output of U9a is connected to the a.m.-f.m. switch U14.

(4) A portion of the linear active detector's output is coupled to a limiter circuit via impedance transformer Q2 and associated components. The limiter, consisting of CR4, CR5, R22 & R17, removes most a.m. from the if. signal. The resulting signal is amplified to TTL levels by amplifier Q1, then differentiated by C9, R19 and R20. The TTL gates U6a and U6b amplify the differentiated signal into a narrow TTL pulse to drive U7, a monostable multivibrator.

(5) The period of U7 is 1.25 us, approximately. The network consisting of R43-R46 and CR8 confines the peak-to-peak amplitude of U7's output to four volts. As the intermediate frequency changes, the duty cycle of the multivibrator--and consequently the average value of the waveform--changes proportionally.

(6) The signal is lightly filtered by R48 and C28, then amplified and level-shifted by U9b. The signal is routed to the a.m.-f.m. switch U10, and to the audio circuits.

c. <u>Calibrator Circuits.</u> The calibrator circuits provide the reference calibration signals for the 8210's a.m. and f.m. detectors. See Figure 3-5. (In addition to the circuit description given below, technical information on design and operation of the calibrator circuits appears in Appendix A.)

(1) The 1.79 MHz signal from U5a, pin 8, is connected to the clock input of synchronous counter U9. The counter is configured to self-load its data inputs at the end of each count cycle. By varying the input data with an 874 Hz signal from U1f, pin 2, the divide modulus is changed from four to five. The signal that results synchronously switches from 357.9 to 447.4 kHz, producing an average frequency of 402.6 kHz and deviation of 89.48 kHz, p-p. This signal is used to calibrate the f.m. discriminator. The signal is connected to data selector U12, along with a signal at 447.4 kHz from U3, pin 6, and an 874 Hz signal from U1f, pin 2. The outputs of the data selector are controlled by the signals from U-16, pins 39 and 17. During the calibration cycle U16, pin 17, is "low;" pin 36 is set "high" for a.m. calibration, and "low" for f.m. calibration.

(2) When the calibration routine initially selects AM FUNCTION, the outputs of the data selector are the signal from U3, and the 874-Hz signal from U1f, pin 2. The 447.4 kHz signal is routed through a low-pass filter consisting of L1, L2, C6, C8 and C10 to the if.

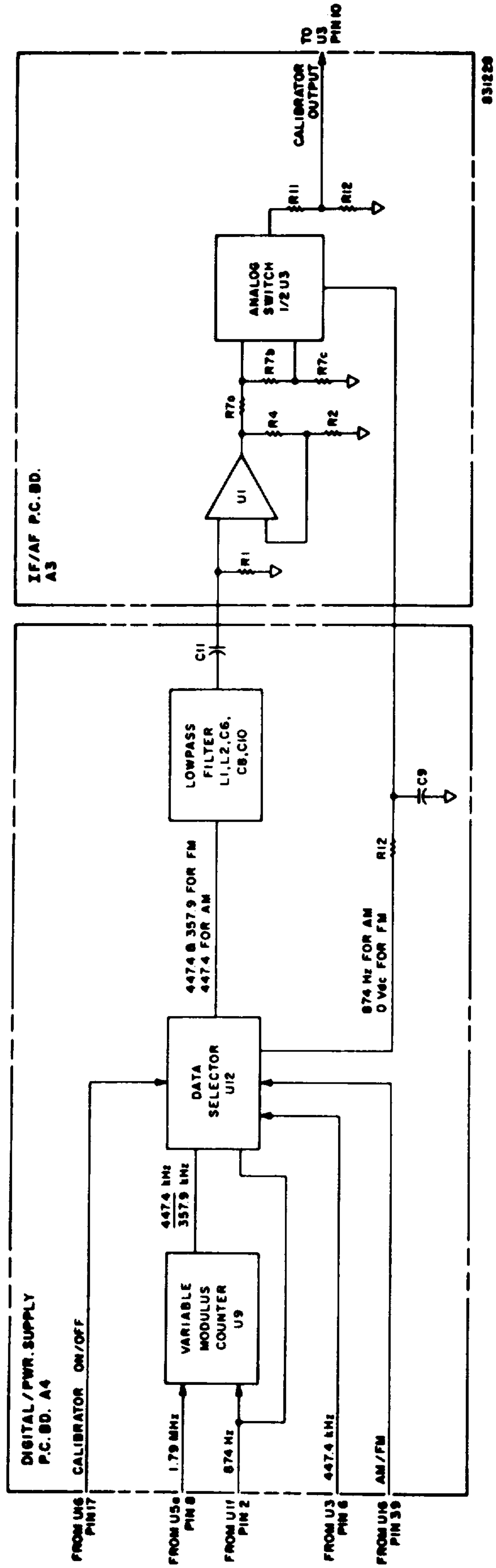


Figure 3-5. Calibrator Circuits: Detailed Block Diagram

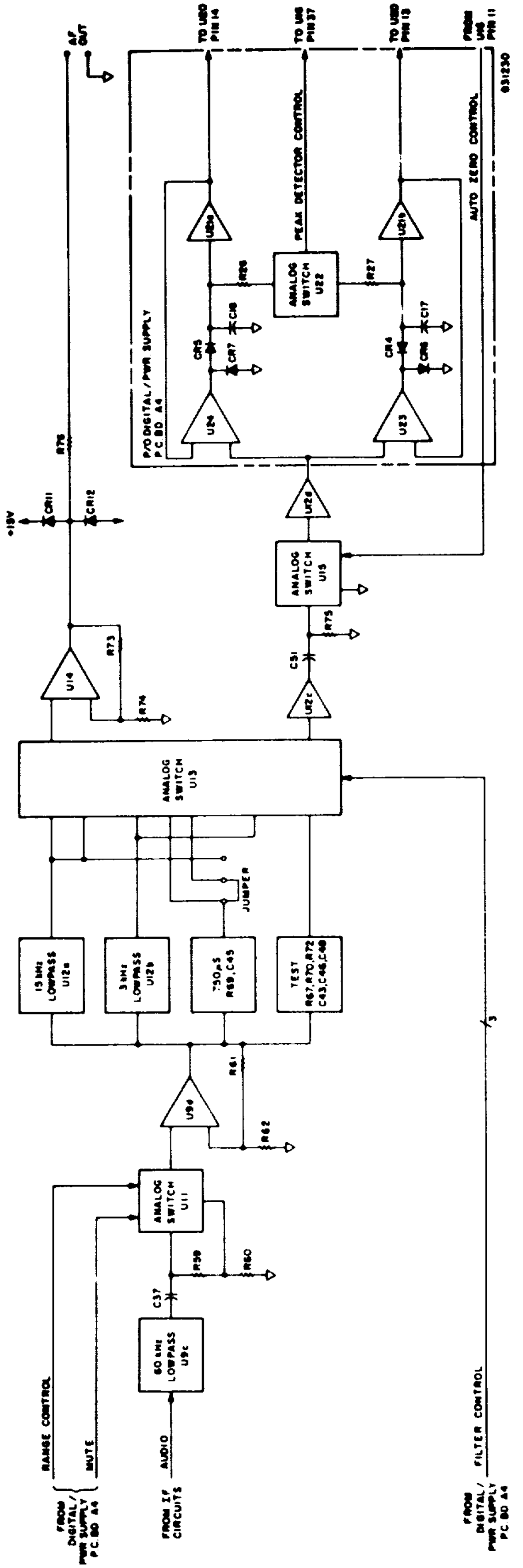


Figure 3-6. A.F. Circuits: Detailed Block Diagram

circuits. This signal is amplified (x2) by A3U1 and applied to the voltage divider A3R7. The analog switch A3U3 is controlled by the 874-Hz signal from A4U12 so as to switch between two taps of the divider. The voltage ratio is exactly two, therefore the equivalent a.m. is 33.33%. This signal is coupled through an attenuator (R11 and R12) and the second half of switch A3U3 to the if. circuitry.

d. A.F. Circuits. The audio circuits process the recovered modulation signal supplied from the a.m. or the f.m. detector circuits--as determined by the front-panel FUNCTION switch. The recovered signal is filtered and converted to a d.c. level, which is then measured; the result is presented on the front-panel LED display. Refer to Figure 3-6.

(1) The signal from the output of the a.m.-f.m. switch U1O, is filtered by active filter U9c and associated components. This filter is part of a three-pole 60 kHz filter, which removes most of the if. component from the recovered signal. The filtered signal is then a.c. coupled to a 20 dB attenuator: R59, R60. CMOS switch U11 selects either the signal, or the attenuated signal, as determined by the front-panel RANGE switch. Additionally, the logic circuitry can program U11 to disconnect the recovered signal in order to prevent audio-circuit overload when the instrument is unlocked.

(2) The signal is then amplified (x11) by U9d and is coupled to the 15 kHz filter, the 3 kHz filter, and the 750 μs de-emphasis network. U12a and associated components form the 15 kHz filter; U16b and associated components form the 3 kHz filter. Both are three-pole Butterworth types. The 750 μs de-emphasis network is a single RC section: R69, C45. A jumper circuit is provided to give the option of connecting the de-emphasis network either before or after the measuring circuits.

(3) CMOS switch U13 selects one of the three filters, as determined by the front-panel FILTER switch. In addition, the logic circuitry can program U13 to select--during calibration--a filter consisting of R67, R70, R72, C43, C46 and C48. One of the outputs of U13 is amplified (x 2.8) by U14 and routed to the front-panel AF OUT connector. The other output is buffered by voltage-follower U12c and a.c. coupled to U15, an auto-zero switch. U15 is operated by the logic circuitry to disconnect the recovered signal for a period of time adequate to determine the output of the peak detectors with no input. The switch is then closed, and the modulation signals are connected through buffer U12d to the peak detectors.

(4) The positive-peak detector consists of U24, U21a, CR1, CR3 and C18. During the positive excursion of the modulating signal, the output of U24 is driven positive; C18 then charges through CR1. U21a buffers the voltage across C18, and adds a small offset. When the output of U21a reaches a value equal to the peak of the waveform plus a small increment, the output of U24 goes negative and thus terminates the charging. The voltage at the output of U21a is then equal to the positive peak of the modulating signal.

(5) Similarly, U23, U21b, CR4, CR6 and C17 constitute a negative-peak detector. In addition, U22 provides a means for resetting both detectors for auto-zero measurements.

e. Logic Circuits. The logic circuits generate all control and display functions in the 8210. The logic circuits consist of a CPU, 4096 bytes of ROM, 2048 bytes of RAM, two PIA's, a DAC, and several IC gates and drivers.

The CPU, U8, is controlled by a program stored in ROM (U11). Temporary program variables and subroutine return addresses are stored in RAM (U13). The control functions of the 821O are directed by U16, a PIA; keyboard

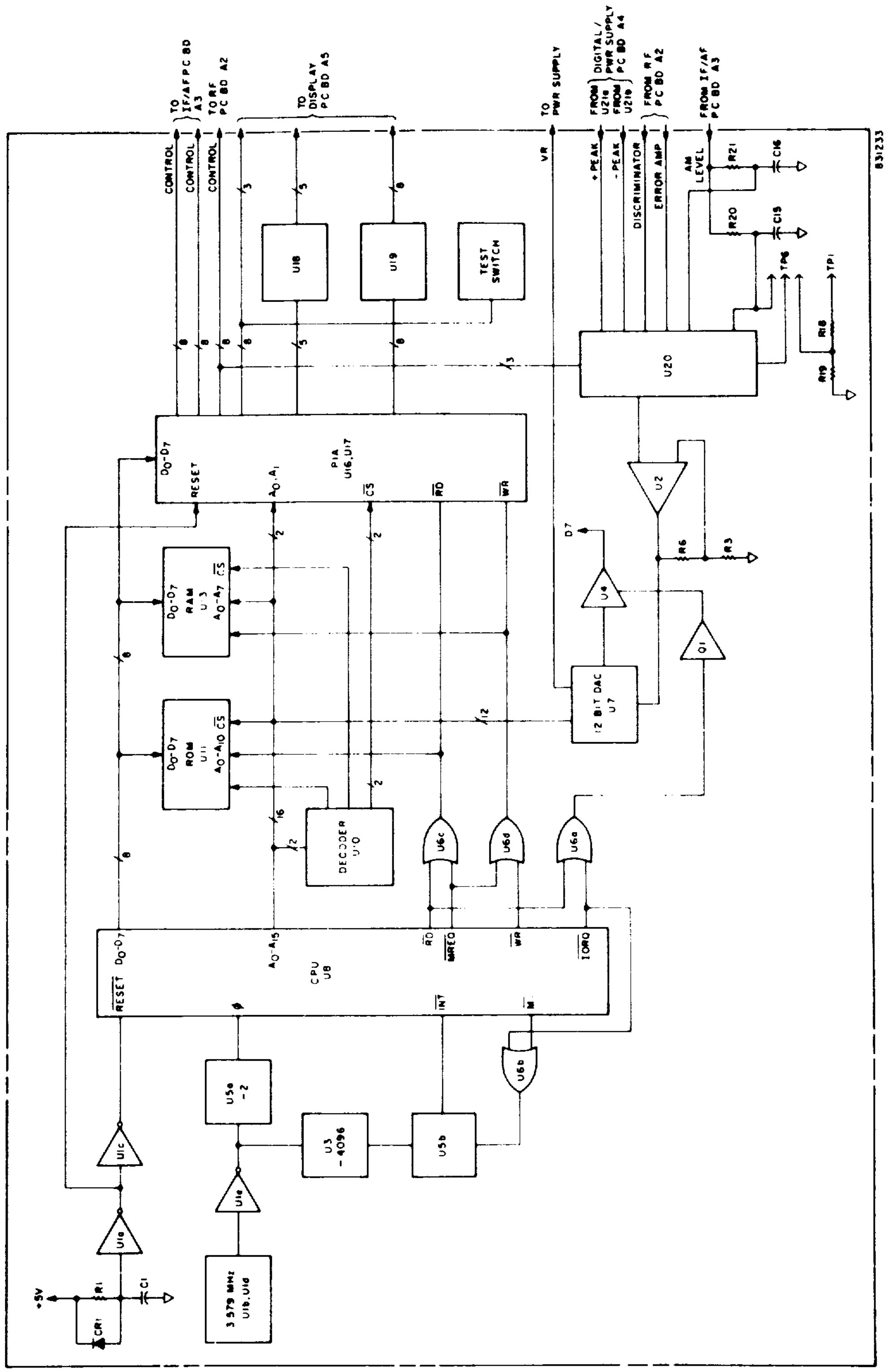


Figure 3-7. Logic Circuits: Detailed Block Diagram

and display functions are directed by the PIA U17. See Figures 3-7 and 3-8.

(1) The control program initializes the RAM and PIA circuits and checks the status of the test switch during the power-up sequence. The display is then enabled, and interrupt processing of the keyboard and the display begins. As each digit of the display is updated, each row of keys is tested simultaneously, and any key closures are detected. The calibration sequence then starts; when it ends, the main program loop begins. The latter places the highest priority on successful frequency acquisition, then on establishing the proper if. level, and finally on measuring the recovered signal. The program checks level and frequency each time through the main loop, so if. errors are detected immediately. When proper operating parameters are established, the recovered signal is processed.

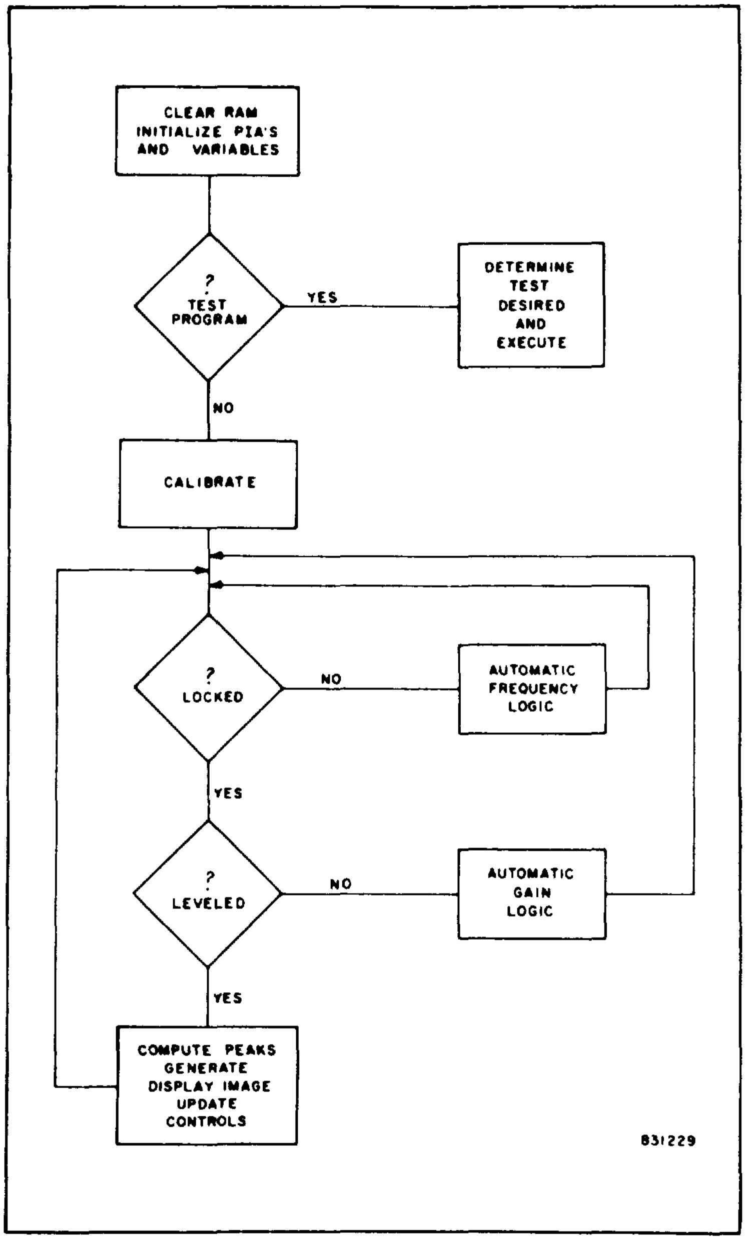


Figure 3-8. Program Flow Diagram

(2) The program executes an auto-zero cycle each time a measurement is made. The audio signal is turned off, the peak detectors are reset and released, and both detectors are read. The information is stored temporarily. The peak detectors are reset, audio is turned on, and the detectors are released. They are read again and the “zero” information is subtracted. The display is then updated with the data determined by the setting of the front-panel PEAK switch.

(3) All d.c. voltage measurements are made by the successive - approximation A-D converter consisting of U7, U4, Q1, and associated components . The successive trial values are software generated, and sent to the 12-bit DAC (U7) via the address bus of the CPU. An I-O read cycle (signalled by IORQ = RD = LO) returns the comparison (made by U4) of the DAC value and the input d.c. signal on data line D7. A complete conversion requires 12 succesive tests to converge within 1 LSB. U2 serves as a fixed-gain buffer to isolate U20, the CMOS multiplexer, from the A-D converter circuit’s low input impedance.

(4) The CMOS multiplexer, U20, is operated by the program to select various voltages from the 8210’s circuits. Both peak detectors are

connected to it, as are the outputs of the integrator and the discriminator from the r.f. circuits, and the d.c. level from the a.m. detector. The a.m. detector output is filtered by R21 and C56 to provide one a.m.-level input and by R20 and C15 to provide another. The two a.m. detector inputs are used during if. level setting and a.m. depth measurements: the moderately filtered one for testing the level, the heavily filtered one for computing a.m.

(5) U1b, U1d, and U5e constitute a crystal-controlled oscillator, with the 3.58 MHz crystal frequency divided by a factor of two by U5a. The output of U5a is connected to the clock input of the CPU. The 3.58 MHZ signal is also divided by a factor of 4096 by U3, to generate the 1.1 ms interrupt signal. U1b is clocked by this signal going high, which activates the INT line of the CPU and causes an interrupt to occur. The CPU recognizes the interrupt; it acknowledges by setting lines IORQ and Ml low. Thus U5b is reset, and the interrupt condition is cleared. The interrupt program updates the display and interrogates the keyboard, then returns to the main program.

(6) U10 decodes the address lines to enable the IC's of ROM, RAM, and PIA. The program ROM is located from adress O to FFF hex; the RAM is located at addresses 2000 to 27FF hex; the display PIA, IC7, is located at address 4000 hex; and the control PIA, IC6, is located at address 6000 hex.

(7) A circuit composed of U1a, U1c, R1, C1 and CR1 resets the CPU and PIA IC's at power-up.

f. Power-Supply Circuits. The power- supply circuits provide d.c. operating power for all other circuits of the instrument. Regulated output voltages of +15, -15, +5(L), +5, and -7.5 volts are provided. The power supplies are designed to operate from a 100, 120, 220, or 240 volt (nominal) a.c. power source. Refer to Figures 6-1 and 6-2.

(1) Power is applied to the primary windings of power transformer T1 through the power connector P1, line fuse F1, line-voltage selector switch S1, and the front-panel LINE switch. S1 is set by the user in accordance with the available a.c. power source.

(2) TWO separate secondary windings of T1 supply a.c. voltages to the rectifier circuits, through connector J6. Bridge rectifier CR8 and capacitor C23 generate an unregulated d.c. output, which supplies power to U26 (a five volt, three-terminal regulator). CR1O and CR15 protect the regulator from reverse voltages during power-on and power-off transients. C26 and C33 improve the transient response of the regulator. The unregulated output of CR8 also is connected to a second regulator, U25, which is enclosed in the feedback loop of U29C. This connection produces a precision +5 volt supply for the analog circuitry of the 8210.

(3) The reference output of U7 is filtered by R31b and C34, and applied to pin 3 of U29a. This provides a reference for the generation of the +15 volt supply. R31 is actually an array of eight matched 10 kΩ resistors, three of which are connected in series between +15 volts and ground. Since the junction of R31a and R31c is connected to pin 2 of U29a, the feedback loop will cause the voltage at this point to be +10.00 volts within the offset of U29a. Consequently, the voltage at the junction of R31c and R31e will be +5.00 volts. This voltage becomes the reference for U29c, which generates the precision +5 volt supply.

(4) The -15 volt supply is generated by U28 and U29b, and associated components. A sample of the regulated output voltage of the supply,

developed by the resistive divider composed of R31d and R31f, is compared to ground. Error voltages are amplified by U29b, and are coupled to regulator U28 in order to adjust the output voltage so as to reduce the error. In this manner the -15 volt supply is made to track the +15 volt supply.

(5) One additional supply voltage is generated; its components are a resistive divider (R31h and R31g), and U29d. The latter is connected as a voltage follower in order to buffer the -7.5 volts at pin 5.

(6) All regulators are protected from reverse bias by diodes both from their outputs to ground, and from their outputs to inputs.

(7) Capacitors at input and output terminals improve the transient response of the supplies.

(8) Diodes CR12, CR14 and CR16 ensure proper start-up of the supplies.

SECTION IV

MAINTENANCE AND ADJUSTMENT

4-1. INTRODUCTION

This section contains maintenance and adjustment instructions for the Model 8210. Symptomatic and systematic troubleshooting procedures for localizing a malfunction are given, as well.

4-2. TEST EQUIPMENT REQUIRED

The test equipment that is required for maintenance and adjustment of the Model 8210 is listed in Table 4-1, below. Other models of test equipment that meet or exceed the Critical Specifications may be used instead.

Table 4-1. Required Test Equipment for Maintenance Adjustment

EQUIPMENT	CRITICAL SPECIFICATIONS	SUGGESTED MODEL
Signal Generator	A.M.-F.M. 0.01 to 520 MHz. -30 to +10 dBm.	Boonton Electronics 102E-19
Oscilloscope	100 MHz Bandwidth. 5 mV Sensitivity.	Hewlett-Packard 1740A
Audio Oscillator	20 Hz to 75 kHz. Constant level of 110 mV, with low distortion.	Hewlett-Packard 204C
A.C. Voltmeter	10 mV to 2 V. Accuracy 1%, 50 Hz to 1 kHz.	Boonton Electronics 93AD
Digital D.C. Voltmeter	100 mV to 20 V. Accuracy 0.15% at 15 V.	Data Precision 1350
Frequency Counter	20 Hz to 5 MHz. Sensitivity 100 mV.	Data Precision 5740
Signature Analyzer	> 3.5 MHz Operating Frequency.	Hewlett-Packard 5004A

4-3. LOCATION OF MAJOR ASSEMBLIES

See Figures 4-1 and 4-2 for the location of the major assemblies of this instrument.

4-4. REMOVAL OF MAJOR ASSEMBLIES AND PARTS

a. Instrument Covers.

(1) Disconnect all signal cables and the power cord from the 8210.

(2) Remove two 4-40 screws securing the top cover at the rear panel.

Digital/Power Supply PCB
(A4)

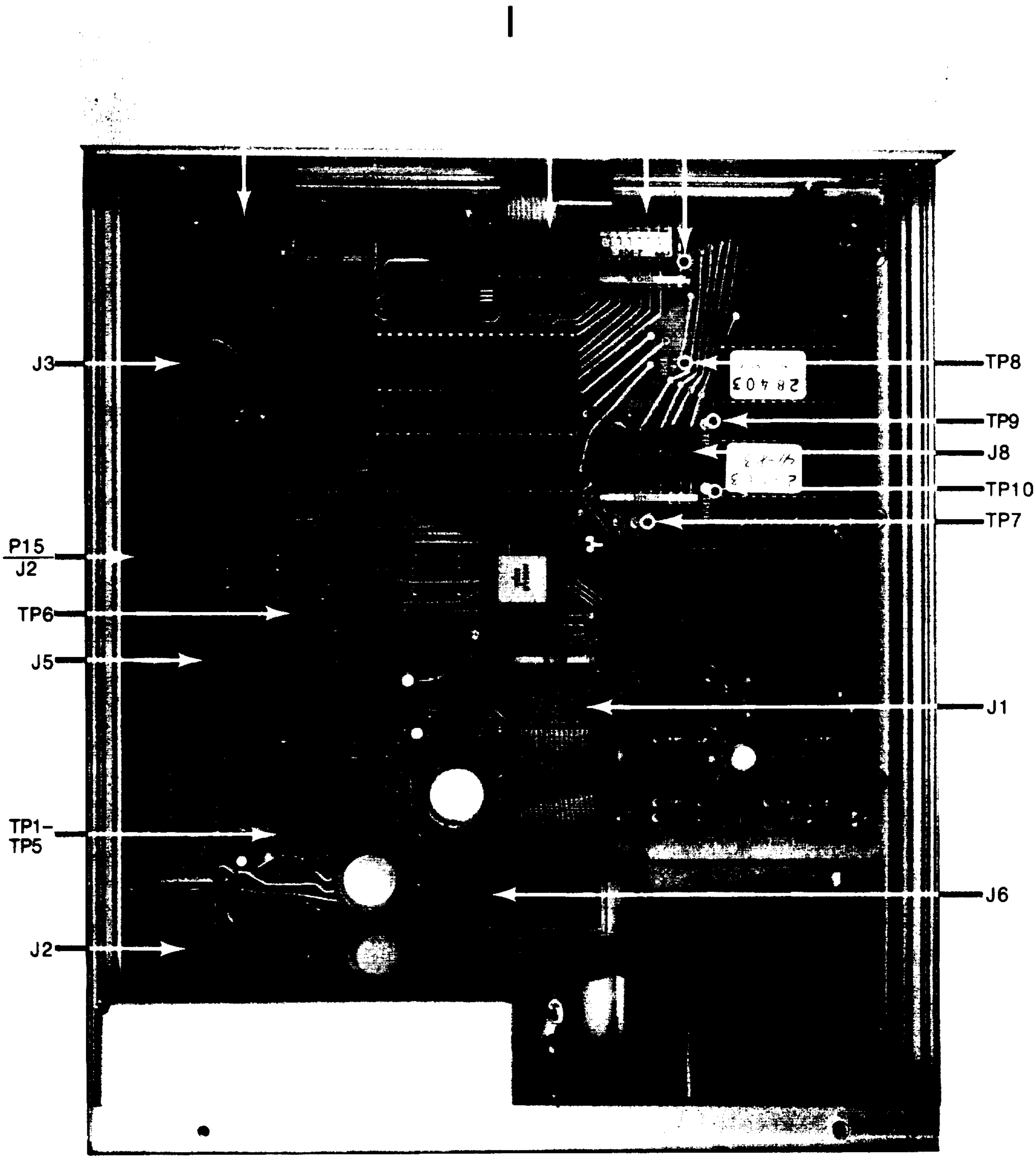


Figure 4-1. Model 8210: Top View with Covers Removed

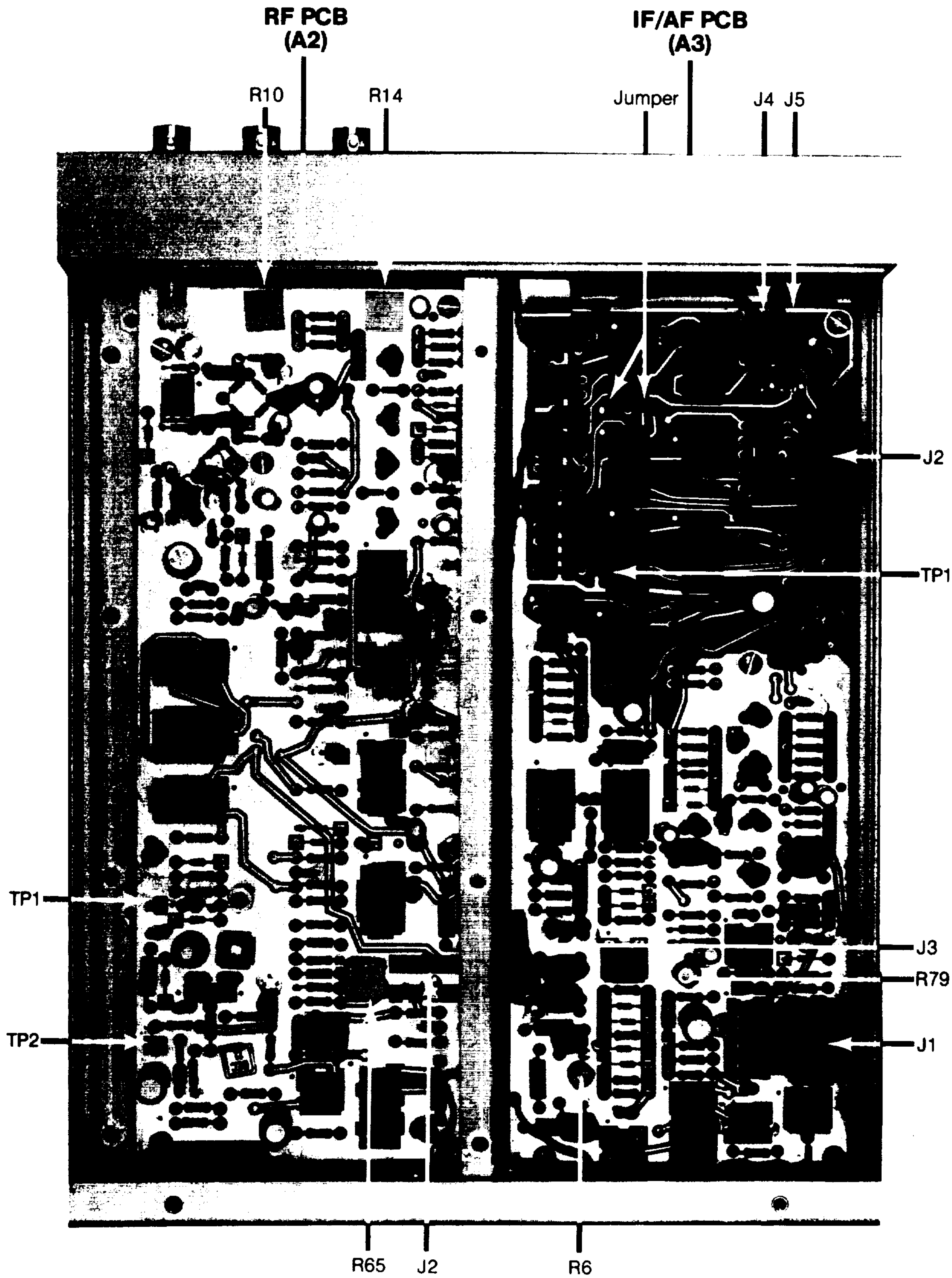


Figure 4-2. Model 8210: Bottom View with Covers Removed

4-4a, Continued.

(3) Remove the cover by lifting up and toward the rear of the unit.

(4) Turn the instrument over and remove the two #4-40 screws securing the bottom cover.

(5) Remove the bottom cover as in Step (3).

b. R.F.-Assembly Cover.

(1) Remove the 8210's covers as in 4-4a.

(2) Place the instrument on a smooth working surface, with the bottom side up.

(3) Remove the nine #4-40 screws that secure the R.F.-Assembly cover.

(4) Push the cover toward the rear of the instrument and lift the front of the cover upwards.

(5) Pull the cover toward the front of the instrument and remove it.

c. R.F. Circuit Board.

(1) Remove the instrument's covers (4-4a).

(2) Remove the cover of the r.f assembly (4-4b).

(3) Remove the if. connection at the r.f. circuit board.

(4) Turn the instrument over and disconnect ribbon connector A1P4.

(5) Remove the five #4-40 screws and the one hex standoff securing the circuit board.

(6) Carefully slide the circuit board toward the rear of the instrument to disengage the r.f. input connector.

(7) Lift the circuit board out of the instrument.

d. I.F.-A.F. Circuit Board.

(1) Remove the instrument's covers (4-4a).

(2) Remove the if. connection at the rear of the i.f.-a.f. circuit board.

(3) Disconnect both ribbon connectors on the left edge of the circuit board.

(4) Disconnect both two-pin connectors at the front edge of the circuit board; disconnect the two-pin connector at the right edge of the circuit board.

(5) Remove the five #4-40 screws securing the circuit board, and lift out the board.

e. Rear-Panel Assembly.

(1) Remove the instrument's covers (4-4a).

(2) Disconnect the power connector, A1P14.

(3) Disconnect the power-switch connector, A1P15.

4-4e, Continued.

(4) Remove three #6-32 screws securing the rear panel to the chassis.

(5) Remove two 44-40 screws securing the rear panel to the power-supply heat sink.

(6) Pull the rear panel away from the chassis.

f. Digital Circuits and Power-Supply Board.

(1) Remove the instrument's covers (14-4a).

(2) Disconnect the four ribbon connectors A1P7, A1P8, A1P9 and A1P11.

(3) Disconnect pin connector A1P13.

(4) Disconnect two-pin connector A1P10.

(5) Remove the rear-panel assembly (4-4e).

(6) Remove seven #4-40 screws securing the circuit board, and lift the board out of the chassis.

g. Display Circuit Board (Access or Removal).

(1) Remove the instrument's covers (4-4a).

(2) Remove three #4-40 screws securing the top trim-strip extrusions and grounding clip.

(3) Grasp the trim strip by its edges and pull it away from the instrument's frame.

(4) Carefully remove the plexiglass display window.

(5) Turn the instrument over and remove the bottom trim-strip extrusion as in steps (2) and (3) , above.

(6) Tilt the bottom of the front trim panel away from the instrument until all switches are cleared, then pull the front panel up and out to clear the center trim extrusion.

NOTE : This completes the procedure for gaining access to the Display Circuit board. If it is necessary to remove the board, carry on as follows:

(7) Disconnect the ribbon-cable connector from the rear of the board.

(8) Disconnect the power-switch connector, A1P15.

(9) Disconnect the power-indicator connector, A1P13.

(10) Remove the two #4 flat-head screws securing the center trim extrusion. Lift out the extrusion.

(11) Remove the four #4-40 screws securing the circuit board, and lift the board out of the instrument.

4-5. REMOVAL OF DETAIL PARTS

In the design of the 8210, much thought was given to maintainability. Most detail parts are readily available for checking and replacement once the instrument's covers and shields are removed. Solid-state components, on plated-through circuit boards, are used throughout the instrument. Sockets are used for all active components except for the power-supply regulators.

Standard printed-circuit-board maintenance techniques are required for the removal and replacement of parts. Excessive heat must be avoided; a low-wattage soldering iron, together with suitable heat sinks, should be used for all soldering and unsoldering operations.

4-6. PRELIMINARY CHECKS

a. Visual Check. If equipment malfunction occurs, perform a visual check of the 8210 before performing electrical tests. Visual checks often help to isolate, quickly and simply, the cause of a malfunction. Inspect for signs of damage caused by excessive shock or vibration, such as: broken wires, loose hardware, and loose electrical connections. Then check for signs of overheating, which may be caused by an electrical short-circuit or an accumulation of dirt and other foreign matter.

Correct any problems discovered through the visual check. If the trouble persists, proceed with the electrical checks.

b. Power-Supply Check. Improper operation of the 8210 may be caused by incorrect d.c. operating voltages. Before proceeding with any other electrical checks, perform the power-supply checks given in Table 4-2.

***** WARNING *****

Line voltages up to 240 volts, a.c., may be encountered in the power-supply circuits. To protect against electrical shock, observe suitable precautions when connecting and disconnecting test equipment, and when making voltage measurements.

Table 4-2. Power-Supply Checks

STEP	PROCEDURE	NORMAL INDICATION
1)	Set the LINE switch to ON. Using a digital voltmeter, measure the d.c. voltage at the +15 V supply rail, A4TP5.	14.75 to 15.25 V
2)	Using a digital voltmeter, measure the d.c. voltage at the -15 V supply rail, A4TP2.	-14.75 to -15.25 V
3)	Using a digital voltmeter, measure the d.c. voltage at the +5 V supply rail, A4TP4.	4.90 to 5.10 V
4)	Using a digital voltmeter, measure the d.c. voltage at the -7.5 V supply rail, A4TP3.	-7.33 to -7.68 V
5)	Using a digital voltmeter, measure the d.c. voltage of the +5(L) supply (pin 24, A4U11).	4.75 to 5.25 V
6)	Using an oscilloscope, measure the a.c. ripple at the +15, -15, +5 and -7.5 V supply rails.	Less than 1 mV, peak-to-peak.

In case of abnormal indications. refer to Table 4-11, a systematic trouble-shooting chart for the power supplies.

4-7. TROUBLESHOOTING

a. Concepts. Logical trouble-localization involves three major procedures:

(1) symptomatic troubleshooting, used to localize the cause of a malfunction to a major circuit group;

(2) systematic troubleshooting within the affected circuit group, used to localize the cause to a specific circuit or stage; and,

(3) voltage measurements, waveform analysis, or signature analysis--all used to isolate the defective part.

b. Symptomatic Troubleshooting: Discussion. The design of the Model 8210 facilitates symptomatic troubleshooting. Various "condition codes" are displayed both" as a guide to proper operation and to localize a malfunction to a major circuit group (see Table 4-3). Moreover, certain circuit groups can be switched in and out of operation by an internal seven-position Test Switch (refer to Table 4-4). with a grasp of the detailed block diagrams (Figures 3-1 through 3-8), and of the function of each position of the Test Switch, along with manipulation of the front-panel controls, the user is well on the path to localizing the cause of a malfunction to one or more of the major circuit groups. In addition, a variety of symptoms is listed in Table 4-5, together with the probable causes of the malfunctions.

c. Systematic Troubleshooting: Discussion. Once you have localized the cause of a malfunction to a major circuit group, refer to the appropriate Systematic Troubleshooting Chart (Tables 4-6 through 4-11). These charts give instructions to help further localize a cause of malfunction to a particular stage or even to the component of that stage likely to be causing the trouble.

d. Measurements and Analyses: Discussion. The 8210 uses both analog and digital circuitry. Tables 4-6 through 4-11, information on the schematic diagrams (Figures 6-1 through 6-7), and waveform data in Table 4-12, are intended to assist in troubleshooting the analog circuits. Frequently this will suffice--without having to look into the digital circuitry. In case the tests in the analog portions have not solved the problem, some of the troubleshooting tables continue with tests (still using an oscilloscope and voltmeter) , for the digital portions of the circuits.

However, the digital circuitry of the 8210 uses a microprocessor in a bus-oriented system. In such circuits, d.c.- and a.c.-measuring instruments are not always adequate to isolating problems, and a new technique, called signature analysis, has been developed. The troubleshooting chart for the 8210's logic circuits accordingly has tests that utilize an oscilloscope, and also has tests that call for signature analysis.

A complete discussion of signature analysis is beyond the scope of this manual; however, a brief description will aid in understanding its use in maintenance of the 8210.

Long, complex data streams are present in any microprocessor bus-oriented system. In signature analysis, with the system operating at normal speed, these data streams are compressed into concise, easy-to-interpret readouts {signatures) measured at pertinent data nodes. By choosing the appropriate measuring periods, or windows, signatures become unique: one, and only one signature occurs at any given node of the instrument in normal operation.

Using a test device known as a signature analyzer you can therefore proceed through the instrument in an orderly fashion: you compare the signature you find at each specified node to the signature that the instrument's manufacturer tells you ought to be at that node, until an improper signature is obtained. General at that Point it is possible for you to deduce which component is the most probable cause of the malfunction.

Table 4-3. Condition-Code Displays

DISPLAY	MEANING
CAL	Instrument in calibration (takes approximately 30 seconds).
cc1	8210 has failed to calibrate properly the a.m. channel.
cc2	8210 has failed to calibrate properly the f.m. channel.
----	8210 is unlocked, due to improper r.f.-input frequency or level or to a malfunction in the r.f. circuits.
--	8210 is in unleveled state, due to low modulation frequency or to a malfunction in the i.f. circuits.
IFLO	R.F. input too low in amplitude, or there is a malfunction in the r.f. circuits.
IFHI	R.F. input too high in amplitude, or there is a malfunction in the r.f., i.f., or a.f. circuits.
dSP	The panel meter is over-ranged.

Table 4-4. Troubleshooting Test-Switch Chart

SWITCH POSITION	FUNCTION	AID IN TROUBLESHOOTING THE FOLLOWING CIRCUITS
1	Disables the automatic frequency-lock loop.	a) Oscillator b) Band-switching c) Attenuator d) Discriminator e) Integrator f) Logic
2	Disables the automatic gain control loop.	a) Automatic gain control b) Logic
3	Disables the frequency-control loop and the auto-zero circuit.	a) Audio b) Peak Detector c) Voltmeter
4	Operates data-acquisition circuits in an endless loop.	a) Voltmeter b) Logic

Table 4-4. Troubleshooting Test-Switch Chart (Continued)

SWITCH POSITION	FUNCTION	AID IN TROUBLESHOOTING THE FOLLOWING CIRCUITS
5	LED test: enables the display (lights all segments), decimal points & annunciators.	a) Logic; ports A, B, & C of U17 and associated buffers. b) Display circuit-board assembly.
5 Plus LEVEL	Tests I/O port of U16. Loads three output ports with hex 55 or hex AA, depending upon PEAK setting.	a) Logic; ports A, B, & C of U16--used for logic control of r.f., i.f., a.f. and calibrator circuits.
6	8210 displays month and year of the installed program.	a) Facilitates testing (signature analysis) of special or updated versions. b) Aids in ordering correct spare PROM's.
7	Operates calibrator circuits in an endless loop.	a) Calibrator b) I.F. c) A.F.

Table 4-5. Symptomatic Troubleshooting Chart

SYMPTOM	PROBABLE CAUSE OF MALFUNCTION
After power-on, instrument fails to display CAL.	One of the Test Switches (A4S1) is on; or defective logic circuits (refer to Table 4-9).
During calibration cycle, 8210 displays ccl.	Defective calibrator circuits (see Table 4-10); or defective i.f. circuits (refer to Table 4-7).
During calibration cycle, 8210 displays cc2.	Defective i.f. circuits (refer to Table 4-7).
The 8210 fails to exit from CAL mode.	Defective logic circuits (refer to Table 4-9).
Instrument fails to lock.	Defective r.f. circuits (Table 4-6).
8210 locks but fails to level properly.	Defective i.f. circuits (refer to Table 4-7).
8210 displays IFLO when proper signal is applied to RF IN.	Defective i.f. circuits (refer to Table 4-7).
8210 displays IFHI when proper signal is applied to RF IN.	Defective i.f. circuits (refer to Table 4-7).

Table 4-5. Symptomatic Troubleshooting Chart (Continued)

SYMPTOM	PROBABLE CAUSE OF MALFUNCTION
A.M. incorrect or inoperative.	Defective r.f. circuits (Table 4-6); defective a.f. circuits (Table 4-8).
F.M. incorrect or inoperative.	Defective a.f. circuits (Table 4-8).
One or more low-pass filters inoperative.	Defective a.f. circuits (refer to Table 4-8).
One or more peak indications incorrect.	Defective a.f. circuits (refer to Table 4-8).
One or more panel switches inoperative.	Defective logic circuits (refer to Table 4-9).
One or more switch annunciators inoperative.	Defective logic circuits (refer to Table 4-9).
All digital panel-meter displays incorrect or inoperative.	Defective logic circuits (refer to Table 4-9).
8210 does not range properly.	Defective a.f. circuits (Table 4-8).
A.F. output missing or incorrect.	Defective a.f. circuits (Table 4-8).
I.F. output missing or incorrect.	Defective i.f. circuits (Table 4-7).

Table 4-6. Systematic Troubleshooting Chart: R.F. Circuits

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
●	OSCILLATOR CIRCUITS	●
1) Power off. Set Test Switch (A4S1) Pos. #1 to "on." Remove r.f. cover & turn power on. Connect 'scope to A2TP1.	R.F. signal between 26 & 38 MHz, > 1 V, p-p.	Isolate defective component in oscillator circuit A2Q8 - A2CR10.
2) Connect 'scope to collector of A2Q7.	TTL signal between 26 & 38 MHz.	Replace A2Q7 or A2CR7.
3) Connect 'scope to pin 8 of IC A2U3d.	TTL signal between 26 & 38 MHz.	Replace A2U3.
4) Connect 'scope to pin 9 of A2U1.	TTL signal between 13 & 19 MHz.	Replace A2U1.
5) Connect 'scope to pin 3 of A2U1. Depress +PEAK button.	TTL signal, approx. 4 MHz.	Replace A2U2, A2U3; or malfunction in logic circuits (Steps 28-33).
6) Depress 3 kHz button	TTL signal; frequency should decrease.	Same as in Step 5.

Table 4-6. Systematic Troubleshooting Chart: R.F. Circuits (Continued)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
• OSCILLATOR CIRCUITS (CONTINUED) •		
7) Depress the 750 μs button.	TTL signal; frequency should decrease.	Same as in Step 5.
8) Connect 'scope to pin 6 of A2U1.	See Waveform 1, in Table 4-12.	Replace A2U1; or check for open A2R13, A2C15.
• PULSE GENERATOR •		
9) Connect 'scope to collector of A2Q1.	See Waveform 2, in Table 4-12.	Check for open A2CR1, A2Q1, A2R1; or replace A2T1 or A2CR3.
10) Connect 'scope to junction of A2R8 and A2C7.	See Waveform 3, in Table 4-12.	Check for open A2C7, A2R8, A2R9, A2R20; or replace A2T2 or A2CR4.
11) Connect 'scope to junction of A2C14 and A2R19.	Same as in Step 10,but with reversed polarity.	Check for open A2C14, A2R19.
• R.F. INPUT, SAMPLER, AND SAMPLING AMPLIFIER •		
12) Connect 'scope to junction of A2R12 and A2CR2b. Connect a 2.4 MHz, +7 dBm signal to RF IN connector.	2.4 MHz signal, approximately 1.4 V, peak-to-peak.	Check for open A2C3 or A2R3.
13) Connect 'scope to junction of A2C23 and A2R32. Depress the 750 μs button.	Approximately 400 kHz, 1.4 V, p-p, with a 2.8 MHz signal added. See Waveform 4, in Table 4-12.	Isolate defective component in sampler or sampling amplifier by d.c. voltage and waveform measurements.
14) Connect 'scope to pin 1, A2U4.	Approximately 5 V, d.c.	Defective 16-conductor ribbon cable W4 (or pin connections); or defective A2U4; or malfunction in logic circuit (Table 4-9).
15) Connect 'scope to pin 6 of A2U5. Depress 10 RANGE button.	Approximately 400 kHz, with a 2.8 MHz signal added; approximately 600 mV, peak-to-peak.	Replace A2U5 or A2U4; refer to Table 4-9.
• AUTOMATIC FREQUENCY-LOCK-LOOP CIRCUITS •		
16) Connect 'scope to pin 8 of A2U4. Depress the 750 μs and the +PEAK buttons.	Approximately 5 V, d.c.	Check for open pin 4 in 16-conductor ribbon cable W4; or replace A2U4; or refer to Steps 34-39.

Table 4-6. Systematic Troubleshooting Chart: R.F. Circuits (Continued)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
• AUTOMATIC FREQUENCY-LOCK-LOOP CIRCUITS (CONTINUED) •		
17) Connect 'scope to junction of A2L9 & A2R53. Depress the 100 RANGE pushbutton.	300 to 500 kHz, with a 2.8 MHz signal added; approximately 2.5 V, peak-to-peak.	Check A2L6 or A2L9 for open circuit; or bad A2U4.
18) Depress the 3 kHz button.	Very small residual of signal in Step 17.	Replace A2U4, or see Table 4-9.
19) Connect 'scope to junction of A2L10 & A2R55. Change frequency of generator to about 2.9 MHz.	300 to 600 kHz, with a 3.3 MHz signal added; approximately 2.5 V, peak-to-peak.	Check A2L7 or A2L10 for open circuit; or bad A2U4.
20) Connect 'scope to pin 14 of A2U8.	Same as Step 19, but attenuated by 20 dB.	Check for open A2C48.
21) Connect 'scope to pin 8 of A2U8. Set generator frequency to 2.4 MHz. Depress the 750 μs button.	300 to 500 kHz square wave, about 3.5 V, p-p, on top of approx. 12 V, d.c.	Check A2CR12 for short circuit; or replace A2U8.
22) Connect 'scope to pin 3 of A2U9. Set i.f. to about 400 kHz by varying generator's frequency above or below 2.4 MHz.	400 kHz square wave, approximately -0.5 to +2 volts.	Check for open A2C57, A2CR12, A2CR11; or replace A2U9.
23) Connect 'scope to pin 6 of A2U9.	TTL signal, with pulse about 2.5 μs wide.	Check for open A2R70, A2C58; or replace A2U9.
24) Connect 'scope to pin 7 of A26U. Depress -PEAK button.	400 kHz square wave, approximately 5.5 V, peak-to-peak.	Check for open A2R65. Replace A2U6. Refer to Steps 34-39.
25) Connect 'scope to pin 1 of A2U6. Depress the 3 kHz and +PEAK buttons.	0 volts, d.c., approx.	Replace A2U7 or A2U6; check for open A2R51. Refer to Steps 34-39.
26) Depress the -PEAK & 750 μs buttons. Vary generator's frequency about 50 kHz above & below the initial setting.	A.C. ripple < 400 mV, p-p. D.C. voltage will move below & above the baseline as the frequency of the r.f signal is changed.	Check for open A2C47. Replace A2U7. Refer to Steps 34-39.
27) Reset generator's frequency for 0 V at pin 1 of A2U6. Press the AVG button. Offset the generator frequency by 100 kHz.	Initially, 0 V, d.c., then slowly drifting to approximately ± 2.4 volts, d.c.	Defective A2C47; or replace A2U7 or A2U6. Refer to Steps 34-39.

Table 4-6. Systematic Troubleshooting Chart: R.F. Circuits (Continued)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
• DIGITAL PORTION: OSCILLATOR BANDSWITCHING •		
28) Connect 'scope to pin 2 of A2U3. Depress 15 kHz button.	5 volts, d.c.	Repair or replace W4 cable, or refer to Table 4-9.
29) Depress the 3 kHz filter button.	0 volts, d.c.	Same as Step 28.
30) Depress the 750 μs filter button.	5 volts, d.c.	Same as Step 28.
31) Connect 'scope to pin 4 of A2U3. Depress 15 kHz button.	0 volts, d.c.	Same as Step 28 or replace defective A2U4.
32) Depress the 3 kHz filter button.	0 volts, d.c.	Same as Step 31.
33) Depress the 750 μs filter button.	5 volts, d.c.	Same as Step 31.
• DIGITAL PORTION: AUTOMATIC FREQUENCY-LOCK-LOOP SWITCHING LOGIC •		
34) Connect 'scope to pin 10 of A2U7. Depress +PEAK button.	5 volts, d.c.	Check for open circuit in W4 cable; replace A2U7; or check malfunction in logic circuits (see Table 4-9).
35) Depress the -PEAK button.	0 volts, d.c.	W4 cable may have a short circuit; or look for malfunction in the logic circuits (see Table 4-9).
36) Depress AVG button.	0 volts, d.c.	Same as Step 34 or 35.
37) Connect 'scope to pin 11 of A2U7.	0 volts, d.c.	Same as Step 34 or 35.
38) Depress the -PEAK button.	5 volts, d.c.	Same as Step 34 or 35.
39) Depress the +PEAK button.	0 volts, d.c.	Same as Step 34 or 35.

Table 4-7. Systematic Troubleshooting Chart: I.F. Circuits

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
1) Power off. Set Test Switch (A4S1) Pos. #7 "on." Power on. Do NOT press LEVEL button.		
2) Connect 'scope to pin 3 of A3U1. Depress the AM button.	447.4 kHz sine wave, approximately 1.9 V, peak-to-peak.	Open pin 15 in W5, the 16-conductor ribbon cable; or malfunction in calibrator circuits (see Table 4-10, Steps 1 through 9).
3) Connect 'scope to pin 6 of A3U1.	Same as Step 2, but doubled in amplitude.	Replace A3U1.
4) Connect 'scope to pin 1 or pin 16 of A3U3.	874 Hz TTL signal.	Open pin 13 in the W5 cable; or check for a malfunction in calibrator circuits (Table 4-10, Steps 2 and 5).
5) Depress FM button.	TTL logic 1.	Malfunction in calibrator circuits (see Table 4-10, Step 8).
6) Depress AM button. Connect 'scope to pin 6 of A3U3.	447 kHz sine wave, audio-modulated at an 874 Hz rate; 1.15 V, p-p. See Waveform 5, Table 4-12.	Check for defective A3R7a through A3R7c; or defective A3U3.
7) Connect 'scope in turn to pins 5 through 12 of A3U4.	On pin 6, a TTL high; on all others, TTL low.	Defective W5 cable; or malfunction in logic circuits (Table 4-9)
8) Connect 'scope to pin 4 of A3U4.	Same waveform as in Step 6; approximately 540 mV, p-p. (Depends upon setting of A3R79.)	Isolate defective component by voltage or waveform measurements. Check for open A3CR13, A3C4, A3C5, A3C6, A3R79; or replace A3U4.
9) Connect 'scope to pin 6 of A3U5.	Same as Step 6, but amplified to approx. 2.85 V, peak-to-peak.	Isolate defective component by voltage or waveform measurements.
10) Connect 'scope to the junction of A3C23 and A3CR6.	Same as Step 6, but amplified to approx. 5.7 V, peak-to-peak.	Isolate defective component by voltage or waveform measurements. Check for open A3C19, A3C22, A3C18, A3CR6, or A3CR7.
11) Connect 'scope to the junction of A3CR7 and A3R41.	The above waveform, half-wave rectified; 2.3 V, p-p. See Waveform 6, Table 4-12.	Same as Step 10.

Table 4-7. Systematic Troubleshooting Chart: I.F. Circuit (Continued)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
12) Connect 'scope to pin 11 of A3U10.	5 volts, d.c.	Defective 16-conductor ribbon cable W6 (or pin connections); or malfunction in logic circuits (Table 4-9).
13) Connect 'scope to pin 8 of A3U9.	874 Hz square wave & added 447 kHz sawtooth; about 1.3 V, p-p. See Waveform 7, Table 4-12.	Defective A3C27, A3R47; or replace A3U9.
14) Connect 'scope to pin 3 of A3U10.	Same as Step 13.	Replace defective A3U10.
15) Connect 'scope to pin 6 of A3U8.	Same as Step 9.	Defective A3U8; "short" in A3CR9 or A3CR10.
16) Connect 'scope to IF OUT connector.	Same as Step 9.	Defective A1P1, A1W1, or A1J3.
17) Connect 'scope to collector of A3Q1; Set time-base of 'scope to 1 μs/div.	447 kHz TTL signal. See Waveform 8 in Table 4-12.	Isolate defective component by voltage or waveform measurements. Suspect A3Q1, A3Q2, A3CR3, A3CR4, or A3CR5.
18) Connect 'scope to pin 1 of A3U7. Time-base at 0.5 μs/div.	A pulse: width about 2.1 to 2.4 μs; amplitude 5 V, p-p.	Width: check timing components A3C20,A3R33; or replace A3U7. Amplitude: check A3R43 through A3R46.
19) Connect 'scope to pin 13 of A3U10. Depress FM pushbutton.	447 kHz sawtooth; -0.5 to -2 volts, p-p.	Isolate defective component by voltage or waveform measurements. Check for open A3C28; or bad logic circuits (see Table 4-9).
20) Set Test-Switch Pos. #7 "off," #2 "on." Power "off," then "on."	12.8 appears on the front-panel display.	Malfunction in logic circuits (Table 4-9).
21) Connect 'scope to junction of A4R20 & A4C15; set for d.c. and V. Sensitivity @ 0.05 V per div. Hold depressed -PEAK button until 8210 displays 1.9 or 2.0.	Approximately 0.25 V, d.c.	Open A3R77; or defect in A1P5, A1W5, A1P8, A4R20, A4C15 or A4U20.
22) Adjust V. Position on 'scope so trace nears bottom of screen. Hold depressed +PEAK pushbutton of 8210.	Rise in d.c. voltage should be smooth (no "steps"), to about 3.5 V, d.c.	Defective A3J1, A1P5, A1W5, A1P8, A4J2, or A3U4; or defective logic circuits (see Table 4-9).

Table 4-7. Systematic Troubleshooting Chart: I.F. Circuits (Continued)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
23) Set Pos. #2 on Test Switch (A4S1) "off." Turn power off, then on. Allow completion of the calibration cycle. To RF IN apply a 30 MHz, -10 dBm signal with 50% 1 kHz a.m. Connect the 'scope to the junction of A3L3 and A3R3.	400 kHz sine wave with a.m.; amplitude approx. 0.82 V, peak-to-peak.	Problem in the i.f. filter circuit. Use waveform measurements to isolate the problem.
24) Connect 'scope to pin 6 of A3U2.	Same as Step 23, but amplitude increased to about 3.5 V, p-p.	Isolate defective component in circuit of input amplifier, using voltage and waveform measurements.
25) Connect 'scope to pin 8 or 9 of A3U3.	A TTL high.	Defective 16-conductor ribbon cable W5 (or pin connections); or malfunction in logic circuits (Table 4-9); or replace defective A3U3.
26) Connect 'scope to pin 6 or 11 of A3U3.	A TTL low.	
27) Increase level of generator to more than +13 dBm.	Display shows IFHI.	Defect in circuits of: a.f. (see Table 4-8); r.f. (Table 4-6); or logic (Table 4-9).
28) Reduce generator's level to -40 dBm.	Display shows IFLO.	Same as Step 27.

Table 4-8. Systematic Troubleshooting Chart: A.F. Circuits

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
1) (a) Power "off." (b) Disconnect A1P1 from A3J3 and connect it to A3TP1.* (c) Remove A3U10. (d) Set Pos. #3 on Test Switch (A4S1) to "on." (e) Set a.f. oscillator for 1 kHz, 106 mV, r.m.s. (f) Apply the a.f. signal to the IF OUT connector (A1J3). (g) Turn power "on." *Early 8210's do not have A3TP1. On these, omit (b), and change (f) as follows: Apply the a.f. signal to pin 3 of the A3U10 socket. Other steps unchanged. NOTE: "INDICATIONS" in this Table are approximate.		
2) Depress the front-panel 10 RANGE push-button. Connect 'scope to pin 13 of A3U11.	1 kHz sine wave; 300 mV, peak-to-peak.	Isolate defective component in the filter circuit A3U9c by waveform measurements. See also Steps 33 - 40.

Table 4-8. Systematic Troubleshooting Chart: A.F. Circuits (Continued)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
3) Set a.f. oscillator to about 72 kHz.	72 kHz sine wave; 210 mV (approx.), p-p	Same as Step 2.
4) Set a.f. oscillator to 1 kHz. Connect 'scope to pin 3, A3U11.	1 kHz sine wave; 300 mV, peak-to-peak.	Defective A3U11; or see Steps 33 - 40.
5) Depress 100 RANGE pushbutton.	As above, amplitude reduced by 20 dB (× 0.1).	As above; also check for defective A3R59.
6) Depress 10 RANGE. Connect 'scope to pin 14 of A3U9.	1 kHz sine wave; 3.3 V, peak-to-peak.	Replace A3U9, A3R61,or A3R63. Check for open decoupling capacitors.
7) Connect 'scope to pin 12 of A3U13.	Same as Step 6.	Isolate defective component in A3U12a circuit; or defective A3U12, A3U13.
8) Set a.f. oscillator to 5 kHz.	5 kHz sine wave; 3.3 V, peak-to-peak.	Same as Step 7.
9) Set a.f. oscillator to 15.00 kHz.	15 kHz sine wave; 2.25 to 2.41 V, p-p.	Check A3R71 or A3C47.
10) Set a.f. oscillator to 750 Hz. Connect 'scope to pin 14, A3U13.	750 Hz sine wave; 3.3 volts, peak-to-peak.	Isolate defective component in A3U12b circuit; or defective A3U12, A3U13.
11) Set a.f. oscillator to 3.00 kHz.	3 kHz sine wave; 2.25 to 2.41 V, p-p.	Check for defective A3R68 or A3C44.
12) Set a.f. oscillator to 50 Hz. Connect 'scope to pin 15, A3U13.	50 Hz sine wave; 3.3 volts, peak-to-peak.	Check for defective A3R69 or A3C45.
13) Set a.f. oscillator to 212 Hz.	212 Hz sine wave; 2.25 to 2.41 V, p-p.	Same as Step 12.
14) Set a.f. oscillator 5.00 kHz. Connect 'scope to pin 11, A3U13.	5 kHz sine wave; 2.2 volts, peak-to-peak.	Check for open/shorted capacitor, or open resistor. Check A3U13.
15) Perform tests given in Steps 38 and 39.		
16) Set a.f. oscillator to 1 kHz. Depress 8210's 15 kHz button. Connect 'scope to A3J4.	1 kHz undistorted waveform; 8.38 volts, peak-to-peak.	Isolate defective component, by voltage and waveform measurements, in A3U14 circuit.
17) Connect 'scope to pin 3 of A3U15. Depress 3 kHz button.	1 kHz sine wave,square-wave modulated; 3.3 V, peak-to-peak.	Isolate bad component, in A3U12-A3U15 circuit, by waveform measurements. See Step 40.

Table 4-8. Systematic Troubleshooting Chart: A.F. Circuits (ContinueD)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
18) Connect 'scope to A3J5. Depress the button labeled 750 μs.	Same as Step 17, but approximately 670 mV, peak-to-peak.	Defective A3U12, or shorted two-conductor cable W7.
19) Connect 'scope to AF OUT. Depress the button labeled 15 kHz.	Same as Step 16.	Defective A1P2, A1W2, or A1J4.
20) Connect 'scope to A4J5.	Same as Step 17.	Repair or Replace W7 (two-conductor cable).
21) Connect 'scope to pin 10 of A4U22.	5 volt logic signal.	Malfunction in logic circuits (Table 4-9).
22) With a 2nd 'scope probe, connect to pin 6, A4U23 (see Table 4-12, Fig.9, for 'scope settings).Connect r.m.s. voltmeter to AF OUT.Set a.f. oscillator to 50 Hz & adjust output for 2 V, r.m.s., on VM.	See Waveform 9 in Table 4-12.	Isolate defective components by waveform measurements. Suspect A4U22, A4U21, A4U23,or open A4CR4, A4CR6.
23) Connect probe B to pin 6, A4U24. See Table 4-12, Fig.10, for 'scope settings.	See Waveform 10 in Table 4-12.	Isolate defective component by waveform measurements. Suspect A4U22, A4U21, A4U24,or open A4CR5, A4CR7.
24) Connect probe B to pin 3, A4U20.	See Waveform 11 in Table 4-12.	Defective A4U20; or malfunction in logic circuits (Table 4-9).
• VOLTMETER SECTION •		
25) Power off. Set Test Switch Pos.#4 "on." Power on. "Short" pins 1 and 2 of A4TP6.		
26) Check the logic on pins 9, 10 & 11 of A4U20.	All high.	Malfunction in logic circuits. See Table 4-9, Steps 49 and 50.
27) Connect d.c. voltmeter to junction of A4R20 and A4C15.	Indicated d.c. voltage should be approx. 1 V.	Check for open circuit at pin 2 of cable W6 (16-conductor cable).
28) Move VM probe to pin 3 of A4U20.	Same as Step 27.	Replace defective A4U20.
29) Move VM probe to pin 6 of A4U2.	Indicated d.c. voltage 2.4 to 2.47 volts.	Replace defective A4U2.

Table 4-8. Systematic Troubleshooting Chart: A.F. Circuits (Continued)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
● VOLTMETER SECTION (CONTINUED) ●		
30) Connect 'scope to pin 6, A4U6. Adjust trigger level of 'scope for stationary display.	TTL signal; period approximately 1.5 μs.	Malfunction in logic circuits. Replace defective A4U6 or A4Q4.
31) Connect 'scope to collector of A4Q4. Adjust trigger level for stationary display.	Similar to Step 30, but signal swings from +12 to +14 volts.	Replace defective A4Q4 or A4U4.
32) Set 'scope for d.c., V. Sens.@ 0.2 V/div. & 0.05 μs/div. Connect probe to pin 2 of A4U4. Set trigger level for a stationary display.	Approximately 0.6 V, d.c.	Check for open diode A4CR2, or malfunction in logic circuits (see Table 4-9, Steps 1-14); or replace A4U4 or A4U7.
33) Remove short from pins 1 & 2, A4TP6.	D.C. voltage will go negative.	Same as Step 32.
● DIGITAL PORTION: A.F. CIRCUITS ●		
34) Connect 'scope to pin 11 of A3U10. Depress the FM FUNCTION pushbutton.	CMOS low.	Defective A3J2, A1P6, A1W6, A1P9; or logic-circuit malfunction (refer to Table 4-9).
35) Depress the AM FUNCTION pushbutton.	CMOS high.	Same as Step 34, or defective A3U10.
36) Connect 'scope to pin 11, A3U11. Depress 100 RANGE button.	CMOS high.	Same as Step 34, or defective A3U11.
37) Depress 10 RANGE.	CMOS low.	Same as Step 34.
38) Connect 'scope to pin 10, A3U11. Power off, then on, quickly.	Normal CMOS "low" will move toward "high" as power is switched on.	Same as Step 36.
39) Connect 'scope to pin 10 of A3U13. Depress, in turn:		
15 kHz pushbutton;	CMOS low.	Same as Step 34.
3 kHz pushbutton;	CMOS high.	As above, or bad A3U13.
750 μs pushbutton.	CMOS low.	Same as Step 34.
40) Connect 'scope to pin 9 of A3U13. Depress, in turn:		
15 kHz pushbutton;	CMOS low.	Same as Step 34.
3 kHz pushbutton;	CMOS low.	Same as Step 34.
750 μs pushbutton.	CMOS high.	As above, or bad A3U13.
41) Connect 'scope to pin 9 of A3U15.	CMOS logic signal.	Same as Step 34, or defective A3U15.

Table 4-9. Systematic Troubleshooting Chart: Logic Circuits

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
1) Connect 'scope to pin 10 of A4U1.	3.579 MHz TTL logic signal.	Replace A4U1, A4Y1, or A4C2.
2) Connect 'scope to pin 8 of A4U1.	Same as Step 1.	Replace A4U5.
3) Connect 'scope to pin 6 of A4U8.	1.789 MHz TTL signal.	Replace A4U5 or A4U9.
4) Connect 'scope to pin 1 of A4U3.	Approximately 874 Hz CMOS logic signal.	Replace A4U3.
5) Connect 'scope to pin 6 of A4U3.	447.35 kHz CMOS logic signal.	Replace A4U3 or A4U12.
6) Connect 'scope to pin 26 of A4U8.	TTL high.	Replace A4U1, or check for shorted A4C1.
7) Power off. Remove jumper A4J8.Connect signature analyzer per Table 4-9a. Power on. Run signature-analysis test of the address bus.	See Table 4-9a.	Defective A4U8, or a "short" in circuitry.
8) Connect 'scope in turn to data bus lines D0 - D7 of A4U8.	TTL signals on all lines.	Same as Step 7.
9) Connect 'scope in turn to remaining pins of A4U8.	TTL signals on pins 19, 21, 27 & 28. Pins 17, 18, 20, 22, 24 and 25 are TTL high.	Same as Step 7.
10) Connect 'scope to pin 8 of A4U6.	TTL logic signal	Defective A4U6, or a "short" in circuitry.
11) Connect signature analyzer per Table 4-9b and run test on the decoder: A4U10.	See Table 4-9b.	Defective A4U10, or a "short" in circuitry.
12) Connect signature analyzer per Table 4-9c; test PROM A4U11.	See Table 4-9c.	Defective A4U11, or a "short" in circuitry.
13) This step deleted, 12/83		
14) Replace jumper A4J8. Connect 'scope to pin 18 of A4U8.	TTL high.	Replace A4U13 or A4U6.
15) Connect 'scope to pin 3 of A4U5.	TTL logic signal, about 874 Hz.	Defective A4U1, or a "short" in circuitry.

Table 4-9. Systematic Troubleshooting Chart: Logic Circuits (Continued)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
16) Connect 'scope to pin 6 of A4U5.	TTL logic signal, 1.15 ms period.	Replace A4U5, A4U6, or A4U8.
17) Connect 'scope to pin 6 of A4U6.	TTL logic signal.	Replace A4U6 or A4Q4.
18) Connect 'scope to pin 8 of A4U6.	TTL logic signal.	Defective A4U6, or a "short" in circuitry.
19) Connect 'scope to pin 35 of A4U16.	TTL low.	Replace A4U1.
20) Connect 'scope to pin 35 of A4U17.	TTL low.	Same as Step 19.
21) Connect 'scope in turn to pins 18 through 22 of A4U17.	TTL logic signal.	Replace A4U17 or A4U18; or check for a "short" in circuitry.
22) Connect 'scope in turn to pins 11 through 15 of A4U18.	Same as in Step 21.	Defective A4U18, or a "short" in circuitry; or defective A4R16.
23) Connect 'scope to pin 4 of A4U17.	TTL low.	Defective A4U17, or a "short" in circuitry.
24) Depress the 15 kHz pushbutton.	See Waveform 12 in Table 4-12.	Check for open circuit: 16-conductor cable W8 (and its connections); also, A4CR8 & A4S8.
25) Depress the +PEAK pushbutton.	Same as in Step 24.	As above: W8 (etc.), A4CR9, A4S9.
26) Depress the FM pushbutton.	Same as in Step 24.	As above: W8 (etc.), A4CR10, A4S10.
27) Depress the 100 RANGE pushbutton.	Same as in Step 24.	As above: W8 (etc.), A4CR11, A4S11.
28) Connect 'scope to pin 3 of A4U17.	TTL low.	Defective A4U17, or a "short" in circuitry.
29) Depress the 3 kHz pushbutton.	Same as in Step 24.	Replace A4U17; check for open circuit in W8 (and its connections), or in A4S4.
30) Depress the -PEAK pushbutton.	Same as in Step 24.	Check for open circuit in W8 (etc.), & A4S5.
31) Depress the AM pushbutton.	Same as in Step 24.	As above: W8 (etc.), A4S6.
32) Depress the 10 RANGE pushbutton.	Same as in Step 24.	As above: W8 (etc.), A4S7.

Table 4-9. Systematic Troubleshooting Chart: Logic Circuits (Continued)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
33) Connect 'scope to pin 2 of A4U17.	TTL low.	Replace A4U17; check "short" in circuitry.
34) Depress the 750 μs pushbutton.	Same as in Step 24.	Check for open circuit: W8 (etc.), A4S1.
35) Depress the AVG pushbutton.	Same as in Step 24.	As above: W8 (etc.), A4S2.
36) Depress the LEVEL pushbutton.	Same as in Step 24.	As above: W8 (etc.), A4S3.
37) Set "on," one at a time, each position of Test Switch, A4S1; as each one is turned on, connect 'scope in turn to pins 3 through 9 of A4R14.	Same as in Step 24, on each pin, as each Test Switch position is turned 'on."	Replace A4U17, A4S1, or A4R14.
38) Set Test Switch Pos. #5 to "on." Turn power off, then on.	All display segments and legends "on."	Continue Steps 39 - 43. (If "Indication" is good, jump to Step 44.)
39) Connect 'scope in turn to pins 1 through 8 of A4U19.	See Waveform 13 in Table 12.	Replace defective A4U17 or A4U19.
40) As above, pins 11 through 18.	See Waveform 14 in Table 4-12.	Defective A4U19, or a "short" in circuitry.
41) Connect 'scope in turn to pins 9 through 16 of A5J1.	Same as in Step 40.	Check for "open" in W8 (etc.); or replace LED A4CR2 through A4CR7.
42) Connect 'scope in turn to pins 14 of A4SD1,A4SD2,A4SD3,A4SD4.	Same as in Step 24.	Check for open circuit in W8 (etc.).
43) Visually inspect display for missing segments or decimal points.	Same as in Step 38.	If the same segment is out on A4SD2 through A4SD4, check for open circuit. If outage is not common, replace faulty display(s).
44) Depress the LEVEL pushbutton.		
45) Depress the +PEAK button. Connect the 'scope in turn to pins PA0 through PA7, A4U16.	A0 A1 A2 A3 A4 A5 A6 A7 1 0 1 0 1 0 1 0	Replace A4U16 or A4U10; or check for a "short" in their circuitry.
46) Depress the -PEAK button. Connect the 'scope in turn to pins PA0 through PA7, A4U16.	0 1 0 1 0 1 0 1	Same as in Step 45.

Table 4-9. Systematic Troubleshooting Chart: Logic Circuite (Continued)

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
47) Connect the 'scope in turn to pins PB0 through PB7 of A4U16.	Same as in Step 46.	Defective A4U16; or a "short" in circuitry.
48) Depress the +PEAK button. Connect the 'scope in turn to pins PB0 through PB7, A4U16.	Same as in Step 45.	Same as in Step 47.
49) Connect the 'scope in turn to pins PC0 through PC7 of A4U16.	Same as in Step 45.	Replace A4U16 or A4U20; or check for a "short" in their circuitry.
50) Depress the -PEAK button. Connect the 'scope in turn to pins PC0 through PC7, A4U16.	Same as in Step 46.	Same as above.
51) Set Test Switch Pos. #5 "off." Power off. Power on.	Instrument is returned to operating condition.	

Table 4-9a. Signature-Analysis Chart: Address Field

PROCEDURE: Power off. Remove jumper A4J8, located on the Power-Supply-and-Digital-Circuits board. Set the Signature Analyzer's controls, and connect it, as shown below. Turn the 8210 "on".

SIGNATURE ANALYZER SWITCH SETTINGS & CABLE-CONNECTION POINTS:

Function	Switch Setting	Cable Connection
START	_┌‾	Pin 5 of A4U8 (TP7)
STOP	‾┐_	Pin 20 of A4U7 (TP7)
CLOCK	‾┐_	Pin 8 of A4U6 (TP8)

SIGNATURE ANALYZER PROBE CONNECTIONS:

Item	Test Point: Pin on A4U8	Correct Signature	Item	Test Point: Pin on A4U8	Correct Signature
Common	29	0000	A7	37	A3C1
V_{CC}	11	755U	A8	38	7707
A0	30	H335	A9	39	577A
A1	31	C113	A10	40	HH86
A2	32	7050	A11	1	89F1
A3	33	0772	A12	2	AC99
A4	34	C4C3	A13	3	PCF3
A5	35	AA08	A14	4	1180
A6	36	7211	A15	5	755U

Table 4-9b. Signature-Analysis Chart: Decoder Circuit

PROCEDURE: Same as in Table 4-9a.

SIGNATURE ANALYZER SWITCH SETTINGS & CABLE-CONNECTION POINTS:

Function	Switch Setting	Cable Connection
START	↑	Pin 5 of A4U8 (TP7)
STOP	↓	Pin 20 of A4U7 (TP7)
CLOCK	↑	Pin 8 of A4U6 (TP8)

SIGNATURE ANALYZER PROBE CONNECTIONS:

Item	Test Point: Pin on A4U10	Correct Signature	Item	Test Point: Pin on A4U10	Correct Signature
Common	8	0000	CS2	3	868C
+5 V	16	755U	CS3	4	970C
CS0	1	1817			
CS1	2	7FF8			

Table 4-9c. Signature-Analysis Chart: PROM A4U11 (June, 1983)*

PROCEDURE: Same as in Table 4-9a.

SIGNATURE ANALYZER SWITCH SETTINGS & CABLE-CONNECTION POINTS:

Function	Switch Setting	Cable Connection
START	↓	Pin 1 of A4U10 (TP9)
STOP	↑	Pin 1 of A4U10 (TP9)
CLOCK	↑	Pin 8 of A4U6 (TP8)

SIGNATURE ANALYZER PROBE CONNECTIONS:

NOTE: PROM A4U11 MAY BE EITHER OF TWO TYPES: 2732, OR 2764.

Item	TYPE 2732 Test Point: Pin on A4U11	Correct Signature	Item	TYPE 2764 Test Point: Pin on A4U13	Correct Signature
Common	12	0000	Common	14	0000
+5 V	24	P254	+5 V	28	P254
D0	9	9738	D0	11	A10F
D1	10	76AA	D1	12	20CU
D2	11	663H	D2	13	1P4P
D3	13	6FFU	D3	15	F64A
D4	14	2CUH	D4	16	A1C7
D5	15	UHC1	D5	17	9056
D6	16	P56U	D6	18	7PF0
D7	17	U75P	D7	19	17H4

* To determine date of PROM: Set Pos. #6 of the Test Switch (A4S1) to "on". Turn power off, then on. The date of the PROM will appear on the 8210's display. Reset the Test Switch (all positions "off").

Table 4-10. Systematic Troubleshooting Chart: Calibrator Circuits

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
1) Power off. Set Pos. #7 of Test Switch (A4S1) "on." Power on. Depress LEVEL button. Connect 'scope to pin 2 of A4U9.	1.79 MHz TTL logic signal.	Replace A4U9, or bad logic circuits (see Table 4-9).
2) Connect 'scope to pin 3 of A4U9.	TTL signal, at about 874 Hz.	Replace A4U9 or A4U12; or defective logic circuits (Table 4-9).
3) Connect 'scope to pin 9 of A4U9.	TTL signal, switching from 357.9 to 447.4 kHz at an 874 Hz rate.	Replace A4U9.
4) Connect 'scope to pin 4 of A4U12.	TTL signal, 447.4 kHz.	Replace A4U12, or bad logic circuits (see Table 4-9).
5) Connect 'scope to pin 12 of A4U12.	TTL signal, 874 Hz.	Same as in Step 2.
6) Connect 'scope to pin 7 of A4U12. Depress the AM button.	TTL signal, 447.4 kHz.	Replace A4U12, or bad logic circuits (Table 4-9, Steps 44 - 50).
7) Connect 'scope to pin 9 of A4U12.	TTL signal, 874 Hz.	Same as in Step 6.
8) Depress FM button.	TTL high.	Same as in Step 6.
9) Connect 'scope to pin 3 of A3U1. Depress the AM button.	Sine wave, 447.4 kHz; approximately 1.9 V, peak-to-peak.	Check for open A4L1, A4L2, A4C8, A4C10, A4C11, or 16-conductor cable W5 (or its connections); or replace defective A3U1.
10) Connect 'scope to pin 6 of A3U1.	Same as in Step 9, but doubled in amplitude.	Replace defective A3U1.
11) Connect 'scope to IF OUT connector.	See Waveform 15, Table 4-12.	Bad i.f. circuits. Refer to Table 4-7, Steps 4 through 9, and 15.
12) Depress FM button	See Waveform 16, Table 4-12.	Replace A4U9; or bad i.f. circuits (see Table 4-7).
13) Connect 'scope to AF OUT connector. Depress the AM button.	874 Hz, 2.5 V, p-p. See Waveform 17, Table 4-12.	Bad i.f. circuits (refer to Table 4-7, Steps 4 through 10); or bad a.f. circuits (refer to Table 4-8, Steps 1 through 6, and 14 through 16).

Table 4-11. Systematic Troubleshooting Chart: Power Supply

STEP PROCEDURE	INDICATION	IF INDICATION IS ABNORMAL
(Line Voltage = 120)		
1) Connect 'scope to the junction of A4CR8 and A4C23.	8.55 to 9.45 V, d.c.; ripple approximately 350 mV, peak-to-peak.	Isolate defective component by voltage or waveform measurements.
2) Connect 'scope to the junction of A4CR9 and A4C24.	19.0 to 21.0 V; ripple approximately 350 mV, peak-to-peak.	Same as above.
3) Connect 'scope to the junction of A4CR9 & A4C25.	-19 to -21 V; ripple approximately 800 mV, peak-to-peak.	Same as above.
4) Connect voltmeter to pin 4, 6, or 8 of A4U7.	9.9 to 10.1 V, d.c.	Check A4C34 for short circuit; or defective A4U29, A4U7.
5) Connect VM & 'scope to the junction of A4CR18 and A4C35.	14.75 to 15.25 V; ripple less than 1 mV, peak-to-peak.	Isolate defective component by voltage measurements.
6) Connect VM & 'scope to the junction of A4CR19 and A4C36.	-14.75 to -15.25 V; ripple less than 1 mV, peak-to-peak.	Same as Step 5.
7) Connect VM & 'scope to pin 7 of A4U29.	7.33 to 7.68 V; ripple less than 1 mV, peak-to-peak.	Same as Step 5.
8) Connect VM & 'scope to the junction of A4CR15 and A4C33.	4.75 to 5.25 V; ripple less than 1 mV, peak-to-peak.	Same as Step 5.
9) Connect VM & 'scope to the junction of A4CR17 and A4C32.	4.90 to 5.10 V; ripple less than 1 mV, peak-to-peak.	Same as Step 5.

4-8. ADJUSTMENT AND ALIGNMENT PROCEDURES

This subsection lists all required adjustments and alignment Procedures. Note, however, that adjustment is not a substitute for troubleshooting: be certain that all other possible causes of equipment malfunction have been eliminated before making adjustments.

Connect the equipment, and depress the switches, as shown in Figure 4-3.

a. <u>I.F. Adjustment.</u>

(1) Remove the r.f.-assembly cover (4-4b).

(2) Set the output frequency of the signal generator to 100 MHZ, c.w., and the output level to 0 dBm.

(3) Adjust potentiometer A2R65 for a reading of 400 kHz, ± 5 kHz, on the frequency counter.

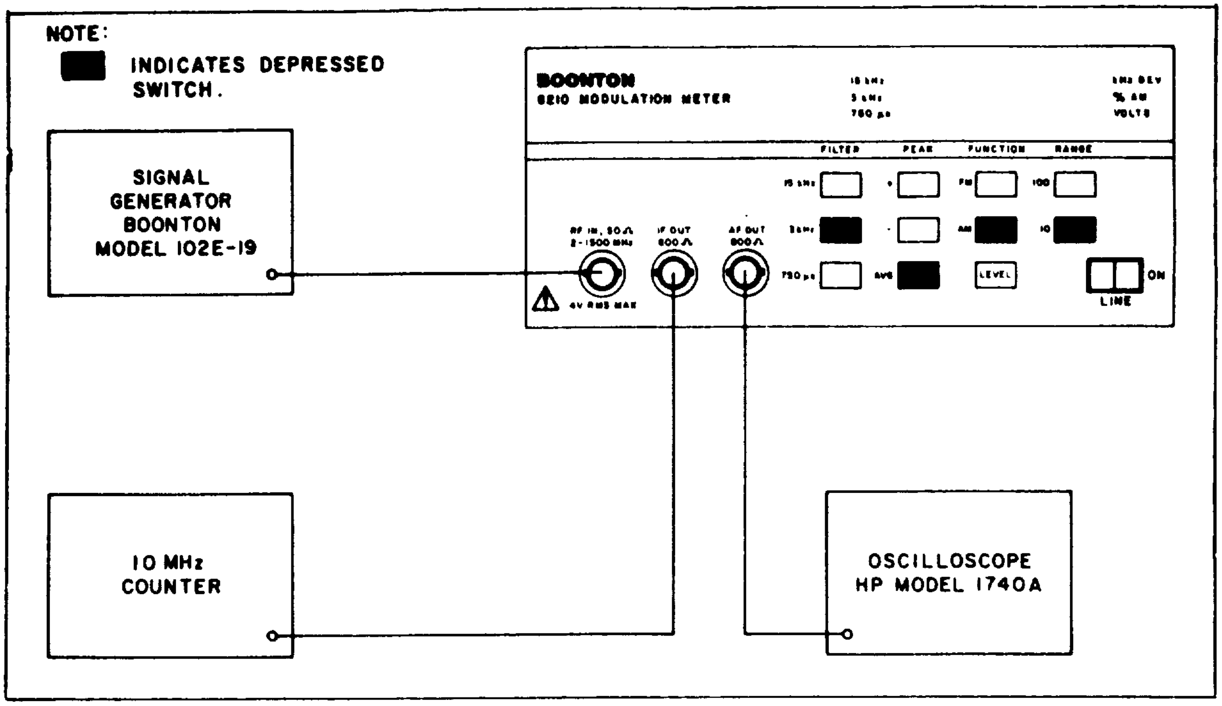


Figure 4-3. Test Setup: Adjustment and Alignment

b. <u>**R.F.** Efficiency and F.M. Rejection.</u>

(1) Replace the r.f.-assembly cover.

(2) Set the oscilloscope to 0.05 V/division and 1 ins/division.

(3) Set the signal generator to 2 **MHz, 0** dBm. Apply 100 kHz deviation at a 1 kHz rate. Let the if. to settle to within ± 5 kHz of 400 kHz (or, disconnect the 8210's r.f. input, then reconnect it).

(4) Adjust potentiometer A2R10 for a minimum indication on the 'scope.

(5) Set 102E-19's r.f. to 3.5 MHz. Wait til if. is 400 kHz ± 5 kHz.

(6) Adjust potentiometer A3R6 for a minimum indication on the 'scope.

(7) Repeat Steps 4-8b(3) through 4-8b(6) until the adjustment of either potentiometer increases the indication on the oscilloscope.

c. <u>R.F. Sensitivity Adjustment</u> (excepting early models: see Note, below).

(1) Set the 102E-19 to 2 MHz, approx. -29.5 dBm. Remove all modulation.

(2) If the 8210 displays IFLO, slowly adjust potentiometer A3R79* until a numeric display (i.e. , a display of residual modulation) appears.
* NOTE: Early model 8210's do not have potentiometer A3R79.

d. <u>R.F. Balance Adjustment.</u>

(1) Disconnect the r.f. input to the 8210.

(2) Disconnect the scope from AF OUT and connect it to RF IN.

(3) Set the 'scope to 0.005 V/div., 50 Ω input, and 0.5 **μs/div.**

(4) Adjust potentiometer A2R14 for a minimum indication on the 'scope.

Table 4-12. Systematic Troubleshooting: Waveforms

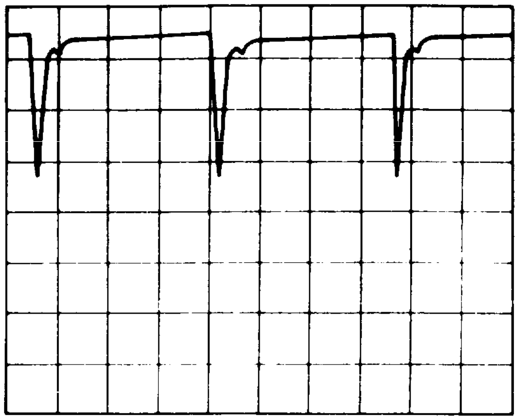
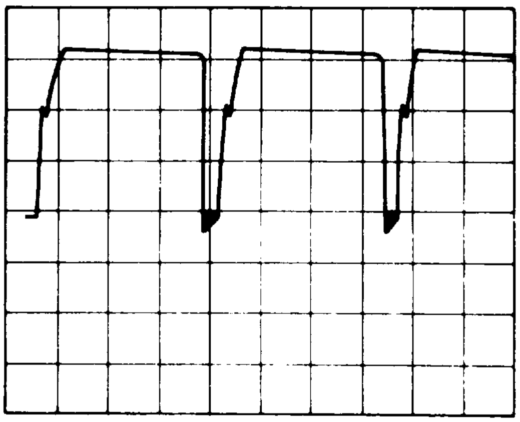
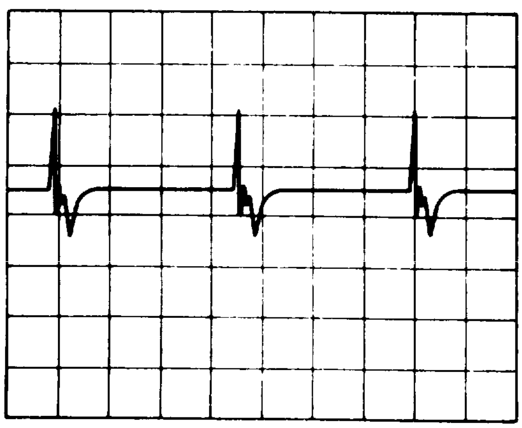
FIG. #	REFERENCE: TABLE	STEP	WAVEFORM	'SCOPE SETTINGS & SIGNAL CONDITIONS
1	4-6	8		Vertical: 1 V/division, d.c. Horizontal: 0.1 µs/division.
2	4-6	9		Vertical: 5 V/division, d.c. Horizontal: 0.1 µs/division.
3	4-6	10		Vertical: 0.5 V/division, a.c. Horizontal: 0.1 µs/division.

Table 4-12. Systematic Troubleshooting: Waveforms (Continued)

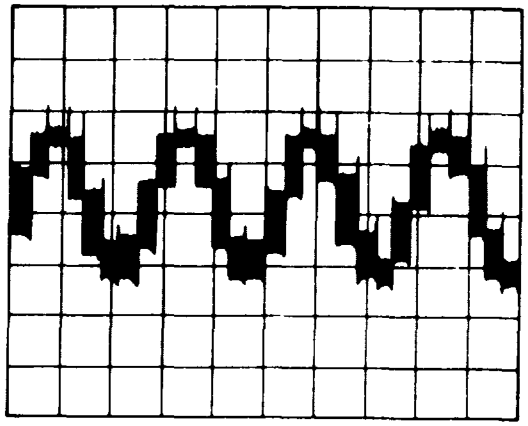
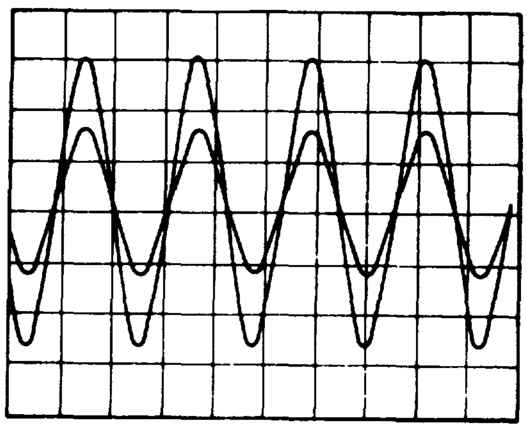
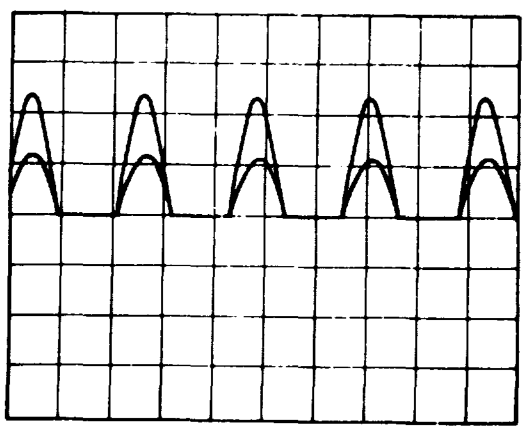
FIG. #	REFERENCE: TABLE	STEP	WAVEFORM	'SCOPE SETTINGS & SIGNAL CONDITIONS
4	4-6	13		Vertical: 0.5 V/division. Horizontal: 1 µs/division.
5	4-7	6		Vertical: 0.2 V/division. Horizontal: 1 µs/division.
6	4-7	11		Vertical: 1 V/division, d.c. Horizontal: 1 µs/division.

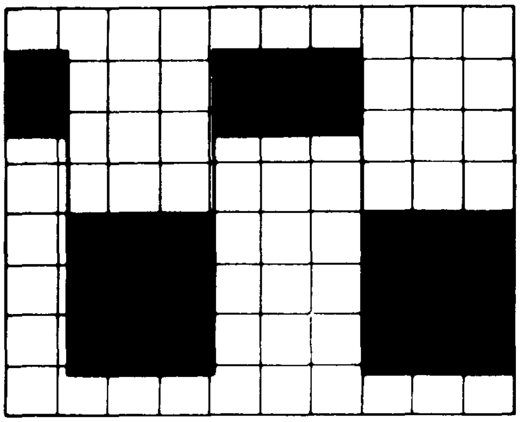
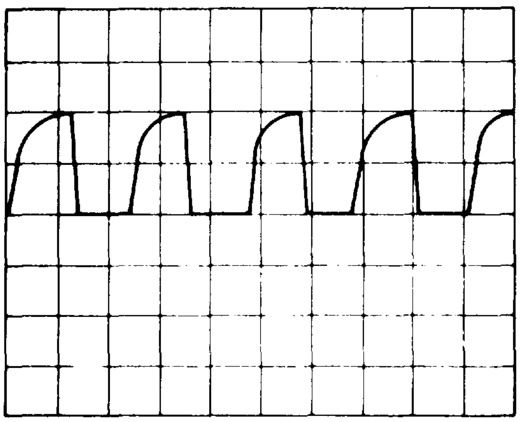
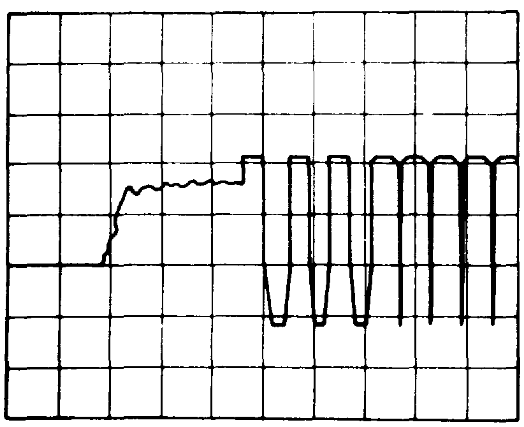
FIG. #	REFERENCE: TABLE	STEP	WAVEFORM	'SCOPE SETTINGS & SIGNAL CONDITIONS
7	4-7	13		Vertical: 0.2 V/division. Horizontal: 0.2 ms/division.
8	4-7	17		Vertical: 1 V/division, d.c. Horizontal: 1 μs/division.
9	4-8	22		Vertical (Channel A): 5 V/division, d.c. Channel-A probe to pin 10 of A4U22. Trigger on A. Negative trigger. Vertical (Channel B): 0.5 V/division, d.c. Display Channel B. Horizontal: Uncalibrated, 10 ms per division.

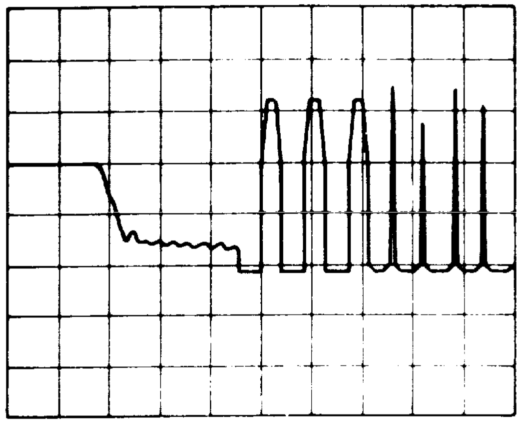
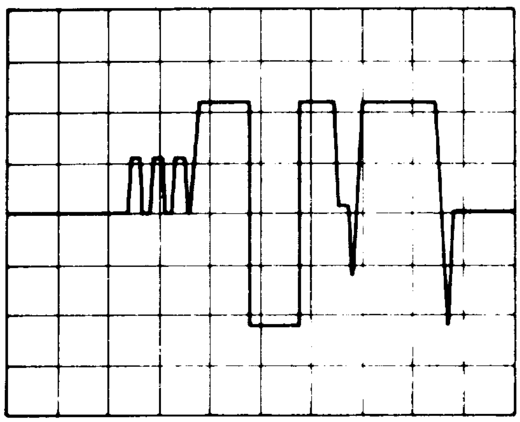
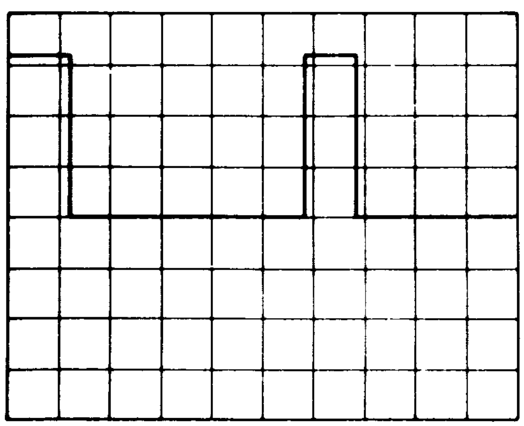
FIG. #	REFERENCE: TABLE	STEP	WAVEFORM	'SCOPE SETTINGS & SIGNAL CONDITIONS
10	**4-8**	**23**		Vertical (Channel A): 5 V/division, d.c. Channel-A probe to pin 10 of A4U22. Trigger on Channel A. Negative trigger. Vertical (Channel B): 0.5 V/division, d.c. Display Channel B. Horizontal: Uncalibrated, 10 ms per division.
11	**4-8**	**24**		Vertical (Channel A): 5 V/division, d.c. Channel-A probe to pin 10 of A4U22. Trigger on Channel A. Negative trigger. Vertical (Channel B): 0.5 V/division, d.c. Display Channel B. Horizontal: Uncalibrated, 20 ms per division.
12	**4-9**	**24**		Vertical: 1 V/division, d.c. Horizontal: 1 ms/division.

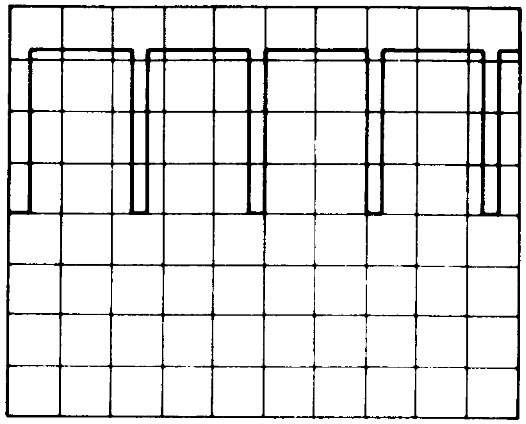
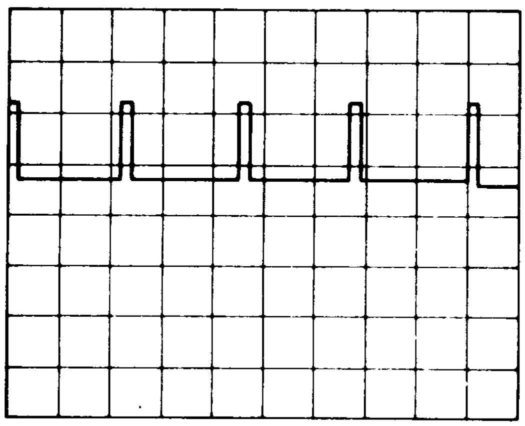
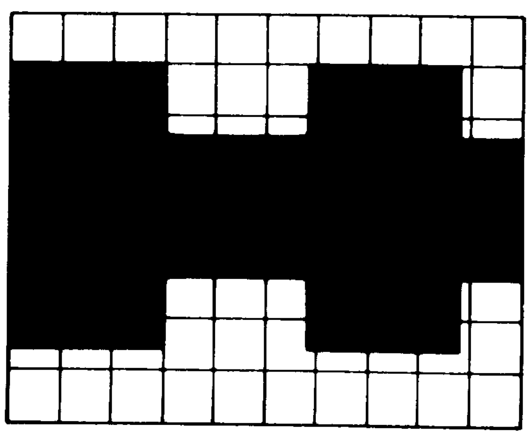
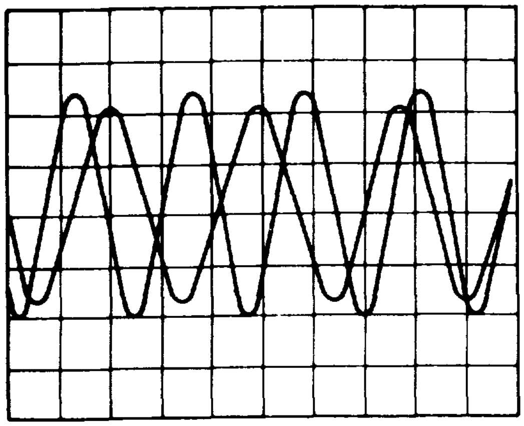
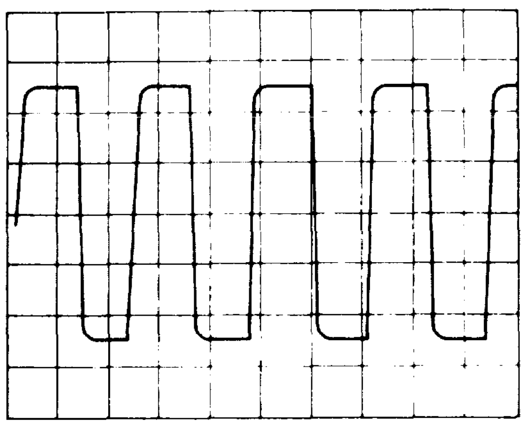
FIG. #	REFERENCE: TABLE	STEP	WAVEFORM	'SCOPE SETTINGS & SIGNAL CONDITIONS
13	4-9	39		Vertical: 1 V/division, d.c. Horizontal: 0.5 ms/division.
14	4-9	40		Vertical: 1 V/division, d.c. Horizontal: 0.5 ms/division.
15	4-10	11		Vertical: 0.5 V/division. Horizontal: 0.2 ms/division.

FIG. #	REFERENCE: TABLE	STEP	WAVEFORM	'SCOPE SETTINGS & SIGNAL CONDITIONS
16	4-10	12		Vertical: 0.5 V/division. Horizontal: 1 ms/division.
17	4-10	13		Vertical: 0.5 V/division. Horizontal: 0.5 ms/division.

SECTION V

REPLACEABLE PARTS

5-1. INTRODUCTION

Table 5-2, Replaceable Parts, identifies the manufacturers of components by five-digit groups taken from the Federal Supply Code for Manufacturers. A list of the applicable code groups and manufacturers is given in Table 5-1.

The Table of Replaceable Parts begins with major assemblies, including PC boards complete with all their parts, followed by miscellaneous parts and components not mounted on PC boards. Then all the components of the individual assemblies (including PC boards) are listed.

To simplify ordering, please note the following:

A. When ordering a component or an assembly, the BEC Part Number is all that we need. However, part numbers can suffer changes during transmission and it is safer to include also a brief description. Examples:

1) BEC Part #200050: Mica Capacitor, 470 pF, 1%, 500V.
2) BEC Part #10249: Oscillator PC Board Assembly

B. The number printed on a PC board is not an assembly number; it is the number for the bare board, alone. To order a complete assembly--the board with all its components installed--specify it by the BEC Part Number given in the Assemblies Section of this table.

C. Unless otherwise identified, the number on a schematic diagram or on a parts-location diagram is not an assembly number; it is the number for just the diagram itself.

Table 5-1. Applicable Federal Supply Code Numbers for Manufacturers

00853	Sangamo Electric	28480	Hewlett-Packard Corp.
01121	Allen Bradley Company	31918	ITT Schadow, Inc.
01295	Texas Instruments	32575	AMP
02735	RCA Solid State Div.	32997	Bourns Inc., Trimpot
03888	Pyrofilm KDI	33883	RMC
04222	AVX Ceramics Company	34335	Advanced Micro Devices
04713	Motorola Semiconductor	34649	Intel Corp.
04901	Boonton Electronics	50316	Mini-Systems, Inc.
06383	Panduit Corp.	51406	Murata Corp. of America
06665	Precision Monolithics	51640	Analog Devices, Inc.
06776	Robinson Nugent, Inc.	52464	OKI
07047	Milton Ross	54420	Dage
07263	Fairchild Semiconductor	54426	Buss Fuses
13812	Amperex, Dialight Div.	56289	Sprague Electric Company
14752	Electro Cube, Inc.	56708	Zilog, Inc.
17117	Electronic Molding	57582	Kahgan Electronics Corp.
19505	Applied Eng'r. Products	59474	Jeffers Electronics, Inc.
19701	Mepco Electra	61637	Union Carbide - Kemet
20307	Arco - Micronics	71279	Cambridge Thermionics
24226	Gowanda Electronics	71450	CTS Corporation
27014	National Semiconductor	73138	Beckman, Helipot Div.
27264	Molex, Inc.	91168	Elmenco
27735	F-Dyne Electronics	95402	Electro Dynamics
27777	Varo Semiconductors	98291	Sealectro Corp.
S4217	United Chemicon, Inc.		

Table 5-2. Replaceable Parts

Item	Description		Mfg.	Mfr's. Part No.	BEC Part No.
	ASSEMBLIES				
A1	Frame Assembly		04901		08210201A
A2	R.F. Board Assembly		04901		08210801K
A3	I.F.-A.F. Board Assembly		04901		08210901J
A4	Digital & Power-Supply Board Assembly		04901		08210701P
A5	Display Board Assembly		04901		08211001E
A6	Line- Switch Connector Assembly		04901		08211500A
A7	Chassis Unit Assembly		04901		08211400A
A8	Sub-Panel Assembly		04901		08210301A
A9	Rear Panel Assembly		04901		08210401C
	R.F. BOARD ASSEMBLY (A2); PART NUMBER 08210801K				
C1	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C2	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C3	Capacitor, Cer. Chip	0.01 µF, 20%, 100V	61637	C1210C103M5XAH	224210000
C4	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C5	Capacitor, Cer. Chip	680 pF, 10%, 50V	61637	C1210C681K5XAH	224377000
C6	Capacitor, Cer.	0.01 µF, 20%, 50V	51406	DD350A10Y5P103M50V	224363000
C7	Capacitor, Mica	100 pF, 1%, 500V	14655	CD15-101F	200045000
C8	Capacitor, Cer.	0.01 µF, 20%, 50V	51406	DD350A10Y5P103M50V	224363000
C9	Capacitor, Mica	100 pF, 5%, 300V	20307	DM5-FC101J	205006000
C10	Capacitor, Tant.	1.0 µF, 10%, 35V	56289	196D105X9035HA1	283216000
C11	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C12	Capacitor, Mica	100 pF, 5%, 300V	20307	DM5-FC101J	205006000
C13	Capacitor, Tant.	1.0 µF, 10%, 35V	56289	196D105X9035HA1	283216000
C14	Capacitor, Mica	100 pF, 1%, 500V	14655	CD15-101F	200045000
C15	Capacitor, Mica	33 pF, 5%, 300V	20307	DM5-EC330J	205010000
C16	Not Used				
C17	Capacitor, Mica	8 pF, 10%, 300V	57582	KD5080D301	205001000
C18	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C19	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C20	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C21	Capacitor, Mica	270 pF, 5%, 50V	57582	KD5271J101	205045000
C22	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C23	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C24	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C25	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C26	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C27	Capacitor, Mica	15 pF, 5%, 300V	14655	CD5CC150J	205035000
C28	Capacitor, Mica	47 pF, 5%, 300V	20307	DM5-EC470J	205018000
C29	Capacitor, Cer.	1000 pF, 10%, 100V	04222	SR151C102KAA	224270000
C30	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C31	Capacitor, Cer.	0.01 µF, 10%, 100V	04222	SR201C103KAA	224269000
C32	Capacitor, El.	100 µF, 20%, 25V	S4217	SM25-VB-100M	283334000
C33	Capacitor, Mica	10 pF, 5%, 300V	14655	CD5WCC100J	205002000
C34	Capacitor, Mica	22 pF, 5%, 300V	14655	CD5WCC220J	205036000
C35	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C36	Capacitor, Mica	270 pF, 5%, 50V	57582	KD5271J101	205045000
C37	Capacitor, Mica	270 pF, 5%, 50V	57582	KD5271J101	205045000
C38	Capacitor, Tant.	10 µF, 20%, 25V	56289	196D106X0025KA1	283293000
C39	Capacitor, Cer.	0.01 µF, 10%, 100V	04222	SR201C103KAA	224269000
C40	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C41	Capacitor, Cer.	0.01 µF, 10%, 100V	04222	SR201C103KAA	224269000
C42	Capacitor, Mica	390 pF, 5%, 500V	S4217	KD15391J501	200108000
C43	Capacitor, Mica	390 pF, 5%, 500V	S4217	KD15391J501	200108000
C44	Capacitor, El.	100 µF, 20%, 25V	S4217	SM25-VB-100M	283334000
C45	Capacitor, Mica	270 pF, 5%, 50V	57582	KD5271J101	205045000
C46	Capacitor, Mica	270 pF, 5%, 50V	57582	KD5271J101	205045000
C47	Capacitor, MPC	1.0 µF, 10%, 50V	14752	652A-1-A-105K	234152000

Table 5-2. Replaceable Parts (Continued)

Item	Description		Mfr.	Mfr's Part #	BEC Part #
	R.F. BOARD ASSEMBLY (A2); PART NUMBER 08210801K				
C48	Capacitor, Tant.	10 µF, 20%, 25V	56289	196D106X0025KA1	283293000
C49	Not Used				
C50	Capacitor, Tant.	10 µF, 20%, 25V	56289	196D106X0025KA1	283293000
C51	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C52	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C53	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C54	Not Used				
C55	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C56	Capacitor, Mica	47 pF, 5%, 300V	20307	DM5-EC470J	205018000
C57	Capacitor, Tant.	1.0 µF, 10%, 35V	56289	196D105X9035HA1	283216000
C58	Capacitor, Mica	100 pF, 5%, 300V	20307	DM5-FC101J	205006000
C59	Capacitor, Cer.	0.1 µF, 20%, 50V	04222	SR215E104MAA	224268000
C60	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
CR1	Diode, Signal	1N6263	28480		530174000
CR2	Diode, Quad	5082-2815	28480		530903000
CR3	Diode, PIN	5082-0180	28480		530168000
CR4	Diode, Signal	1N6263	28480		530174000
CR5	Diode, Signal	1N914	01295		530058000
CR6	Diode, Signal	1N914	01295		530058000
CR7	Diode, Signal	1N6263	28480		530174000
CR8	Diode, Signal	1N6263	28480		530174000
CR9	Diode, Varactor	MV2115	04713		530760000
CR10	Diode, Varactor	MV2115	04713		530760000
CR11	Diode, Signal	1N914	01295		530058000
CR12	Diode, Signal	1N914	01295		530058000
CR13	Diode, Signal	1N6263	28480		530174000
J2	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
L1	Choke, R.F.	33 µH, 5%	59474	4465-2K	400310000
L2	Coil, Osc.	0.72 µH	04901		40041700A
L3	Choke, R.F.	4.7 µH, 10%	59474	4425-14K	400292000
L4	Choke, R.F.	4.7 µH, 10%	24226	10/471	400384000
L5	Choke, R.F.	5.6 µH, 10%	24226	15/561	400308000
L6	Choke, R.F.	68 µH, 10%	24226	10/682	400411000
L7	Choke, R.F.	39 µH, 10%	24226	10/392	400387000
L8	Choke, R.F.	5.6 µH, 10%	24226	15/561	400308000
L9	Choke, R.F.	68 µH, 10%	24226	10/682	400411000
L10	Choke, R.F.	39 µH, 10%	24226	10/392	400387000
L11	Choke, R.F.	5.6 µH, 10%	24226	15/561	400308000
P1	Connector, R.F.		98291	52-054-0000	479336000
P17	Connector Pin		71279	450-3367-01-03-00	479417000
Q1	Transistor, NPN	2N3866	04713		528116000
Q2	Transistor, FET	2N4416	04713		528072000
Q3	Transistor, PNP	2N3906	04713		528076000
Q4	Transistor, NPN	2N3904	04713		528071000
Q5	Transistor, NPN	2N3904	04713		528071000
Q6	Transistor, PNP	2N3906	04713		528076000
Q7	Transistor, NPN	MPS-6507	04713		528070000
Q8	Transistor, FET	2N4416	04713		528072000
R1	Resistor, MF	33.2 ohm 1%	19701	5034ED33R20F	341150000
R2	Resistor, MF	301 ohm 1%	19701	5043ED301R0F	341246000
R3	Resistor, Chip	18 ohm 5% 1/2W	50316	WA-7PG-180JS	339996000
R4	Resistor, MF	301 ohm 1%	19701	5043ED301R0F	341246000
R5	Resistor, MF	332 ohm 1%	19701	5043ED332R0F	341250000
R6	Resistor, MF	100 ohm 1%	19701	5043ED100R0F	341200000
R7	Resistor, MF	6.81k ohm 1%	19701	5043ED6K810F	341380000
R8	Resistor, Comp.	100 ohm 5% 1/8W	01121	BB1015	331058000
R9	Resistor, Comp.	100 ohm 5% 1/8W	01121	BB1015	331058000
R10	Resistor, Var.	50k ohm 10% 0.5W	73138	72PR50K	311393000
R11	Resistor, MF	7.5k ohm 1%	19701	5043ED7K500F	341384000
R12	Resistor, Comp.	200 ohm 5% 1/8W	01121	BB2015	331065000

Table 5-2. Replaceable Parts (Continued)

Item	Description		Mfr.	Mfr's Part #	BEC Part #
R.F. BOARD ASSEMBLY (A2), CONTINUED; PART NUMBER 08210801K					
R13	Resistor, MF	33.2 ohm 1%	19701	5034ED33R20F	341150000
R14	Resistor, Var.	10k ohm 10% 0.5W	73138	72PR10K	311328000
R15	Resistor, MF	5.11k ohm 1%	19701	5043ED5K110F	341368000
R16	Resistor, MF	7.5k ohm 1%	19701	5043ED7K500F	341384000
R17	Resistor, Comp.	200 ohm 5% 1/8W	01121	BB2015	331065000
R18	Resistor, MF	6.81k ohm 1%	19701	5043ED6K810F	341380000
R19	Resistor, Comp.	100 ohm 5% 1/8W	01121	BB1015	331058000
R20	Resistor, MF	100 ohm 5% 1/8W	01121	BB1015	331058000
R21	Resistor, MF	100 ohm 1%	19701	5043ED100R0F	341200000
R22	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R23	Resistor, MF	3.92k ohm 1%	19701	5043ED3K920F	341357000
R24	Resistor, MF	20k ohm 1%	19701	5043ED20K00F	341429000
R25	Resistor, MF	7.5k ohm 1%	19701	5043ED7K500F	341384000
R26	Resistor, MF	511 ohm 1%	19701	5043ED511R0F	341268000
R27	Resistor, MF	22.1 ohm 1%	19701	5043ED22R10F	341133000
R28	Resistor, MF	511 ohm 1%	19701	5043ED511R0F	341268000
R29	Resistor, Comp.	47 ohm 5% 1/8W	01121	BB4705	331050000
R30	Resistor, MF	47.5 ohm 1%	19701	5043ED47R50F	341165000
R31	Resistor, Comp.	47 ohm 5% 1/8W	01121	BB4705	331050000
R32	Resistor, MF	22.1 ohm 1%	19701	5043ED22R10F	341133000
R33	Resistor, MF	100 ohm 1%	19701	5043ED100R0F	341200000
R34	Resistor, MF	4.75k ohm 1%	19701	5043ED4K750F	341365000
R35	Resistor, MF	511 ohm 1%	19701	5043ED511R0F	341268000
R36	Resistor, MF	511 ohm 1%	19701	5043ED511R0F	341268000
R37	Resistor, MF	15k ohm 1%	19701	5043ED15K00F	341417000
R38	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R39	Resistor, MF	511 ohm 1%	19701	5043ED511R0F	341268000
R40	Resistor, MF	3.01k ohm 1%	19701	5043ED3K010F	341346000
R41	Resistor, MF	357 ohm 1%	19701	5043ED357R0F	341253000
R42	Resistor, MF	51.1k ohm 1%	19701	5043ED51K10F	341468000
R43	Resistor, MF	243 ohm 1%	19701	5043ED243R0F	341237000
R44	Resistor, MF	47.5k ohm 1%	19701	5043ED47K50F	341465000
R45	Resistor, MF	20.0k ohm 1%	19701	5043ED20K00F	341429000
R46	Resistor, MF	47.5k ohm 1%	19701	5043ED47K50F	341465000
R47	Resistor, MF	90.9k ohm 1%	19701	5043ED90K90F	341492000
R48	Resistor, Comp.	47 ohm 5% 1/8W	01121	BB4705	331050000
R49	Resistor, MF	10.0k ohm 1%	19701	5043ED10K00F	341400000
R50	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R51	Resistor, MF	5.11k ohm 1%	19701	5043ED5K110F	341368000
R52	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R53	Resistor, MF	511 ohm 1%	19701	5043ED511R0F	341268000
R54	Resistor, MF	47.5 ohm 1%	19701	5043ED47R50F	341165000
R55	Resistor, MF	511 ohm 1%	19701	5043ED511R0F	341268000
R56	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R57	Resistor, MF	200k ohm 1%	19701	5043ED200K0F	341529000
R58	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R59	Resistor, MF	2k ohm 1%	19701	5043ED2K000F	341329000
R60	Resistor, MF	200k ohm 1%	19701	5043ED200K0F	341529000
R61	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R62	Resistor, MF	2k ohm 1%	19701	5043ED2K000F	341329000
R63	Resistor, MF	825 ohm 1%	19701	5043ED825R0F	341288000
R64	Resistor, MF	8.25k ohm 1%	19701	5043ED8K250F	341388000
R65	Resistor, Var.	5k ohm 10% 0.5W	73138	72PR2K	311308000
R66	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R67	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R68	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R69	Resistor, MF	4.75k ohm 1%	19701	5043ED4K750F	341365000
R70	Resistor, MF	24.3k ohm 1%	19701	5043ED24K30F	341437000
R71	Resistor, MF	39.2k ohm 1%	19701	5043ED39K20F	341457000
R72	Resistor, Comp.	200 ohm 5% 1/8W	01121	BB2015	331065000
R73	Resistor, Comp.	200 ohm 5% 1/8W	01121	BB2015	331065000

Table 5-2. Replaceable Parts (Continued)

Item	Description		Mfr.	Mfr's Part #	BEC Part #
	R.F. BOARD ASSEMBLY (A2), CONTINUED; PART NUMBER 08210801K				
T1	Transformer, Pulse Gen.		04901	41009000B	41009000B
T2	Transformer, Balun		15542	T1-1	410089000
TP1	Connector		27264	22-03-2021	477361000
TP2	Connector		27264	22-03-2021	477361000
U1	Integrated Circuit	SN74ALS74N	01295		534281000
U2	Integrated Circuit	SN74LS163N	01295		534279000
U3	Integrated Circuit	SN74LS00N	01295		534167000
U4	Analog Switch	LF13333N	27014		535095000
U5	Oper. Amplifier	LF357N	27014		535096000
U6	Oper. Amplifier	TL072CP	01295		535092000
U7	Integrated Circuit	CD4051BE	02735		534209000
U8	Oper. Amplifier	MC1355P	04713		535038000
U9	Integrated Circuit	SN74LS122N	01295		534280000
XQ2	Socket Transistor 4 Pin		17117	7004-265-5	473051000
XQ8	Socket Transistor 4 Pin		17717	7004-265-5	473051000
XU1	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU2	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU3	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU4	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU5	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU6	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU7	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU8	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU9	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
	I.F.-A.F. BOARD ASSEMBLY (A3); PART NUMBER 08210901J				
C1	Capacitor, Mica	470 pF, 1%, 500V	14655	DM15-471F	200050000
C2	Capacitor, Mica	240 pF, 1%, 500V	00853	D10-FD-241-F03	200124000
C3	Capacitor, Mica	15 pF, 5%, 300V	14655	CD5-CC150J	205035000
C4	Capacitor, Cer.	0.01 μF, 10%, 100V	04222	SR201C103KAA	224269000
C5	Capacitor, Tant.	1.0 μF, 10%, 35V	56289	196D105X9035HA1	283216000
C6	Capacitor, El.	100 μF, 20%, 25V	S4217	SM25-VB-100M	283334000
C7	Capacitor, Cer.	0.1 μF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C8	Capacitor, Tant.	1.0 μF, 10%, 35V	56289	196D105X9035HA1	283216000
C9	Capacitor, Mica	150 pF, 5%, 100V	57582	DM5-FA151J	205009000
C10	Capacitor, Mica	100 pF, 5%, 300V	20307	DM5-FC101J	205006000
C11	Capacitor, El.	10 μF, 20%, 25V	S4217	SM25-VB-10M	283336000
C12	Capacitor, Mica	33 pF, 5%, 300V	20307	DM5-EC330J	205010000
C13	Capacitor, Cer.	0.1 μF, 20%, 50V	04222	SR215E104MAA	224268000
C14	Capacitor, El.	10 μF, 20%, 25V	S4217	SM25-VB-10M	283336000
C15	Capacitor, Cer.	0.1 μF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C16	Not Used				
C17	Capacitor, El.	10 μF, 20%, 25V	S4217	SM25-VB-10M	283336000
C18	Capacitor, Cer.	0.1 μF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C19	Capacitor, El.	10 μF, 20%, 25V	S4217	SM25-VB-10M	283336000
C20	Capacitor, Mica	39 pF, 1%, 300V	57582	KD50390F301	205049000
C21	Capacitor, Tant.	10 μF, 20%, 25V	56289	196D106X0025KA1	283293000
C22	Capacitor, Cer.	0.1 μF, 20%, 50V	04222	SR215E104MAA	224268000
C23	Capacitor, Cer.	1.0 μF, 20%, 50V	04222	SR305E105MAA	224264000
C24	Capacitor, El.	10 μF, 20%, 25V	S4217	SM25-VB-10M	283336000
C25	Capacitor, El.	100 μF, 20%, 25V	S4217	SM25-VB-100M	283334000
C26	Capacitor, El.	100 μF, 20%, 25V	S4217	SM25-VB-100M	283334000
C27	Capacitor, Mica	47 pF, 5%, 300V	20307	DM5-EC470J	205018000
C28	Capacitor, Mica	47 pF, 5%, 300V	20307	DM5-EC470J	205018000
C29	Capacitor, Cer.	0.1 μF, 20%, 50V	04222	SR215E104MAA	224268000
C30	Capacitor, Cer.	0.1 μF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C31	Capacitor, El.	10 μF, 20%, 25V	S4217	SM25-VB-10M	283336000
C32	Capacitor, El.	10 μF, 20%, 25V	S4217	SM25-VB-10M	283336000
C33	Capacitor, El.	100 μF, 20%, 25V	S4217	SM25-VB-100M	283334000

Table 5-2. Replaceable Parts (Continued)

Item	Description		Mfr.	Mfr's Part #	BEC Part #
	I.F.-A.F. BOARD ASSEMBLY (A3); PART NUMBER 08210901J				
C34	Capacitor, El.	100 μF, 20%, 25V	S4217	SM25-VB-100M	283334000
C35	Capacitor, Mica	500 pF, 1%, 500V	00853	D15-5-F-501-F-O	200123000
C36	Capacitor, Mica	120 pF, 5%, 100V	14655	DM5-FC121J	205022000
C37	Capacitor, Tant.	10 μF, 20%, 25V	56289	196D106X0025KA1	283293000
C38	Capacitor, Mica	1000 pF, 1%, 100V	51406	DM15-102F	200113000
C39	Capacitor, Mica	1000 pF, 1%, 100V	51406	DM15-102F	200113000
C40	Capacitor, Mica	240 pF, 1%, 500V	00853	D10-FD-241-FO3	200124000
C41	Capacitor, Mica	200 pF, 2%, 500V	14655	DM15-201G	200053000
C42	Capacitor, Cer.	0.1 μF, 20%, 50V	04222	SR215E104MAA	224268000
C43	Capacitor, Mica	100 pF, 5%, 300V	20307	DM5-FC101J	205006000
C44	Capacitor, MPC	0.01 μF, 2%, 50V	14752	652A-1A-103G	234142000
C45	Capacitor, MPC	0.1 μF, 2%, 50V	27735	MPC-53-.1-50-2	234139000
C46	Capacitor, Mica	100 pF, 5%, 300V	20307	DM5-FC101J	205006000
C47	Capacitor, MPC	0.01 μF, 2%, 50V	14752	652A-1A-103G	234142000
C48	Capacitor, Mica	100 pF, 5%, 300V	20307	DM5-FC101J	205006000
C49	Capacitor, Cer.	0.1 μF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C50	Capacitor, Cer.	0.1 μF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C51	Capacitor, Tant.	10 μF, 20%, 25V	56289	196D106X0025KA1	283293000
C52	Capacitor, Cer.	0.1 μF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C53	Capacitor, Mica	20 pF, 5%, 300V	14655	CD5CC200J	205017000
CR1	Diode, Signal	1N914	01295		530058000
CR2	Diode, Signal	1N914	01295		530058000
CR3	Diode, Signal	1N6263	28480		530174000
CR4	Diode, Signal	1N6263	28480		530174000
CR5	Diode, Signal	1N6263	28480		530174000
CR6	Diode, Signal	1N6263	28480		530174000
CR7	Diode, Signal	1N6263	28480		530174000
CR8	Diode, Signal	1N914	01295		530058000
CR9	Diode, Signal	1N914	01295		530058000
CR10	Diode, Signal	1N914	01295		530058000
CR11	Diode, Signal	1N914	01295		530058000
CR12	Diode, Signal	1N914	01295		530058000
CR13	Diode, Signal	1N914	01295		530058000
CR14	Diode, Signal	1N914	01295		530058000
CR15	Diode, Signal	1N914	01295		530058000
J1	Connector, 16-pin		06776		473042000
J2	Connector, 16-pin		06776		473042000
J3	Connector, 2-pin		06383	HFAS100-2-C	477367000
J4	Connector, 2-pin		06383	HFAS100-2-C	477367000
J5	Connector, 2-pin		06383	HFAS100-2-C	477367000
L1	Choke, R.F.	100 μH, 5%	59474	1315-12J	400295000
L2	Choke, R.F.	91 μH, 5%	59474	1311-11J	400416000
L3	Choke. R.F.	20 μH, 5%	59474	4445-6J	400258000
L4	Choke, R.F.	150 μH, 5%	59474	1315-16J	400415000
L5	Choke, Wide-band		02114	VK200-20/4B	400409000
L6	Choke, R.F.	5.6 μH, 10%	24226	15/561	400308000
L7	Choke, R.F.	5.6 μH, 10%	24226	15/561	400308000
L8	Choke, R.F.	5.6 μH, 10%	24226	15/561	400308000
L9	Choke, R.F.	5.6 μH, 10%	24226	15/561	400308000
P16	Connector Pin		71279	450-3367-01-03-00	479417000
Q1	Transistor, NPN	2N3904	04713		528071000
Q2	Transistor, PNP	2N3906	04713		528076000
Q3	Transistor, NPN	2N3904	04713		528071000
Q4	Transistor, PNP	2N3906	04713		528076000
Q5	Transistor, PNP	2N3906	04713		528076000
Q6	Transistor, NPN	2N3904	04713		528071000
R1	Resistor, Comp.	330 ohm 5% 1/8W	01121	BB3315	331070000
R2	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R3	Resistor, MF	221 ohm 1%	19701	5043ED221R0F	341233000
R4	Resistor, MF	200 ohm 1%	19701	5043ED200R0F	341229000

Table 5-2. Replaceable Parts (Continued)

Item	Description		Mfr.	Mfr's Part #	BEC Part #
	I.F.-A.F. BOARD ASSEMBLY (A3), CONTINUED; PART NUMBER 08210901J				
R5	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R6	Resistor, Var.	100 ohm 10% 0.5W	32997	3329H-1-101	311406000
R7	Resistor Network	500 ohm 0.5% 0.5W	73138	694-3-R500D	345035000
R8	Resistor, MF	2k ohm 1%	19701	5043ED2K000F	341329000
R9	Resistor, MF	5.11k ohm 1%	19701	5043ED5K110F	341368000
R10	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R11	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R12	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R13	Resistor, MF	100 ohm 1%	19701	5043ED100R0F	341200000
R14	Resistor, MF	15k ohm 1%	19701	5043ED15K00F	341417000
R15	Resistor, MF	1.82k ohm 1%	19701	5043ED1K820F	341325000
R16	Resistor, MF	1.5k ohm 1%	19701	5043ED1K500F	341317000
R17	Resistor, MF	475 ohm 1%	19701	5043ED475R0F	341265000
R18	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R19	Resistor, MF	3.32k ohm 1%	19701	5043ED3K320F	341350000
R20	Resistor, MF	6.19k ohm 1%	19701	5043ED6K190F	341376000
R21	Resistor, MF	511 ohm 1%	19701	5043ED511R0F	341268000
R22	Resistor, MF	475 ohm 1%	19701	5043ED475R0F	341265000
R23	Resistor, MF	1.5k ohm 1%	19701	5043ED1K500F	341317000
R24	Resistor, MF	47.5 ohm 1%	19701	5043ED47R50F	341165000
R25	Resistor, MF	2.21k ohm 1%	19701	5043ED2K210F	341333000
R26	Resistor, MF	2k ohm 1%	19701	5043ED2K000F	341329000
R27	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R28	Resistor, MF	47.5 ohm 1%	19701	5043ED47R50F	341165000
R29	Resistor, MF	100 ohm 1%	19701	5043ED100R0F	341200000
R30	Resistor, MF	15k ohm 1%	19701	5043ED15K00F	341417000
R31	Resistor, MF	6.19k ohm 1%	19701	5043ED6K190F	341376000
R32	Resistor, MF	15k ohm 1%	19701	5043ED15K00F	341417000
R33	Resistor, MF	39.2k ohm 1%	19701	5043ED39K20F	341457000
R34	Resistor, MF	47.5 ohm 1%	19701	5043ED47R50F	341165000
R35	Resistor, MF	475 ohm 1%	19701	5043ED475R0F	341265000
R36	Resistor, MF	475 ohm 1%	19701	5043ED475R0F	341265000
R37	Resistor, MF	47.5 ohm 1%	19701	5043ED47R50F	341165000
R38	Resistor, MF	2k ohm 1%	19701	5043ED2K000F	341329000
R39	Resistor, MF	6.19k ohm 1%	19701	5043ED6K190F	341376000
R40	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R41	Resistor, MF	2k ohm 1%	19701	5043ED2K000F	341329000
R42	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R43	Resistor, MF	243 ohm1%	19701	5043ED243R0F	341237000
R44	Resistor, MF	2.0k ohm 1%	19701	5043ED2K000F	341329000
R45	Resistor, MF	150 ohm 1%	19701	5043ED150R0F	341217000
R46	Resistor, MF	1.0k ohm 1%	19701	5043ED1K000F	341300000
R47	Resistor, MF	52.3k ohm 1%	19701	5043ED52K30F	341469000
R48	Resistor, MF	52.3k ohm 1%	19701	5043ED52K30F	341469000
R49	Not Used				
R50	Resistor, MF	10.0k ohm 1%	19701	5043ED10K00F	341400000
R51	Resistor, MF	10.0k ohm 1%	19701	5043ED10K00F	341400000
R52	Resistor, MF	10.0k ohm 1%	19701	5043ED10K00F	341400000
R53	Resistor, MF	15.0k ohm 1%	19701	5043ED15K00F	341417000
R54	Not Used				
R55	Resistor, MF	30.1k ohm 1%	19701	5043ED30K10F	341446000
R56	Resistor, MF	604 ohm 1%	19701	5043ED604R0F	341275000
R57	Resistor, MF	13.3k ohm 1%	19701	5043ED13K30F	341412000
R58	Resistor, MF	8.87k ohm 1%	19701	5043ED8K870F	341391000
R59	Resistor, MF	9.000k ohm 0.1% 1/8W	19701	PME55-T2	324354000
R60	Resistor, MF	1.000k ohm o.1% 1/8W	03888	PME55-T2	324241000
R61	Resistor, MF	10.0k ohm 1%	19701	5043ED10K00F	341400000
R62	Resistor, MF	1.0k ohm 1%	19701	5043ED1K000F	341300000

Table 5-2. Replaceable Parts (Continued)

Item	Description		Mfr.	Mfr's Part #	BEC Part #
	I.F.-A.F. BOARD ASSEMBLY (A3), CONTINUED; PART NUMBER 08210901J				
R63*	Resistor, MF	26.7k ohm 1%	19701	5043ED26K70F	341441000
R64	Resistor, MF	182k ohm 1%	19701	5043ED182K0F	341525000
R65*	Resistor, MF	16.9k ohm 1%	19701	5043ED16K90F	341422000
* When Option -01 is installed, these components are changed as follows:					
R63	Resistor, MF	12.7k ohm 1%	19701	5043ED12K70F	341410000
R65	Resistor, MF	8.25k ohm 1%	19701	5043ED8K250F	341388000
R66	Resistor, MF	73.2k ohm 1%	19701	5043ED73K20F	341483000
R67	Resistor, MF	51.1k ohm 1%	19701	5043ED51K10F	341468000
R68	Resistor, MF	4.99k ohm 1%	19701	5043ED4K990F	341367000
R69	Resistor, MF	7.50k ohm 1%	19701	5043ED7K500F	341384000
R70	Resistor, MF	51.1k ohm 1%	19701	5043ED51K10F	341468000
R71*	Resistor, MF	1.00k ohm 1%	19701	5043ED1K000F	341300000
R72	Resistor, MF	51.1k ohm 1%	19701	5043ED51K10F	341468000
R73	Resistor, MF	1.54k ohm 1%	19701	5043ED1K540F	341318000
R74	Resistor, MF	1.0k ohm 1%	19701	5043ED1K000F	341300000
R75	Resistor, MF	100k ohm 1%	19701	5043ED100K0F	341500000
R76	Resistor, MF	604 ohm 1%	19701	5043ED604R0F	341275000
R77	Resistor, MF	2.00k ohm 1%	19701	5043ED2K000F	341329000
R78	Resistor, MF	511k ohm 1%	19701	5043ED511K0F	341568000
R79	Resistor, Var.	1k ohm 10% 0.5W	32997	3329H-1-102	311404000
* When Option -01 is installed, this component changes as follows:					
R71	Resistor, MF	499 ohm 1%	19701	5043ED499R0F	341267000
TP1	Connector		27264	22-03-2021	477361000
U1	Oper. Amplifier	LF356P	01295		535040000
U2	Oper. Amplifier	NE5534AN	18324		535061000
U3	Analog Switch	LF13333N	27014		535095000
U4	D-A Converter	DAC-08EP	06665		421037000
U5	Oper. Amplifier	NE5534AN	18324		535061000
U6	Integrated Circuit	SN74LS00N	01295		534167000
U7	Integrated Circuit	SN74121N	01295		534038000
U8	Oper. Amplifier	LF356P	01295		535040000
U9	Oper. Amplifier	TL074CN	01295		535082000
U10	Integrated Circuit	CD4051BE	02735		534209000
U11	Integrated Circuit	CD4051BE	02735		534209000
U12	Oper. Amplifier	TL074CN	01295		535082000
U13	Integrated Circuit	CD4052BE	02735		534140000
U14	Oper. Amplifier	LF356P	01295		535040000
U15	Integrated Circuit	CD4051BE	02735		534209000
XU1	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU2	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU3	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU4	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU5	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU6	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU7	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU8	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU9	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU10	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU11	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU12	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU13	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU14	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU15	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000

Table 5-2. Replaceable Parts (Continued)

Item	Description		Mfr.	Mfr's Part #	BEC Part #
DIGITAL & POWER-SUPPLY BOARD ASSEMBLY (A4); PART NUMBER 08210701P					
C1	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C2	Capacitor, Mica	51 pF, 5%, 300V	57582	KD5510J301	205020000
C3	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C4	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C5	Capacitor, Cer.	0.1 µF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C6	Capacitor, Mica	1100 pF, 5%, 100V	14655	DM15-112J	200111000
C7	Capacitor, Cer.	0.1 µF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C8	Capacitor, MPC	0.002 µF, 2%, 50V	27735	MPC-53-.002-50-2	234140000
C9	Capacitor, Cer.	0.001 µF, 10%, 100V	04222	SR151C102KAA	224270000
C10	Capacitor, Mica	1100 pF, 5%, 100V	14655	DM15-112J	200111000
C11	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C12	Capacitor, Cer.	0.1 µF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C13	Capacitor, Cer.	0.1 µF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C14	Capacitor, Cer.	0.1 µF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C15	Capacitor, Tant.	10 µF, 20%, 25V	56289	196D106X0025KA1	283293000
C16	Capacitor, Tant.	1.0 µF, 20%, 35V	56289	196D105X9035HA1	283216000
C17	Capacitor, Mylar	0.1 µF, 10%, 100V	19701	C280MAH/A100K	234080000
C18	Capacitor, Mylar	0.1 µF, 10%, 100V	19701	C280MAH/A100K	234080000
C19	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C20	Capacitor, El.	10 µF, 20%, 25V	S4217	SM25-VB-10M	283336000
C21	Not Used				
C22	Not Used				
C23	Capacitor, El.	4700 µF, 16V	57582	KSMM-4700-16	283352000
C24	Capacitor, El.	2200 µF, 35V	57582	KSMM-2200-35	283351000
C25	Capacitor, El.	2200 µF, 35V	57582	KSMM-2200-35	283351000
C26	Capacitor, Cer.	0.1 µF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C27	Capacitor, Cer.	0.1 µF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C28	Capacitor, Cer.	0.1 µF, 20%, 25V	51406	DD312E10Y5P104M25V	224364000
C29	Capacitor, Cer.	0.001 µF, 10%, 100V	04222	SR151C102KAA	224270000
C30	Capacitor, Cer.	0.001 µF, 10%, 100V	04222	SR151C102KAA	224270000
C31	Capacitor, Cer.	0.001 µF, 10%, 100V	04222	SR151C102KAA	224270000
C32	Capacitor, Tant.	10 µF, 20%, 25V	56289	196D106X0025KA1	283293000
C33	Capacitor, El.	100 µF, 20%, 25V	S4217	SM25-VB-100M	283334000
C34	Capacitor, Tant.	10 µF, 20%, 25V	56289	196D106X0025KA1	283293000
C35	Capacitor, Tant.	10 µF, 20%, 25V	56289	196D106X0025KA1	283293000
C36	Capacitor, Tant.	10 µF, 20%, 25V	56289	196D106X0025KA1	283293000
C37	Capacitor, Cer.	0.001 µF, 10%, 100V	04222	SR151C102KAA	224270000
CR1	Diode, Signal	1N914	01295		530058000
CR2	Diode, Signal	1N914	01295		530058000
CR3	Diode, Signal	1N914	01295		530058000
CR4	Diode, Signal	FDH-300	07263		530052000
CR5	Diode, Signal	FDH-300	07263		530052000
CR6	Diode, Signal	1N914	01295		530058000
CR7	Diode, Signal	1N914	01295		530058000
CR8	Diode Bridge	VM-18	27777		532031000
CR9	Diode Bridge	VM-18	27777		532031000
CR10	Diode, Signal	1N4001	04713		530151000
CR11	Diode, Signal	1N4001	04713		530151000
CR12	Diode, Zener	1N5242B (12V)	04713		530146000
CR13	Diode, Signal	1N4001	04713		530151000
CR14	Diode, Zener	1N5242B (12V)	04713		530146000
CR15	Diode, Signal	1N4001	04713		530151000
CR16	Diode, Signal	1N4001	04713		530151000
CR17	Diode, Signal	1N4001	04713		530151000
CR18	Diode, Signal	1N4001	04713		530151000
CR19	Diode, Signal	1N4001	04713		530151000
CR20	Diode, Signal	1N4001	04713		530151000
CR21	Diode, Signal	1N914	01295		530058000
J1	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
J2	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000

Table 5-2. Replaceable Parts (Continued)

Item	Description		Mfr.	Mfr's Part #	BEC Part #
	DIGITAL & POWER-SUPPLY BOARD ASSEMBLY (A4); PART NUMBER 08210701P				
J3	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
J4	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
J5	Connector 2 Pin		27264	22-03-2021	477361000
J6	Header 5 Pin		06383	MPSS156-5-D	477345000
J7	Connector Pin (M)		98291	229-1086-000-550	477240000
J8	Shunt 8 Circuit		32575	435704-8	483226000
L1	Choke, R.F.	150 µH, 5%	59474	1315-16J	400415000
L2	Choke, R.F.	150 µH, 5%	59474	1315-16J	400415000
L3	Choke, R.F.	39 µH, 10%	24226	10/392	400387000
Q1	Transistor, NPN	2N3904	04713		528071000
R1	Resistor, MF	22.1k ohm 1%	19701	RN55D-2212-F	341433000
R2	Not Used				
R3	Resistor, MF	10.0k ohm 1%	19701	5043ED10K00F	341400000
R4	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R5	Resistor, MF	4.75k ohm 1%	19701	5043ED4K750F	341365000
R6	Resistor, MF	14.3k ohm 1%	19701	5043ED14K30F	341415000
R7	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R8	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R9	Resistor Network	10k ohm 2%, 1.5W	71450	750-101-R3.3K	345038000
R10	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R11	Resistor, MF	332 ohm 1%	19701	5043ED332R0F	341250000
R12	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R13	Resistor Network	3.3k ohm 2% 1.5W	71450	750-101-R3.3K	345030000
R14	Resistor Network	3.3k ohm 2% 1.5W	71450	750-101-R3.3K	345030000
R15	Resistor Network	3.3k ohm 2% 2W	75378	784-1-R3.3K	345017000
R16	Resistor Network	3.3k ohm 2% 2W	75378	784-1-R3.3K	345017000
R17	Resistor Network	22 ohm +/-2 ohm 2W	01121	316B-220	345034000
R18	Resistor, MF	909k ohm 1%	91637	RN60D9093F	342592000
R19	Resistor, MF	100k ohm 1%	19701	5043ED100K0F	341500000
R20	Resistor, MF	100k ohm 1%	19701	5043ED100K0F	341500000
R21	Resistor, MF	47.5k ohm 1%	19701	5043ED47K50F	341465000
R22	Resistor, MF	22.1k ohm 1%	19701	RN55D-2212-F	341433000
R23	Resistor, MF	200 ohm 1%	19701	5043ED200R0F	341229000
R24	Resistor, MF	200 ohm 1%	19701	5043ED200R0F	341229000
R25	Resistor, MF	33.2k ohm 1%	19701	5043ED33K20F	341450000
R26	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R27	Resistor, MF	1k ohm 1%	19701	5043ED1K000F	341300000
R28	Resistor, MF	22.1k ohm 1%	19701	RN55D-2212-F	341433000
R29	Resistor, MF	22.1k ohm 1%	19701	RN55D-2212-F	341433000
R30	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
R31	Resistor Network	10k ohm .1% 1.5W	73138	698-3R10KD	345010000
R32	Resistor, MF	909 ohm 1%	09701	5043ED909R0F	341292000
R33	Resistor, MF	2.0k ohm 1%	19701	5043ED2K000F	341329000
R34	Resistor, MF	357 ohm 1%	19701	5043ED357R0F	341253000
R35	Resistor, MF	750 ohm 1%	19701	5043ED750R0F	341284000
R36	Resistor, MF	1.82k ohm 1%	19701	5043ED1K820F	341325000
R37	Resistor, MF	4.99k ohm 1%	19701	5043ED4K990F	341367000
R38	Resistor, MF	49.9k ohm 1%	19701	5043ED49K90F	341467000
R39	Resistor, MF	10k ohm 1%	19701	5043ED10K00F	341400000
S1	Switch. DIP	7-section	75378	206-7	46530007A
TP1	Conn M		06383	MFSS100-5-C-A	477365000
TP2	Conn M		06383	MFSS100-5-C-A	477365000
TP3	Conn M		06383	MFSS100-5-C-A	477365000
TP4	Conn M		06383	MFSS100-5-C-A	477365000
TP5	Conn M		06383	MFSS100-5-C-A	477365000
TP6	Conn M		06383	MFSS100-3-C-A	477364000
TP7	Test Point		31313	TP-103-02	48330600A
TP8	Test Point		31313	TP-103-02	48330600A
TP9	Test Point		31313	TP-103-02	48330600A
TP10	Test Point		31313	TP-103-02	48330600A

Table 5-2. Replaceable Parts (Continued)

Item	Description		Mfr.	Mfr's Part #	BEC Part #
DIGITAL & POWER-SUPPLY BOARD ASSEMBLY (A4), CONTINUED; PART NUMBER 08210701P					
U1	Integrated Circuit	SN74LS04N	01295		534155000
U2	Oper. Amplifier	LF356N	01295		535040000
U3	Integrated Circuit	CD4040BE	02735		534275000
U4	Oper. Amplifier	LM311N	27014		535035400
U5	Integrated Circuit	SN74LS74N	01295		534157000
U6	Integrated Circuit	SN74LS32N	01295		534168000
U7	A-D Converter	AD565AJD/BIN	24355		421034000
U8	CPU	Z80-CPU-PS	56708		534159000
U9	Integrated Circuit	SN74LS163AN	01295		534279000
U10	Integrated Circuit	SN74LS42N	01295		534210000
U11	EPROM		04901		53444300B
U12	Integrated Circuit	SN74LS153N	01295		534278000
U13	RAM	MSM5128-20-RS	52464		534304000
U14	Not Used				
U15	Not Used				
U16	Integrated Circuit	AM8255AAPC	34335		534171000
U17	Integrated Circuit	AM8255AAPC	34335		534171000
U18	Integrated Circuit	UDN2983A	56289		534255000
U19	Transistor Array	ULN2803A	56289		534274000
U20	Integrated Circuit	CD4051BE	02735		534209000
U21	Oper. Amplifier	TL072CP	01295		535092000
U22	Integrated Circuit	CD4052BE	02735		534140000
U23	Oper. Amplifier	CA3080E	02735		535091000
U24	Oper. Amplifier	CA3080E	02735		535091000
U25	Integrated Circuit	MC78M05CT	04713		535046000
U26	Integrated Circuit	uA7805UC	07263		53511700A
U27	Integrated Circuit	MC78M05CT	04713		535046000
U28	Integrated Circuit	uA79M05AUC	07263		535093000
U29	Oper. Amplifier	LM324N	27014		535068000
U30	Oper. Amplifier	LM10CLN	27014		53512200A
U31	Integrated Circuit	DS1210			53514300A
XBT1	Battery Holder		25441	BH-906	483263000
XJ8	Socket IC 16 Pin		06776	ICN-163-S3-G	473024000
XQ1	Socket Transistor		07047	90363-202	473046000
XU1	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU2	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU3	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU4	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU5	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU6	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU7	Socket IC 24 Pin		06776	ICN-246-S4-G	473043000
XU8	Socket IC 40 Pin		06776	ICN-406-S4-TG	473052000
XU9	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU10	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU11	Socket IC 28 Pin		06776	ICN-286-S4-TG	473044000
XU12	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU13	Socket IC 24 Pin		06776	ICN-246-S4-G	473043000
XU16	Socket IC 40 Pin		06776	ICN-406-S4-G	473052000
XU17	Socket IC 40 Pin		06776	ICN-406-S4-G	473052000
XU18	Socket IC 18 Pin		06776	ICN-183-S3-TG	473045000
XU19	Socket IC 18 Pin		06776	ICN-183-S3-TG	473045000
XU20	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU21	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU22	Socket IC 16 Pin		06776	ICN-163-S3-G	473042000
XU23	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU24	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
XU29	Socket IC 14 Pin		06776	ICN-143-S3-G	473019000
XU30	Socket IC 8 Pin		06776	ICN-083-S3-G	473041000
Y1	Crystal	3.579545 MHz	EDMAR	MQC035A	547035000

Table 5-2. Replaceable Parts (Continued)

Item	Description		Mfr.	Mfr's Part #	BEC Part #
	DISPLAY BOARD ASSEMBLY (A5); PART NUMBER 08211001E				
CR1	Diode, LED	HLMP-1401 (Yellow)	28480		536034000
CR2	Diode, LED	HLMP-1301 (Red)	28480		536024000
CR3	Diode, LED	HLMP-1301 (Red)	28480		536024000
CR4	Diode, LED	HLMP-1301 (Red)	28480		536024000
CR5	Diode, LED	HLMP-1301 (Red)	28480		536024000
CR6	Diode, LED	HLMP-1301 (Red)	28480		536024000
CR7	Diode, LED	HLMP-1301 (Red)	28480		536024000
CR8	Diode, Signal	1N914	01295		530058000
CR9	Diode, Signal	1N914	01295		530058000
CR10	Diode, Signal	1N914	01295		530058000
CR11	Diode, Signal	1N914	01295		530058000
DS1	Display, Numeric	5082-7656	28480		536812000
DS2	Display, Numeric	5082-7651	28480		536811000
DS3	Display, Numeric	5082-7651	28480		536811000
DS4	Display, Numeric	5082-7651	28480		536811000
J1	Socket IC 16 PIN	ICN-163-S3-G	06776		473042000
S1	Switch, Pushbutton	Type D7	31918		465287000
S2	Switch, Pushbutton	Type D7	31918		465287000
S3	Switch, Pushbutton	Type D7	31918		465287000
S4	Switch, Pushbutton	Type D7	31918		465287000
S5	Switch, Pushbutton	Type D7	31918		465287000
S6	Switch, Pushbutton	Type D7	31918		465287000
S7	Switch, Pushbutton	Type D7	31918		465287000
S8	Switch, Pushbutton	Type D7	31918		465287000
S9	Switch, Pushbutton	Type D7	31918		465287000
S10	Switch, Pushbutton	Type D7	31918		465287000
S11	Switch, Pushbutton	Type D7	31918		465287000
XDS1	Socket, IC 14 PIN	ICN-143-S3-G	06776		473019000
XDS2	Socket, IC 14 PIN	ICN-143-S3-G	06776		473019000
XDS3	Socket, IC 14 PIN	ICN-143-S3-G	06776		473019000
XDS4	Socket, IC 14 PIN	ICN-143-S3-G	06776		473019000
	SUB-PANEL ASSEMBLY (A8) ; PART NUMBER 08210301A				
P13	Connector		27264	02-06-1231	479320000
J2	Connector "SMB" 50 ohm		19505	2019-7511-000	477305000
J3	Connector Coax BNC		54420	UG-625B/U	479123000
J4	Connector Coax BNC		54420	UG-625B/U	479123000
W1	Cable Assy		04901		57116200B
W2	Cable Assy		04901		57116000A
	REAR PANEL ASSEMBLY (9) ; PART NUMBER 08210401C				
C1	Capacitor, Cer.	0.001 μF, 20%, 1000V	33883	B W/FDCL	224229000
C2	Capacitor, Cer.	0.001 μF, 20% 1000V	33883	B W/FDCL	224229000
F1	Fuse	.25A 250V Slow-Blow	54426	MDL-1/4A	545511000
J5 (W10)			27264	03-06-1043	479340000
P14	Connector 5 Circuit		06383	CE156F24-5-C	479394000
T1	Transformer Power		04901		44610100A
	LINE-SWITCH CONNECTOR ASSEMBLY, (A6) ; PART NUMBER 08211500A				
P15	Connector Housing		27264	30-06-2043	477306000
S2	Switch Power		13812	572-2121-0103-010	465286000

SECTION VI

SCHEMATIC DIAGRAMS

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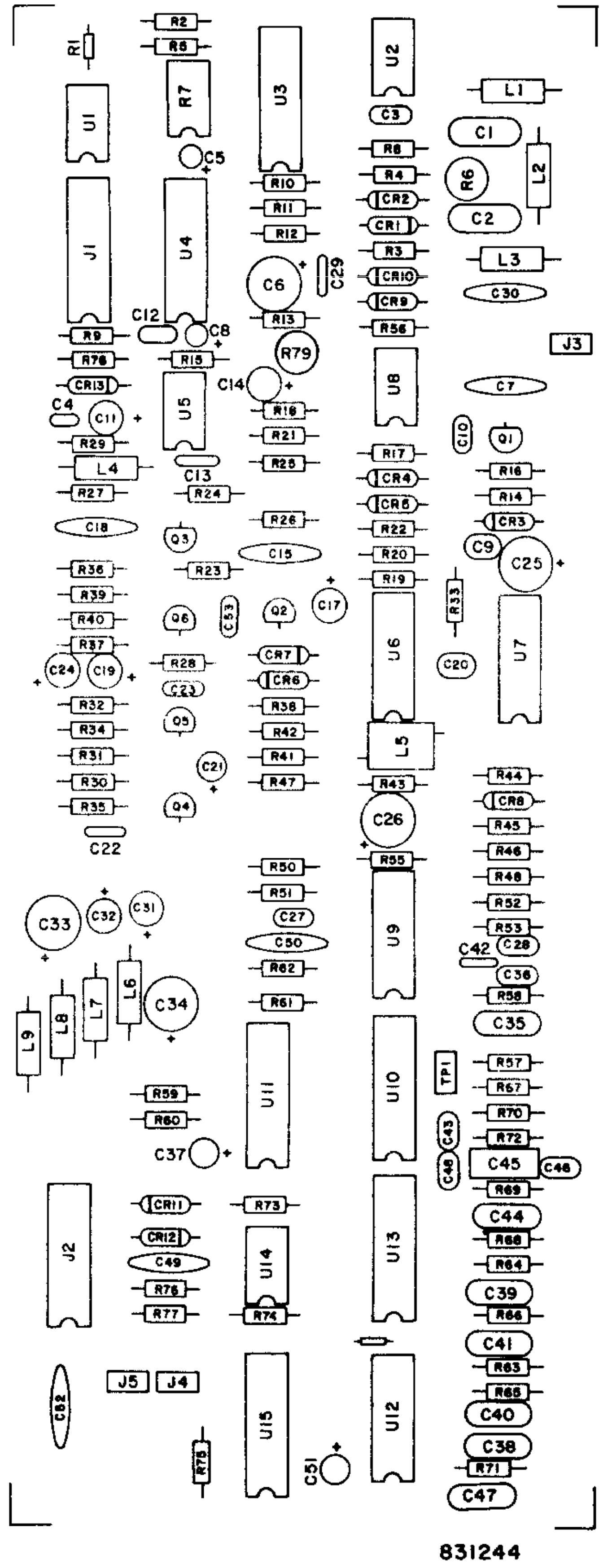
Figure **Page**

N O T E S



I.F.-A.F. Board, Parts-Location Diagram (D831244D)

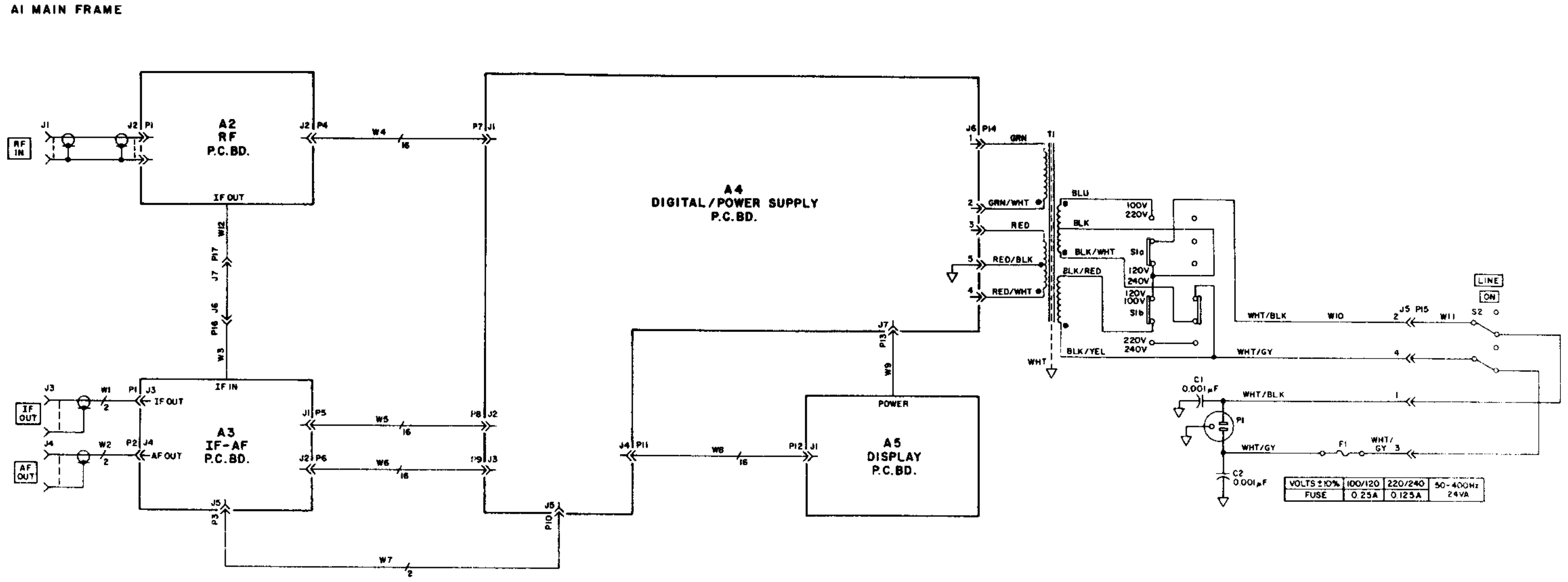


Figure 6-1.
Main-Frame Schematic
(E831193C, Sheet 1 of 4)

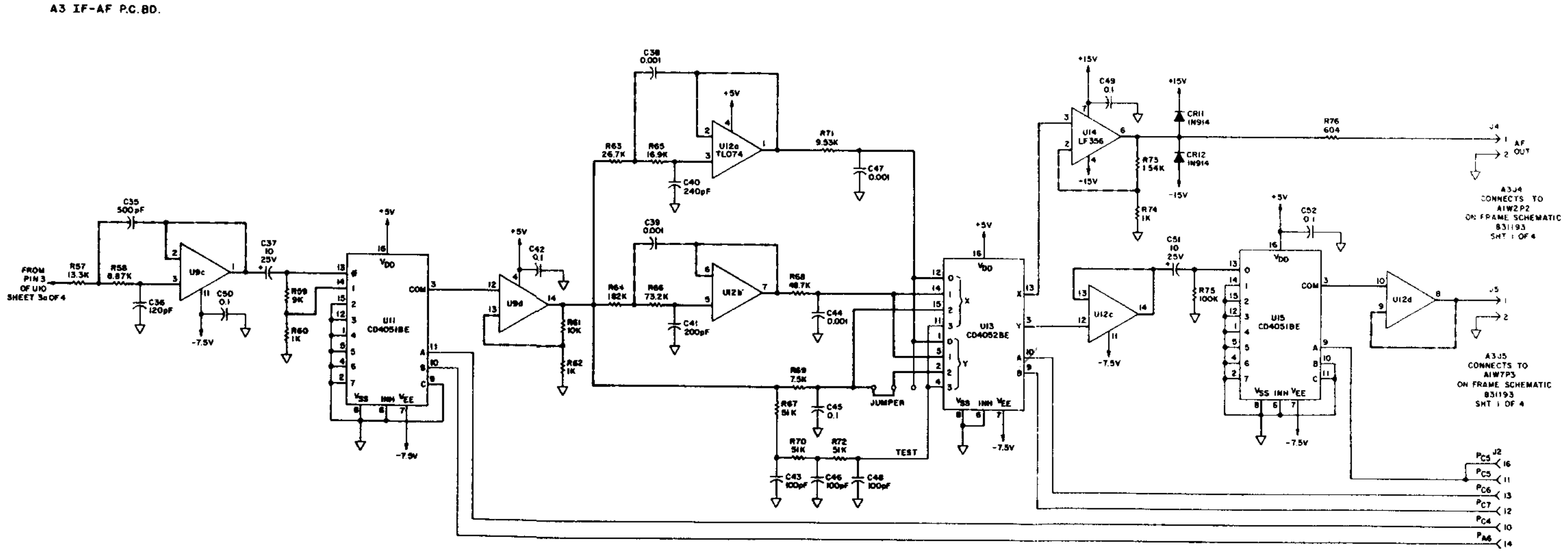
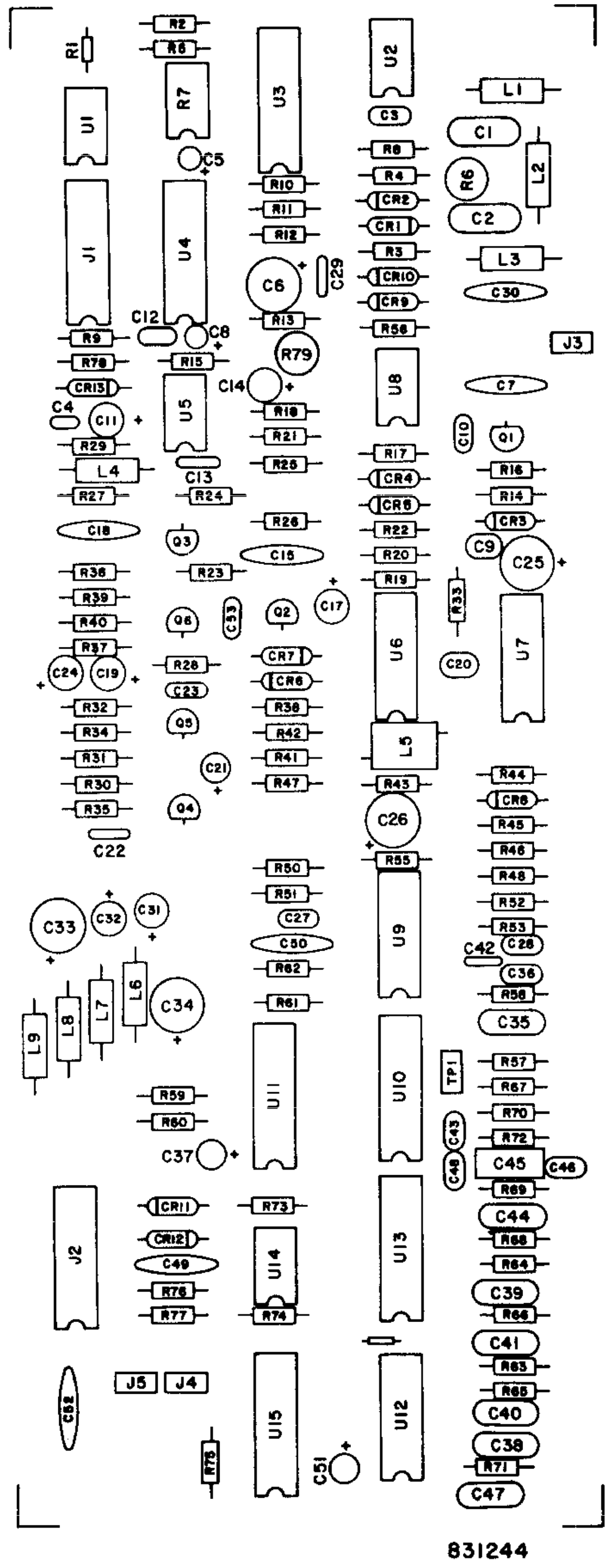


Figure 6-2.
I.F.-A.F. Board Schematic
(E831193C, Sheet 3b of 4)



I.F.-A.F. Board, Parts-Location Diagram (D831244D)

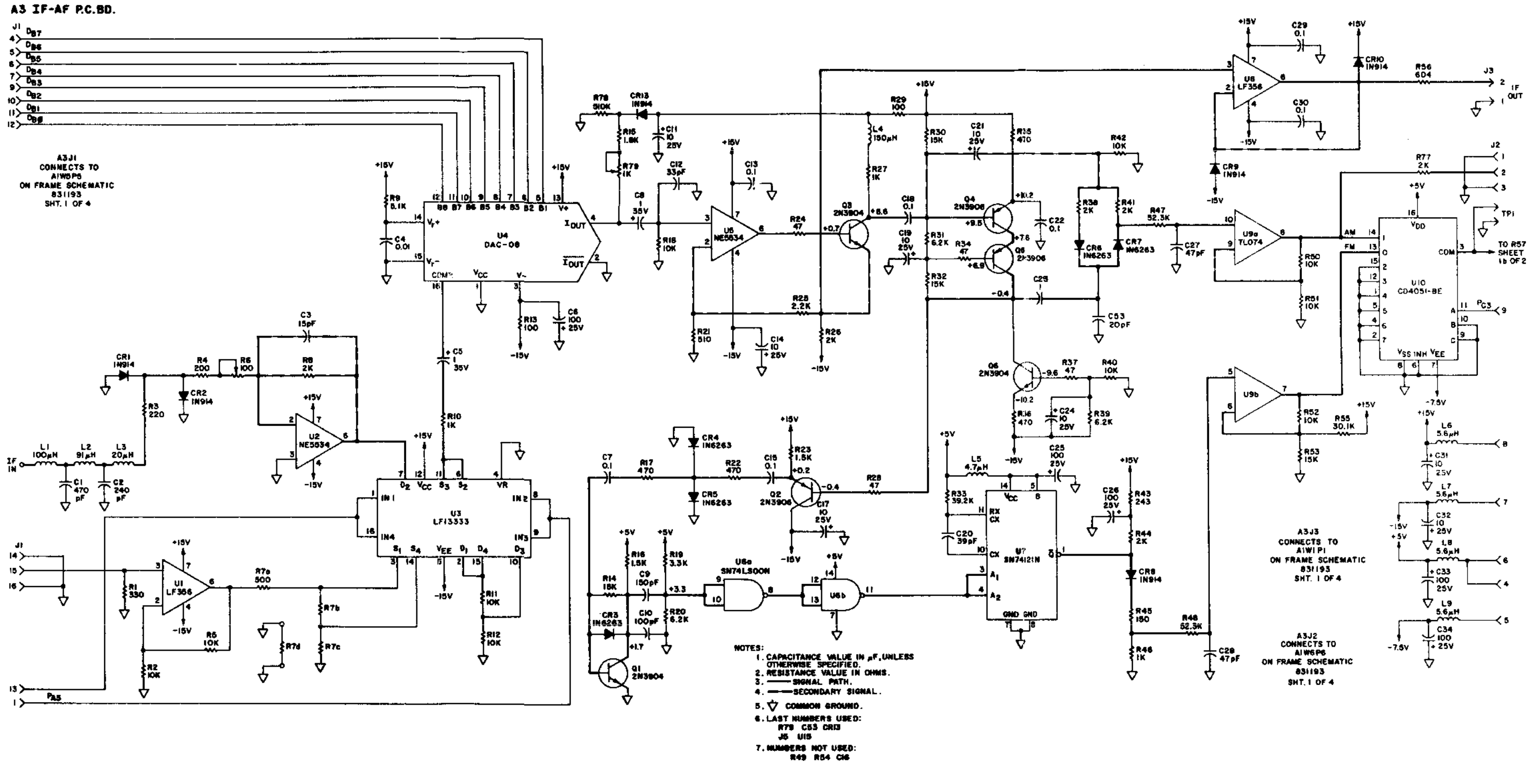
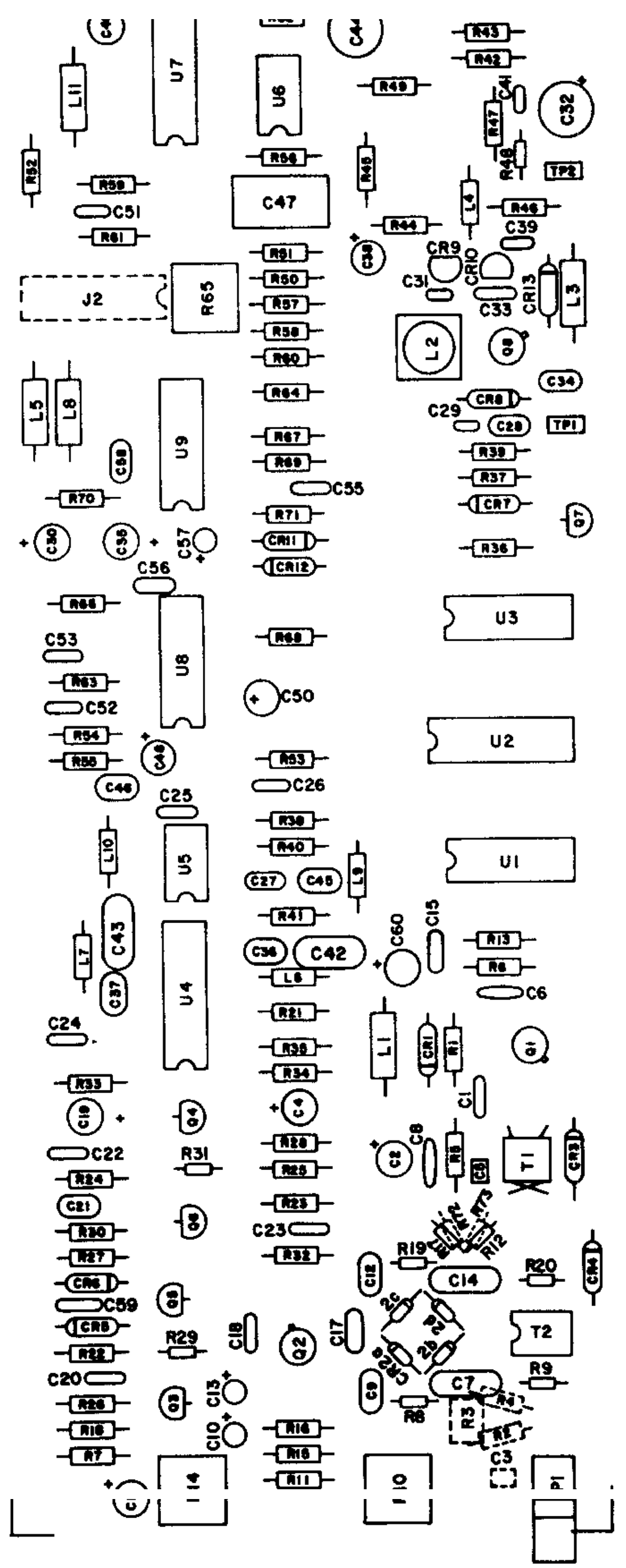


Figure 6-3.
I.F.-A.F. Board Schematic
(ES31193D, Sheet 3a of 4)



R.F. Board Parts-Location Diagram
(D831245B)

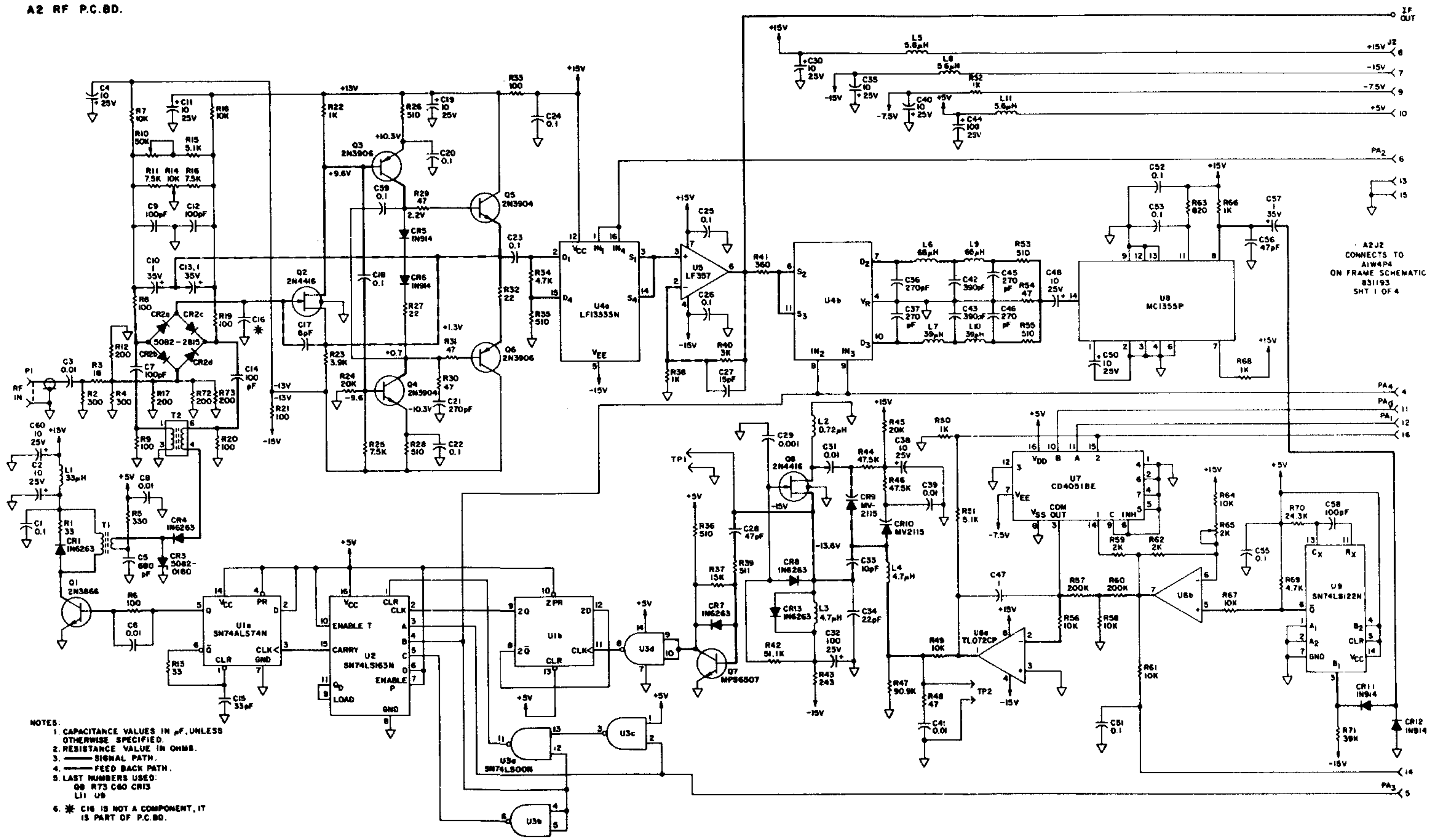
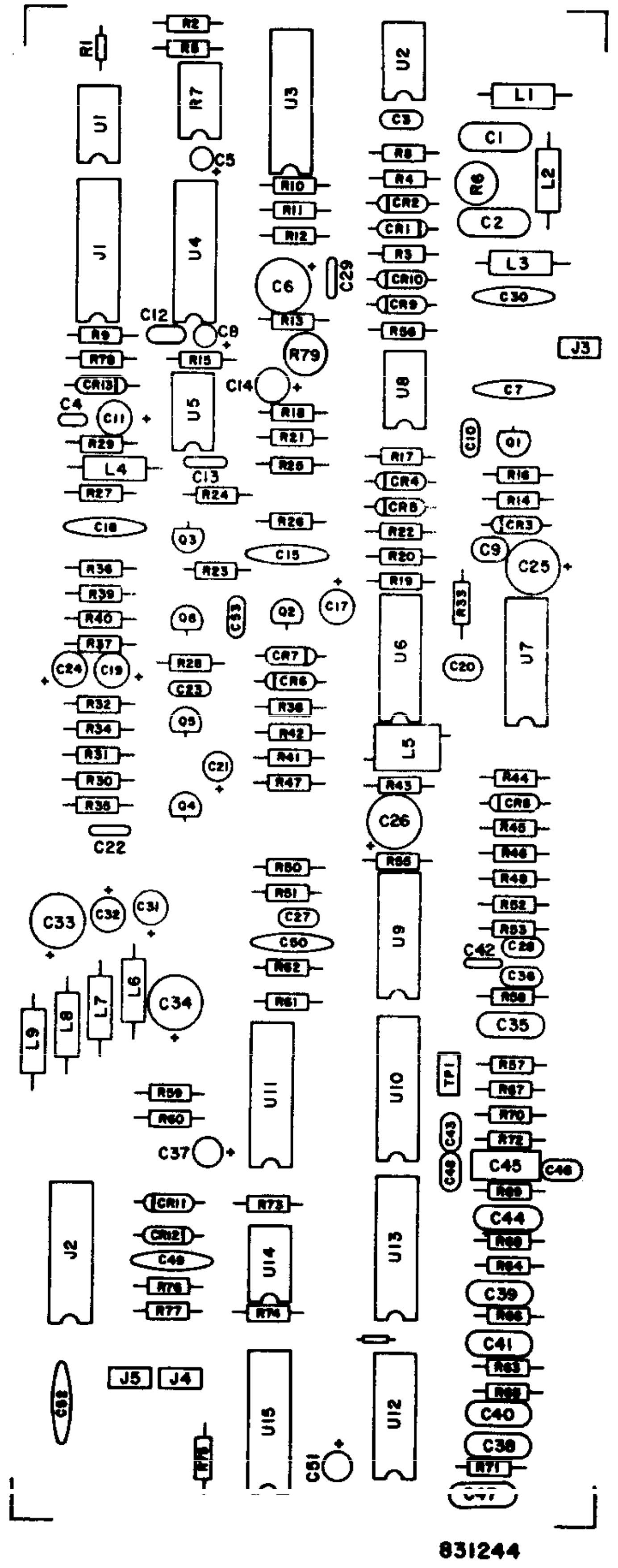


Figure 6-4.
R.F. Board Schematic
(E831193D, Sheet 2 of 4)



I.F.-A.F. Board, Parts-Location Diagram (D831244D)

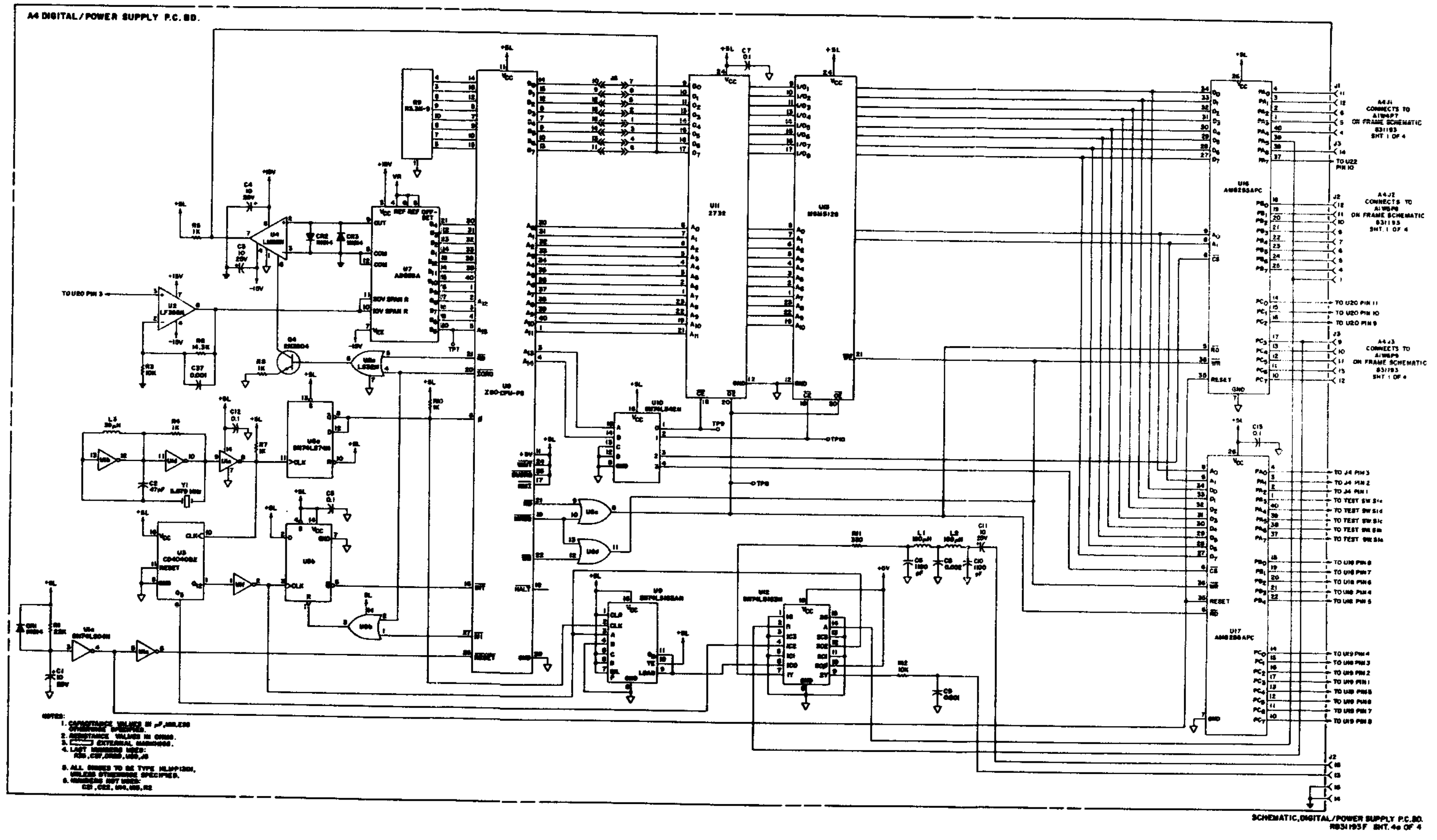
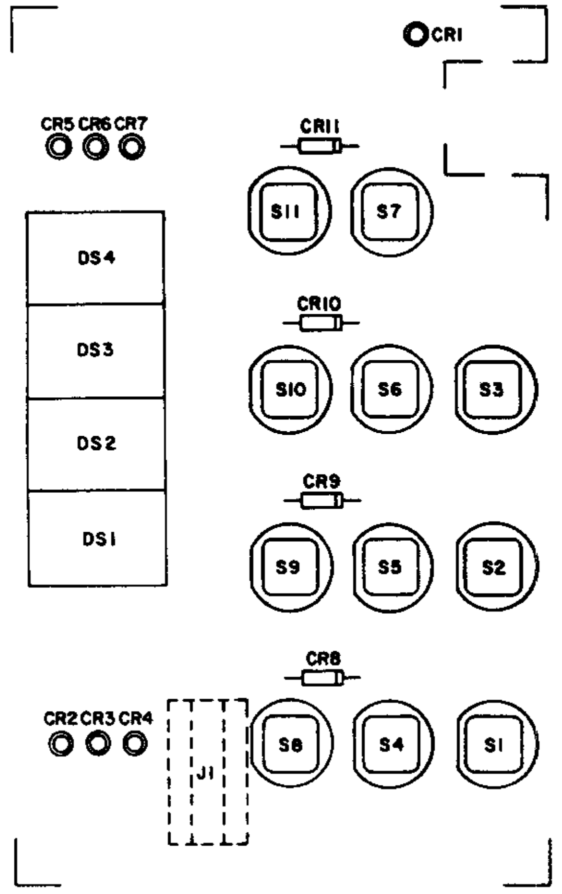
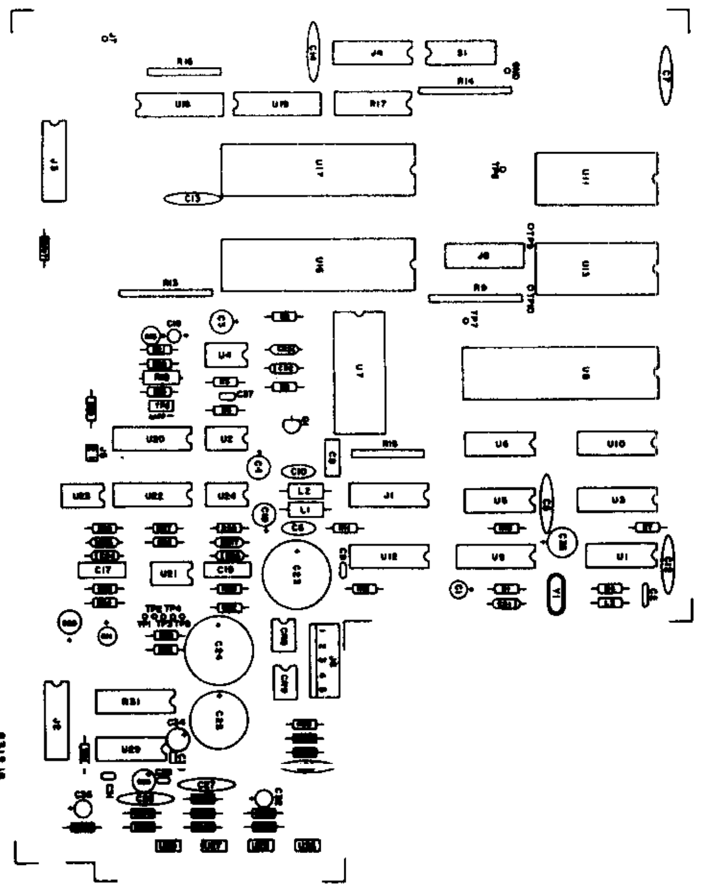


Figure 6-5. Digital & Power-Supply Board Schematic (R831193F, Sheet 4a of 4)



Display Board Parts-Location Diagram (C831250A)



Digital & Power-Supply Board Parts-Location Diagram (D831248F)

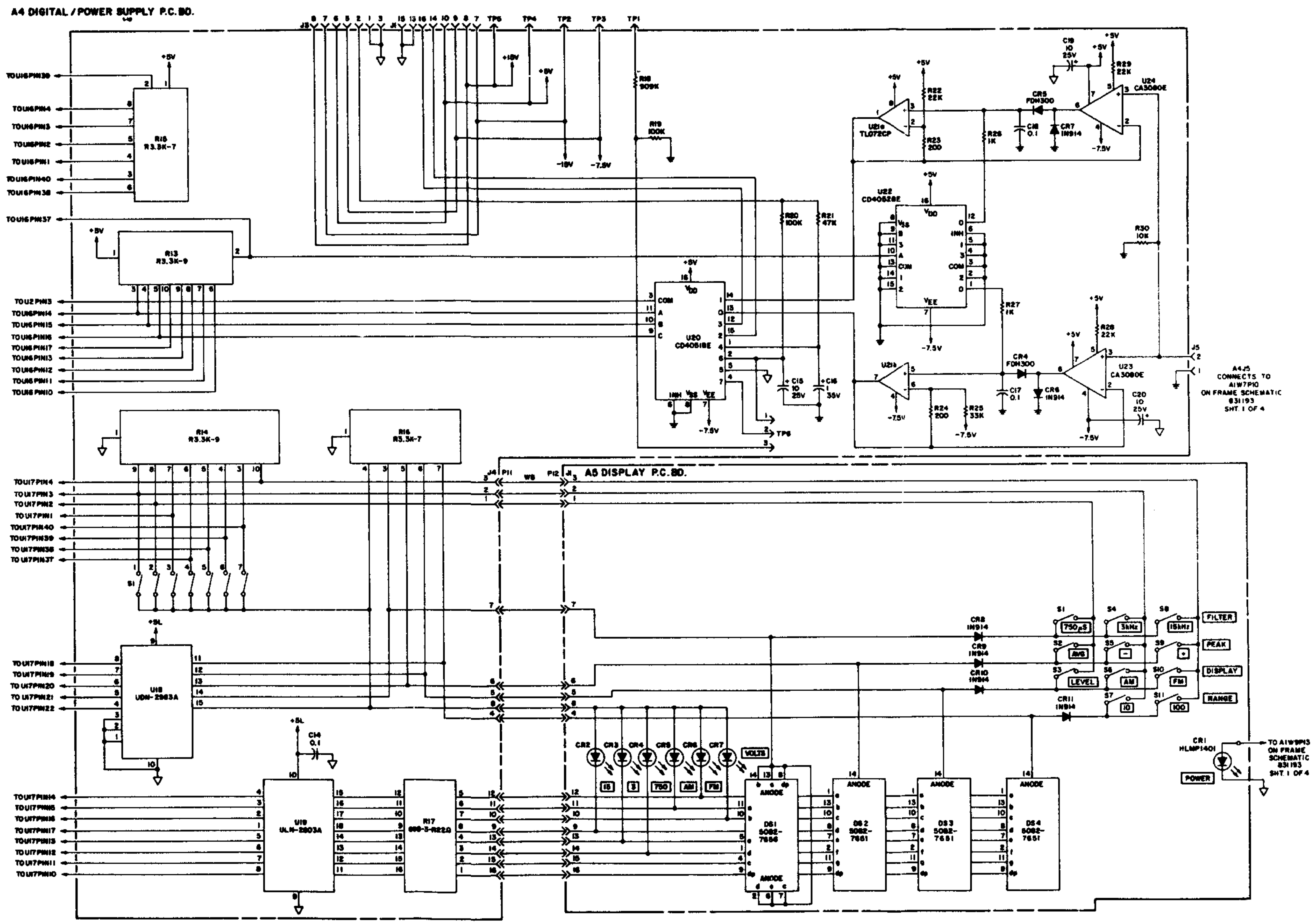
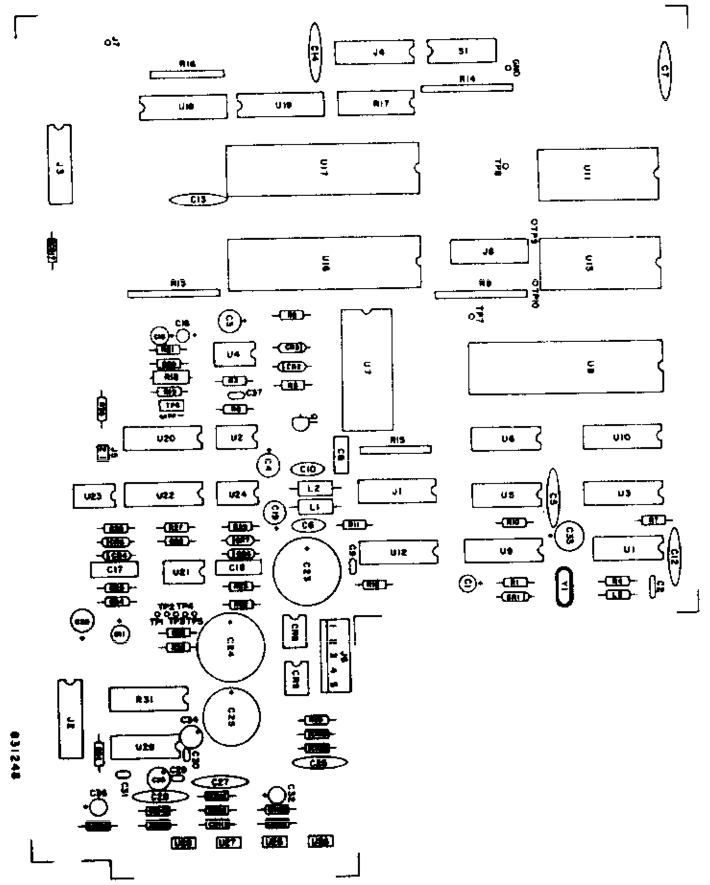


Figure 6-6. Digital & Power-Supply Board Schematic (E831193D, Sheet 4b of 4)



Digital & Power-Supply Board
Parts-Location Diagram (D831248F)

A4 DIGITAL/POWER SUPPLY P.C.BD.

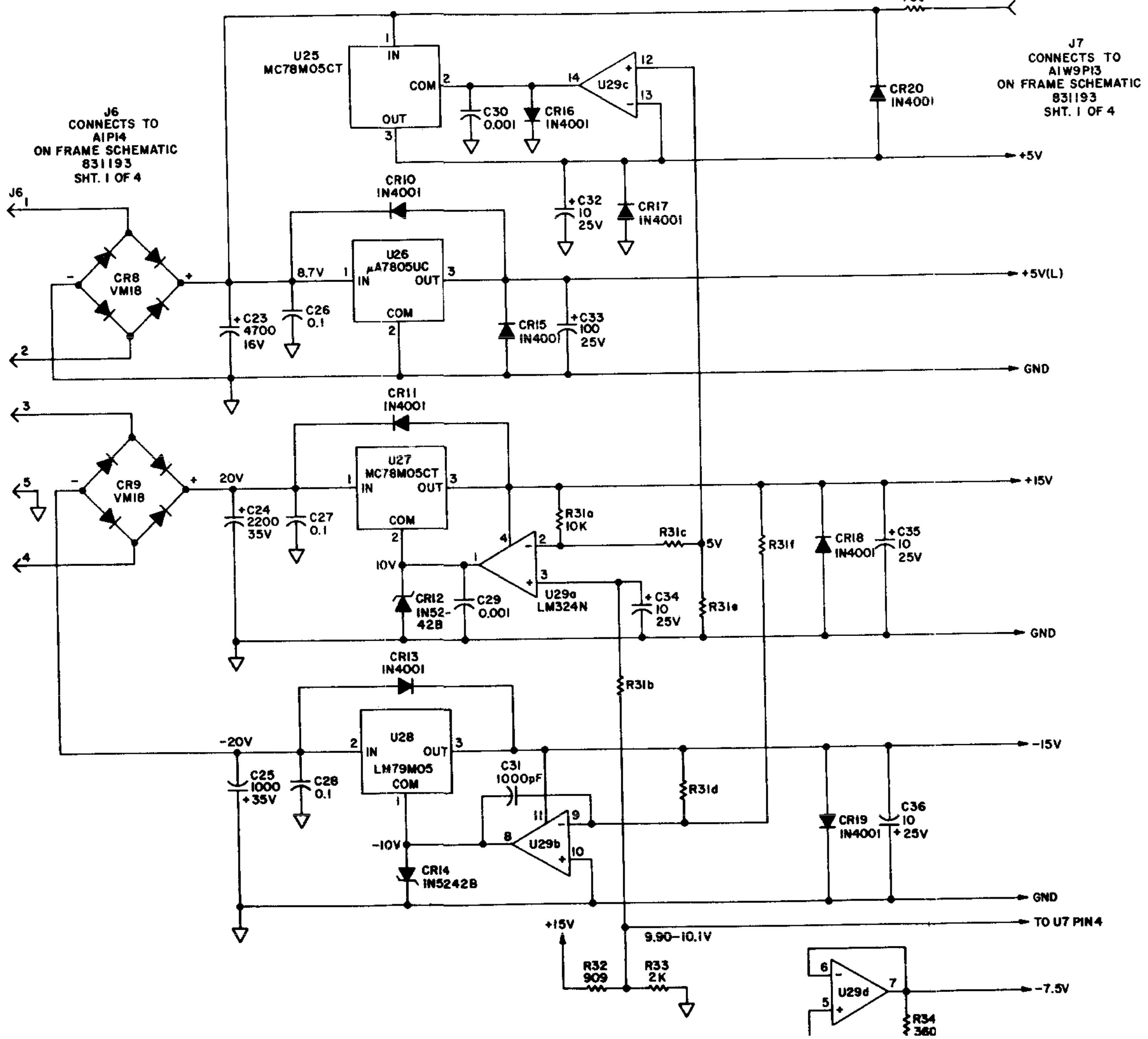


Figure 6-7.
Digital & Power-Supply Board
Schematic (D831193D, Sheet 4c of 4)

APPENDIX A

CALIBRATOR OPERATION

A-1. INTRODUCTION
The internal calibrators of the Model 8210 provide modulation standards for a.m. and f.m. measurements; they are activated each time the instrument is turned on. This section of the manual provides technical information concerning the operation and design of the calibrators.

A-2. TECHNICAL DISCUSSION
a. F.M. Calibrator. The calibration process consists of (lst) applying to the f.m. discriminator, in alternation, two accurately controlled frequencies; (2nd) measuring the resulting recovered modulation information: and (3rd) computing a correction factor for subsequent f.m measurements. As an aid in following this discussion refer to Figure 3-5.

(1) The input signal to pin 2 of A4U9 is the microprocessor's crystal-oscillator signal divided by two: 1.79 MHz. The preset inputs, A - D, of A4U9 are alternately programmed to be 12 (decimal) or 13 (decimal), depending upon the sense of the signal on pin 3 of A4U9. This latter signal is generated by dividing the 3.58 MHz crystal-oscillator frequency by 4096. The resulting frequency is 874 Hz.

(2) When the preset inputs are programmed to decimal 12, five clock cycles (i.e., at 1.79 MHZ) are required to cause the counter to overflow. The Q_D output then goes low, which reloads the preset inputs. Under these conditions, the counter is dividing the signal by a factor of five, resulting in an output frequency of 357.9 kHz. Similarly, when the preset inputs are programmed to decimal 13, the counter divides by four. The resulting frequency is then 447.4 kHz. The "average" frequency, therefore, is 402.6 kHz. The peak-to-peak deviation is 89.5 kHz and peak deviation is 44.75 kHz.

(3) To verify the accuracy of the f.m. calibrator, it is required only that the microprocessor's clock frequency be measured accurately. (Naturally, counter U9 must be operating properly as well.) Manual verification of the two (programmed) frequencies can be performed by lifting pin 2 of A4U9, shorting it alternately to +5 V and to ground, and measuring the resulting frequencies.

(4) The calibration program accumulates ten readings, and averages them to eliminate the last-digit uncertainty. The voltmeter, however, can resolve the actual deviation only to 1 part in 447. Thus the worst-case quantizing error is ± 0.22%. F.M. noise is of little or no consequence in determining calibrator deviation, since the two frequencies are crystal controlled and the r.f. circuitry is bypassed for calibration.

(5) Cross-correlation measurements using a Bessel null technique indicate that the actual calibration uncertainty for 100 calibrations is close to ± 0.11%, or one-half digit. (When employing Bessel null correlation, care should be taken to use a carrier with the lowest possible noise--and to take noise residuals into account--while keeping audio distortion to less than 0.1%.)

b. A.M. Calibrator. The operation of the a.m. calibrator is similar to that of the f.m. calibrator. Refer to Figure 3-5.

(1) During a.m. calibration the count modulus of A4U9 is fixed at four. The resulting frequency, 447.5 kHz, is low-pass filtered by A4L1, L2, C6, C8 and C10 to remove harmonics. The signal's amplitude is

not critical since the a.g.c. system is used to normalize the a.m. detector output.

(2) The filtered signal is routed to the i.f.-a.f. circuit board via C11, which removes any d.c. component, and thence to the input of buffer U1. Amplifier U1 increases the level of the signal, and more importantly, provides a very low output impedance to drive the voltage divider consisting of A3R7a, b, and c. The signal is kept at a high level in its passage through A3U3 in order to reduce the effects of switching transients and feed-through. The attenuator consisting of R11 & R12 reduces the signal to the correct level after modulation.

(3) The voltage divider comprising A3R7a, b, c, is a precision-resistor array. The absolute value of the resistors, however, is not as important as is the match between them. Thus, resistors R7b and R7c are guaranteed to a ± 0.1% match with R7a.

Maintaining this voltage divider at a constant impedance minimizes the loading effect of attenuator A3R11-R12.

(4) The voltage at the junction of A3R7a and R7b is two-thirds of the output voltage of A3U1; the voltage at the junction of R7b and R7c is one-third. The ratio of these two voltages is 2:1. The equivalent a.m. percentage is then derived as follows:

NOTE:
p_+ = +peak
p_- = −peak

$$\% \, p_+ = \frac{E_{max} - E_{avg}}{E_{avg}} \times 100 \qquad (1)$$

$$\% \, p_- = \frac{E_{avg} - E_{min}}{E_{avg}} \times 100 \qquad (2)$$

$$\text{peak average } \% = \frac{p_+ - p_-}{2} \times 100 \qquad (3)$$

Therefore, combining Eqs. 1, 2 & 3, for symetrical modulation,

$$\% \text{ a.m.} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100 \qquad (4)$$

And for a 2:1 ratio,

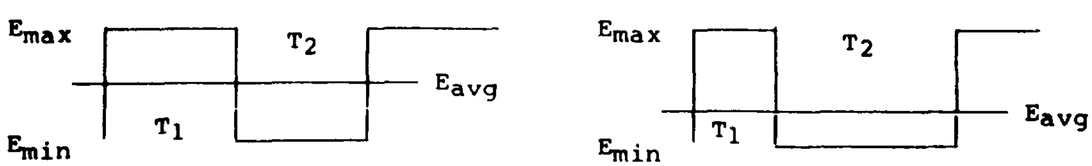
$$= \frac{2 - 1}{2 + 1} \times 100$$

$$= 33.33\%$$

(5) The above equations assume that the modulation is symmetrical (i.e. perfectly so). Should that not be the case, a d.c. shift occurs and the plus and minus peaks are not symmetrical. The calibrator program eliminates such an error by calculating a.m. as:

$$\text{peak average} = \frac{p_+ + 2p_-}{3} \qquad (5)$$

This expression is determined as follows:



Symmetric (Ideal) Modulation　　　Asymmetric Modulation

Calibrator Undulation Signal

¶A-2b(5), Continued.

Now, since the peak detectors are a.c. coupled,

$$(p+)(T_1) - (p\_)(T_2) = 0 \quad \text{(0 volts, d.c.)} \tag{6}$$

And:

$$T_1 + T_2 = 1 \tag{7}$$

$$(p+)(T_1) - (p\_)(1 - T_1) = 0 \tag{8}$$

$$T_1 = \frac{p-}{p+ + p-} \tag{9}$$

Now:

$$E_{avg} = E_{min} + (E_{max} - E_{min}) \frac{T_1}{T_1 + T_2} \tag{10}$$

And, in the 8210:
[see ¶A-2b(4)]

$$E_{max} = 2E_{min} \tag{11}$$

Combining Eqs. 7,10 & 11:

$$E_{avg} = E_{min} + E_{min}(T_1) \tag{12}$$

$$E_{avg} = E_{min}(1 + T_1) \tag{13}$$

If symmetry is perfect:

$$E_{avg} = E_{min}(1.5) \tag{14}$$

If symmetry is less than perfect, the d.c. ratio error, R (that is, Eq. 13 vs. Eq 14), will be:

$$R = (1 + T_1)/1.5 \tag{15}$$

Combining Eqs. 9 & 15:

$$R = \frac{p+ + 2p-}{1.5\,(p+ + p-)} \tag{16}$$

The uncorrected a.m.,
(Eavg normalized to 1):

$$= \frac{p+ + p-}{2} \tag{17}$$

The corrected a.m. is then:

$$= \frac{p+ + p-}{2} \times R \tag{18}$$

And, from Eqs. 16 & 18,

$$= \frac{P+ + 2p-}{3} \tag{19}$$

(6) It should be noted that only the ratio of the two modulating levels is important--not their absolute values. The two a.m. levels can be measured at the AF OUT connector by manually operating the IC analog switch A3U3 as follows:

(a) With power off, set Pos. #7 of Test Switch A4S1 "on."

(b) Power on. Connect a voltmeter to the AF OUT connector.

(c) Connect a clip lead from pin 1 or 16 of A3U3 to ground. (These pins are resistively isolated, so no harm will occur in grounding them.)

(d) Depress the AM FUNCTION button and measure the AF OUT voltage.

(e) Disconnect the clip lead from ground and connect it to +5 volts (pin 14 of A3U6).

(f) Measure the AF OUT voltage.

The ratio of the two voltages should be exactly 2:1, within ± 0.1% (The voltmeter should be able to resolve a 0.1% error at 447.4 kHz; a thermocouple type is suggested.)

The procedure given above is not intended to be a performance test;

it is included only to satisfy one who is curious as to the operation of the calibrator.

(7) The calibration program accumulates ten readings, and averages them to eliminate the last-digit uncertainty in the scaling operation. The voltmeter, however, can resolve the reading only to 1 part in 333. Therefore, the worst-case quantification error is ± 0.3%. A.M. noise is of little consequence in determining calibrator depth since the level is determined by TTL gates before filtering, and the frequency is crystal-controlled. Actual noise levels are less than 1 part in 3333.

(8) Cross-correlation measurements using a specially calibrated Model 82AD F.M.-A.M. Modulation Meter (Boonton electronics) indicate that the actual calibration uncertainty for 100 calibrations is approximately ± 0.15%.

c. <u>Audio Processing.</u> During calibration, a three-pole gaussian filter is used to remove high-frequency signal components. The filter time-constants are selected so as to provide the required filtering without affecting the absolute peak values of the recovered signal. The use of a gaussian filter ensures that there will be no overshoot on the recovered audio signal.

d. <u>R.F. Circuitry.</u> The Model 8210's r.f. circuitry is designed to have exceptional linearity so that a.m. performance is not degraded. As noted earlier, however, the r.f. circuits are not included in the modulation-calibration process. Consequently, during a.m. measurements, errors can occur if there is a malfunction in the r.f. section. These errors will usually be obvious to the user.

For f.m. measurements, the bypassing of r.f. circuitry during modulation calibration does not present a problem, since frequency modulation is the same before and after frequency conversion.

W A R R A N T Y

Boonton Electronics Corporation warrants its products to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to active devices that have given normal service, to sealed assemblies which have been opened or to any item which has been repaired or altered without our authorization.

We will repair, or at our option, replace any of our products which are found to be defective under the terms of this warranty.

There will be no charge for parts, labor, or forward and return normal ground transportation during the first three months of this warranty.

There will be no charge for parts, labor, or return normal ground transportation during the fourth through twelfth month of this warranty.

Except for such repair or replace[illegible] liable for any incidental damages or for any consequential damag[illegible] are defined in Section 2-715 of the Uniform Commercial Code, in [illegible] with products covered by this warranty.

*For *overseas shipments*, there will be no charge for Air Freight during these specified time periods.

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