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53A-243 ARBITRARY WAVEFORM GENERATOR CARD

OPERATING MANUAL

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Printed in U.S.A.

02/17/92 9101-02-A

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53A-243 ARBITRARY WAVEFORM GENERATOR CARD

OPERATING MANUAL

DESCRIPTION 1

CONTROLS AND INDICATORS
- Address-Select Switch 2
- Power LED 2
- Fuses 2
- SMB-Connector Inputs and Outputs 2
- Function LEDs and Switches 2

SPECIFICATIONS 4

OPERATION
- Overview 8
- Command Summary 8
- Card Commands 10

INSTALLATION 25

APPENDIX A
- 53/63 SYSTEM COMMANDS 26

APPENDIX B
- INPUT/OUTPUT CONNECTIONS 27

APPENDIX C
- CALIBRATION PROCEDURE 28

APPENDIX D
- ADVANCED PROGRAM CAPABILITIES 32

APPENDIX E
- SAMPLE PROGRAMS FOR THE 53A-243 34

53A-243 ARBITRARY WAVEFORM GENERATOR CARD

DESCRIPTION

The 53A-243 Arbitrary Waveform Generator (ARB) Card is a printed circuit board assembly for use in a CDS 53/63 Series System. The card produces a programmable series of output-voltage steps that can be used to create precise sinusoidal, triangular, square, or other user-defined arbitrary waveforms. The ARB Card produces an analog output of either ±5.11 V, programmable in 10-mV steps, when driving a 50-Ohm load; or ±10.22 V, programmable in 20-mV steps, when driving a high-impedance load.

Sample rates are programmable from a period of 40 nanoseconds to a period of 671 milliseconds in 40 nanosecond steps, using the internal clock.

A waveform consisting of up to 16,384 10-bit voltage points can be programmed into the on-card memory. The waveform may be of any length up to 16,384 samples. The output waveform may be programmed to repeat from 1 through 255 times, or continuously.

Break points may be programmed in any nonconsecutive memory locations except the first location in memory. A break point causes the waveform to pause until it is retriggered by software or by a TTL trigger from an external source. This feature is particularly useful in applications where it is desirable to coordinate portions of the output waveform with other portions of the test.

Multiple ARB Cards can be slaved to a single card or to a common external clock source to allow output waveforms to be phase synchronized. This feature gives greater flexibility in using the ARB. For example, the phase relationship between waveforms that have been synchronized in this manner can be varied under program control by specifying a new starting memory location for each individual output waveform.

Memory locations are easily programmed using a string of numeric ASCII characters which directly specify the output voltage for each sample. An editing capability allows individual points in the waveform to be changed without requiring a complete memory reload. In addition, memory loading is further optimized during a block waveform load by an auto-increment feature. With this, the user need only program the starting waveform address at the beginning of the block waveform load.

Auxiliary inputs provide for an external clock input (up to 25 MHz), and for an external trigger. Auxiliary outputs provide a clock output at a frequency equivalent to the programmed sample rate, and a synchronization pulse that is generated at the end of each waveform cycle.

CONTROLS AND INDICATORS

The following controls and indicators are provided to select and display the functions of the 53A-243 Card's operating environment.

Address-Select Switch

The 53A-243 Card has a miniature 10-position switch which selects the 53A-243 Card's address (0-9) in the 53/63 Series System. Open the switch's cover and use a screwdriver with a narrow, flat blade to turn the cam-action wiper to the desired position.

Power LED

The Power LED provides a valuable diagnostic tool by giving the system programmer a visual indication of the action which the system is currently taking. Whenever the 53A-243 Card is addressed by the system controller, the Power LED goes out. The LED remains out until another function card is addressed. Since only one function card can be addressed at a time, an unlit Power LED indicates the function card with which the system controller is currently communicating. The Power LED being lit not only indicates that the 53A-243 Card is unaddressed, but that all required dc power (5 V dc, ±15 V dc) is being supplied.

Fuses

The 5-volt dc and ±15-volt dc power buses each have a fuse that protects the system from overloads. If any fuse has blown, the Power LED will not light.

SMB-Connector Inputs and Outputs

Four SMB connectors provide the Arbitrary Waveform Output, External Trigger Input, External Clock Input, and Sync Output signals. See Appendix B for a detailed description of these signals.

Function LEDs and Switches

The following LEDs are provided at the top front edge of the 53A-243 Card to indicate the status of the card's operation.

LED	Lit when:
RUN	- memory is actively transmitting.
BPNT	- a memory breakpoint is active.
XCKE	- the external clock input is enabled.
XTRE	- the external trigger input is enabled.
ERR	- an error condition has been detected.

Halt Switch

This two-position slide switch is located near the card's backplane edge connector. It selects the state of the 53A-243 Card after an @XH (Halt) or STOP command is received by the 53/63 Series System.

a. If the Halt switch is in the ON position, then the 53A-243 Card is reset to its power-up state, all parameters are reset to their default values, and the Power LED is lit.

b. If the Halt switch is in the OFF position, then the 53A-243 Card becomes unaddressed, the Power LED is lit, and any programmed parameters of the card remain unchanged.

SPECIFICATIONS

Number of Channels:	Single channel.
Amplitude Resolution:	10 bits (1,024 vertical samples).
Waveform Memory:	16,384 memory locations (horizontal samples).
Memory-Update Capability:	Random-access update of any point in waveforms.
	Automatic increment of address for sequential memory points.
Waveform-Repeat Capability:	Waveform programmable for a repeat count of 1 through 255 times, or continuous.
Waveform Triggering:	Triggering under program control, or with external trigger.
External Trigger Input:	Enabled or disabled under program control.
Breakpoint-Capability:	Any points in a waveform, except the first sample point in the waveform or any two sequential sample points, can be programmed to pause transmission until the card is retriggered (by hardware or software trigger).
Interrupt Capability:	Programmable interrupt at end of transmission, on breakpoint(s) or any combination.
Output Amplitude:	±5.11 V dc in a 50-Ohm load, programmable in 10-mV steps; ±10.22 V dc into a high impedance load, programmable in 20-mV steps.
Output Accuracy:	
DC Accuracy:	±0.2% of full scale into 50 ohms. ±0.5% of full scale into open impedance.
DC Temperature Drift:	0.02%/* C of full scale.
Settling Time (full scale):	100 ns (to dc accuracy). 75 ns (to 1.5% accuracy).
Output Current:	100 mA, maximum. Short circuit protected.
Maximum Output Sample Rate:	25 MHz.
Output Filter:	User selectable 4 MHz low pass filter.

Programmable Sample Rates:	25 MHz to 1.5 Hz, rounded to the nearest 40 nanosecond period increment.
Programming:	Programmable as a 6 significant digit period or as a 1 to 16,777,215 integer multiple of the basic 40 nanosecond period.
Frequency Accuracy:	0.005% (0°C to 50°C).
External Clock Input:	User-supplied, 0 Hz to 25 MHz, TTL-compatible signal. Minimum clock duration: Clock high - 14 ns. Clock low - 17 ns.
External Trigger Input:	User-supplied, active-low, TTL-compatible pulse, edge triggered. Minimum pulse width: 80 ns.
Byte Throughput Rate:	Binary byte transfer rate: 17,8000 bytes/sec. ASCII byte transfer rate: 26,300 bytes/sec. ASCII computation rate: 830 bytes/sec.
Time to Load Memory and Trigger 1st Sample*:	ASCII Data: 120 sec. Binary Data: 1.84 sec. * 16,384 samples, exclusive of system controller overhead.
Programming:	ASCII characters or binary, representing value of output sample in volts.
Input Data Buffer Size: (ASCII Data)	23,000 bytes. NOTE: ASCII byte transfer rate will be equal to ASCII byte transfer rate until buffer is full, and equal to the ASCII computation rate after buffer is full.
Power-up Default Programming:	Sampling Frequency - 25 MHz Voltage Waveform - 0 V dc waveform. Repeat Count - Continuous. External Trigger - Disabled. Interrupt - Disabled. Low Pass Filter - Disabled. Memory Edit Address - 0 Error Status - Cleared. Output State - Not triggered. External Clock - Disabled.
Auxiliary I/O Capability:	End-of-waveform output. External-clock input. External-trigger input.
Auxiliary Outputs:	Advanced Schottky-TTL drive, 40 standard TTL loads.

Auxiliary Inputs:	Advanced Schottky-TTL load, 0.3 standard TTL load.
Power Requirements:	5-volt and ±15-volt dc power is provided by the internal Power Supply in the 53/63 Series Card Cage.
Voltage (5-volt Supply):	4.75 V dc to 5.25 V dc.
Current (5-volt Supply):	1.25 A, maximum quiescent. 1.5 A, peak.
Voltage: (+/-15-volt Supplies):	+14.5 V dc to +15.5 V dc. -14.5 V dc to -15.5 V dc.
Current (+/-15-volt Supplies):	150 mA, maximum quiescent. 175 mA, peak.
Cooling:	Provided by the fan in the 53/63 Series Card Cage.
Temperature:	-10°C to +65°C, operating (assumes ambient temperature of 55° and airflow to assure less than 10°C temperature rise). -40°C to +85°C, storage.
Humidity:	Less than 95% R.H. non-condensing, -10°C to +30°C. Less than 75% R.H. non-condensing, +31°C to +40°C. Less than 45% R.H. non-condensing, +41°C to +55°C.
Dimensions:	197 mm high, 221 mm deep, 13 mm wide. (7.75 in x 8.69 in x 0.5 in).
Dimensions, Shipping:	When ordered with a 53/63 Series Card Cage, the card is installed in one of the card cage's function-card slots. When ordered alone, shipping dimensions are: 254 mm x 254 mm x 127 mm. (10 in x 10 in x 5 in).
Weight:	0.34 kg. (0.75 lb).
Weight, Shipping:	When ordered with a 53/63 Card Cage, the card is installed in one of the card cage's function-card slots. When ordered alone, shipping weight is: 1 kg. (2.2 lb).
Mounting Position:	Any orientation.
Mounting Location:	Installs in any function-card slot of the 53/63 Series Card Cage.

I/O Connections: SMB snap-on connectors; 1 SMB-to- BNC male adapter cable is supplied.

Equipment Supplied:

1 - 53A-243 Arbitrary Waveform Generator Card.
1 - 53A-729 SMB-to-BNC Male Adapter Cable (10 ft).
1 - Spare fuse (Part# 42202-52003).
1 - Operating manual (Part# 00000-12430).
1 - Service manual (Part# 00000-22430).

OPERATION

Overview

The 53A-243 Card is programmed by ASCII characters issued from the system controller to the 53/63 System's communications card. The 53A-243 Card is interfaced to the communications card through the 53 Series or 63 Series Card Cage's backplane.

To address a function card for the first time, the system command @XY must be issued. X is the mainframe address (0-9) selected on the 53A-171 Control Card in the addressed mainframe; Y is the 53A-243 Card's address (0-9) within the addressed mainframe. The 53A-243 Card's address is selected using the card's Address Select switch. Once a function card is addressed, it remains addressed until the system receives another @ character. Appendix A fully discusses the @XY command and the other 53/63 System commands. After the 53A-243 Card is addressed, the commands listed below may be issued until another function card is addressed.

If desired, carriage return, line feed, and null or space characters may be inserted between any complete commands without affecting operation. They may not be inserted within commands.

Command Summary

An overview of the ARB Card's commands, in the order they would typically be programmed, is as follows:

Command	Description
C	Clock command programs the external clock input enable.
P	Period command programs the basic sample rate of the card.
V	Voltage command sequentially programs the arbitrary-waveform voltages. The B, W, and Z commands are variations of the V command that program a breakpoint, end-of-waveform, or a breakpoint and end of waveform, respectively, in addition to the voltage sample.
R	Repeat command programs the number of times to repeat the waveform, or programs continuous transmission.
L	Low-pass filter command controls the filter on the analog output.
X	eXternal trigger programs the external-trigger mode.
I	Interrupt command programs the interrupt mode.
T	Trigger command resets the memory to the first location and starts actual transmission of the programmed waveform(s), or retriggers the card when it is halted at a breakpoint.
Q	Quit command may be used to halt output of a waveform.

Command	Description
M	Memory edit command allows random access to any location in the memory partition for updating of any point(s) in the waveform with a subsequent V command. The M command can also be used to cause waveform output to begin at a memory location other than zero when a 1T Trigger command is issued.
?	Status command reports the card's status and clears errors the card has detected.
K	Kill command resets the card to its power-up state.
[n]D #[n][m]	The D (Divide) and # (Binary) commands, described in Appendix D, Advanced Programming Capabilities, are for the more experienced programmer. The Binary command programs the arbitrary-waveform voltage in binary and is used in place of the V command for high speed downloading of voltage values.

Card Commands

Detailed descriptions of the 53A-243 Card's commands, in the same order as listed above, are presented on the following pages. The bracketed [ ] variables shown with some commands are additional arguments for the command. The allowable values for the variable are included in the command description.

Command	Description

C

On power-up, Internal Clock is selected. If External Clock is to be programmed, it should be the first command received by the card.

Syntax: [n]C

[n]	Clock Selected
1	External Clock
0	Internal Clock

If External Clock Input is selected, the ARB Card's 25-MHz internal clock is replaced with the clock appearing at the External Clock Input connector. The period programmed by the subsequent P or D command is then given by the formula:

$$PA = (PE/40) * PP$$

where: PA = Actual programmed period in ns.
PE = Period of external clock in ns (25 MHz, maximum).
PP = Period programmed with P or D command.

The clock source selected by the C command will remain unchanged when a Q (Quit) command is received by the card. The clock source is returned to internal by a K (Kill) command, or by a STOP command if the Halt Switch is in the ON position (see Appendix A for information on the STOP command).

Command	Description
P	The P (Period) command is used to set the period of the output sample rate clock.

Syntax: [n]P

The value of [n] is in seconds. The period may be programmed as any valid floating point number with or without exponent and is rounded off to the nearest six significant digit floating point value. The value programmed will also be rounded off to the nearest integer multiple of the basic 40 nanosecond period interval of the card.

Example: A .5P command will set the period of the sample clock to 0.5 seconds (a 2 Hz sample rate).

Example: A 2.05647E-3P command will set the period of the sample clock to 2.05648 milliseconds (a frequency of 486.26779 Hertz).

To program a precise integer multiple of the basic 40 ns clock period, see the D command in Appendix E. The D command may also be used at low frequencies to program more than 6 significant digits of accuracy up to the 24 bit capability of the card. The maximum sample period value available is (40 E-9) * (2^{24}), or approximately 0.67 seconds.

On power-up, the value of the P command is set to a 40 ns period. The value of the P command is not altered by a Q (Quit) command, but is reset to the power-up value by a K (Kill) command, or by a STOP command if the Halt Switch is in the ON position (see Appendix A for STOP command information).

Command	Description

V

The V (Voltage) command is used to load the memory partition with the desired voltage to be output during a sample period.

Syntax: [pv]V

The programmed voltage, [pv], is a number from -5.11 to +5.11. When entering [pv], a minus sign must prefix negative values; a plus sign is optional for positive values. Leading spaces are ignored. The programmed voltage is formatted as a decimal value with two digits following the decimal point. If the [pv] value entered does not have a decimal point and two digits following the decimal point, then an error is generated. The examples below show the resulting programmed voltage for correctly and incorrectly formatted [pv] values.

Examples: [pv] Entered

Correctly Formatted	Programmed Voltage (V)
.01	0.01
0.10	0.10
1.00	1.00
-2.57	-2.57
0.23	0.23
-0.11	-0.11
.00	0.00

Incorrectly Formatted:

.001	error
.1	error
.100	error
1	error
1.0	error
10	error
10.	error
100	error
100.	error
0	error

The programmed voltage assumes a 50 Ohm load at the ARB Card's output. The ARB Card is factory-calibrated with a 50 Ohm impedance applied directly at the connector output. For applications where the 50 Ohm load is at the end of a cable, the cable's impedance must be taken into consideration in order to achieve the accuracy shown in the ARB Card's published specifications.

The ARB Card's output has an internal 50 Ohm source impedance located on the card. When a very high or open impedance is driven, the output voltage will be twice that programmed, giving a maximum range of -10.22 V to +10.22 V dc.

For load impedances other than 50 Ohms, or an open impedance, the following simple resistance calculation can be used to calculate the output voltage at the connector:

$$V_{out} = 2(V_p)(R_L)/(50.0 + R_L)$$

where: V_{out} = ARB Card's output voltage
V_p = Programmed output voltage
R_L = ARB Card's output load including cabling resistance

The V command also instructs the card's memory pointer to advance immediately to the next memory position in preparation for receiving the next voltage sample.

Variations:

The V command specifies a voltage level without a breakpoint or end of waveform. The B, W, and Z commands below are alternate forms of the V command which program a voltage and also provide a breakpoint and/or end of waveform capability. They should be used in place of the V command for and end of waveform or when there is a breakpoint.

[pv]B — The B (Breakpoint voltage) command is used to load the memory with the desired voltage to be output during a sample period with a programmed breakpoint.

Use of the [pv] number is the same as described for the V command. The B loads the memory with the voltages described for the V command and in addition loads a memory breakpoint. The output will stop after the programmed voltage sample until a 1T (continue trigger) or external trigger (assuming the external trigger is armed) is received.

[pv]W — The W (end of Waveform voltage) command is used to load the memory with the desired voltage to be output during a sample period and designates this sample as the last sample in the waveform.

Use of the [pv] number is the same as described for the V command. The W loads the memory with the voltage as explained in the V command and in addition defines this sample as the last sample in the waveform. The output will stop if the repeat count has been reached, otherwise it will start the waveform over again at the first voltage sample.

[pv]Z — The Z (breakpoint and end of waveform voltage) command is used to load the memory with the desired voltage to be output during a sample period with a programmed breakpoint and also defines this sample as the last sample in the waveform.

The [pv] number is the same as described for the V command. The Z loads the memory with the voltage as explained in the V command and in addition loads a breakpoint and end of waveform indicator. The output will stop at the programmed voltage sample until a 1T (continue trigger) is received. Upon receiving the trigger command it will stop the output if the repeat

count has been reached, otherwise it will start the waveform over again at the first voltage sample.

Consecutive V (or B, W or Z) commands load into consecutive memory locations. To program a waveform, send a 0M command to reset the memory pointer so that programming begins in the first memory location. The memory pointer is automatically incremented by 1 after each V, B, W or Z command is issued.

The contents of memory, as programmed by the V, B, W or Z command, are not altered unless power is cycled, a STOP input is sent to the card (see Appendix A), or a K (Kill) command is programmed. In these cases, a value of 0 V dc is programmed in the first two locations with an end of waveform indication in the second location. The remainder of memory is undefined.

CAUTION:

When the ARB Card is halted at a breakpoint, caution is required in the use of any command which changes the memory pointer. If V commands are issued to a breakpoint-halted memory, they will be loaded into memory by the card and the memory pointer changed. As a result, the breakpoint "continue at" address will change.

For an application which requires commands that change the memory pointer during a breakpoint, the memory pointer must be returned to the desired location with the M command before the card is triggered.

Example of a memory load:

@110M800E-9P00R0.00V1.00V2.00V3.00V4.00V5.00W

The above command is decoded as follows:

The 53A-243 Card is assumed to be in mainframe 1 and set to card address 1. The memory pointer is set to zero and the card is programmed to operate at a sample rate of 800 ns between samples. When the card is triggered, the waveform will continuously repeat until a Q or K command or an @XH command is received by the card. A step function is programmed for 0 V, 1 V, 2 V, 3 V, 4 V, and 5 V, which then repeats continuously.

To start the ARB Card outputting the waveform defined above, the system controller would send the command string:

@11T

Mainframe 1, card address 1, is again addressed; the memory pointers are reset; and the card is triggered, with output starting at the voltage defined in memory location 0. If no other function cards have been addressed between this command string and the previous command string used to define the waveform, @11T can be shortened to simply T.

Command	Description
R	The R (Repeat) command specifies the number of times the memory is to repeat its stored waveform.

Syntax: [n]R

[n] is a 0- to 3-digit decimal number from 0 to 255 that specifies the number of repetitions. A value of 0 specifies a continuous repeat. The Repeat value will remain at the last programmed value unless power is cycled or a STOP command is sent to the card (see Appendix A). On power up or upon receipt of a STOP command, the repeat count is set to the default value of continuous.

Examples:

1. 99R causes the stored waveform to repeat 99 times.

2. 00R causes the stored waveform to repeat continuously until the sequence is halted by a Q or K command, or by a STOP command if the card's Halt switch is in the ON position. The same programming result is achieved by sending an R or 0R.

Command	Description

L

The L (Low Pass Filter) command enables or disables the 4 MHZ low pass filter on the output of the Arbitrary Waveform Generator.

Syntax: [n]L

[n] is a 1-digit decimal number defined as follows:

n	Effect
0	Low pass filter switched off.
1	Low pass filter switched on. (The 1 may be omitted.)

The filter helps to remove switching transients caused by the digital to analog converter, but also limits the output slew rate.

On power-up, the low pass filter is switched off. The value of the L command is not altered by a Q (Quit) command, but is reset to the power-up value by a K (Kill) command, or by a STOP command if the Halt switch is in the ON position (see Appendix A for STOP command).

Command	Description

X

The X (eXternal trigger) command is used to enable or disable the ARB Card's external-trigger function.

Syntax: [n]X

1X enables the external trigger function and reset the memory pointer to 0.

0X disables the external trigger function.

When the external-trigger is enabled, the ARB Card can be triggered either by sending a T command to the card or by sending an external-trigger pulse to the card's External Trigger Input.

The external-trigger function will remain at its last programmed value unless power is cycled, a STOP input is sent to the card (see Appendix A) or a K (Kill) command is received by the card, in which case the external trigger function will be disabled.

NOTE: The 1X command must be sent at the end of a command set, rather than the start or middle, so that waveform output will begin at the start of memory when an external trigger is received. Since the external trigger function resets the memory pointer to the first location in memory, any previously entered voltage samples will be lost (written over) if any V, B, W, or Z commands are sent after the 1X command.

Command	Description
I	The I (Interrupt) command enables or disables generation of 53/63 System interrupts by the ARB Card.

Syntax: [n]I

[n] is a 1-digit decimal number (0 to 3) that programs the interrupt mode as follows:

[n]	Interrupt Mode
0	Interrupts disabled.
1	Breakpoint interrupts enabled. An interrupt is generated whenever a breakpoint occurs, as programmed by the B or Z commands.
2	End-of-transmission interrupts enabled. A single interrupt is generated at the completion of the total programmed waveform after the specified number of repeats has occurred.
3	Breakpoint and end-of transmission both generate an interrupt.

After an interrupt occurs, it is latched by the ARB Card. The ARB Card will continue to generate a 53/63 System interrupt until the interrupt status of the 53/63 System is checked using the @XS command described in Appendix A. Depending on the type of communications card installed in the System, a backplane interrupt may also generate an interrupt back to the system controller. In the case of a 53A-128 Communications Card, for example, a backplane interrupt generates an SRQ (service request) on the IEEE-488 bus.

The Interrupt Mode will remain at the last programmed state unless power is cycled, a STOP input is sent to the card (see Appendix A) and the Halt Switch is ON, or a K (Kill) command is programmed, in which case interrupts are disabled (Interrupt Mode 0).

Command	Description
T	The T (Trigger) command triggers the ARB Card to output the waveform stored in memory. Syntax: [n]T [n] is either 0 or 1. After a T (or 0T) command is sent, the card is triggered to reset the memory to the first voltage sample and then the programmed waveform is output at the sample rate specified by the D or P commands, and repeated for the number of times specified by the R command. A 1T command can be issued when the ARB Card is currently at a programmed breakpoint. This command triggers the output without resetting the memory pointers so that the next voltage sample sent will be the one following the breakpoint. The Hardware External Trigger is the same as a 1T command. It allows triggering from a breakpoint without moving the memory pointer. The X command (external trigger enable) may be issued to reset the memory pointer to the first location in memory. The external hardware trigger will then start the waveform from the first location. The X command should be sent after V, W, B, or Z commands to keep the memory pointer from changing from zero.

Command	Description
Q	The Q (quit) command terminates the ARB Card's output. When the Q command is issued, the output will stop, and the ARB Card's output voltage will go to zero volts. Any voltages, modes, or sample rates previously programmed will remain unchanged after a Q command is issued.

Command	Description
M	The M (Memory edit) command specifies a memory location in the waveform sample to be programmed or reprogrammed.

Syntax: [n]M

[n] is a 1- to 5-digit decimal number, from 0 to 16,383, that specifies the initial memory location for editing or outputting.

The M command may be followed by a V command to load the specified memory location. If subsequent V commands are issued, data will be loaded into sequential memory locations following the location specified by the M command.

The M command may also be issued just prior to a 1T command to cause the ARB Card's output to begin at a memory location other than 0. If a repeat count or continuous output is programmed, the output will continue to location 0 after the end of the waveform is reached.

Examples:

1. 4021M1.12V2.30V directs the value in memory location 4021 of the memory partition to be changed to 1.12 V, and the value in memory location 4022 to be changed to 2.30 V.

2. 500M1T causes the ARB Card to begin outputting from memory location 500.

Command	Description

?

The ? (Status) command causes the ARB to return the current status of the card when the system controller next requests input from the card. The card's internal status register is automatically updated at the time the system controller's input request is received by the card.

The ARB status is returned as five ASCII digits, $D_1D_2D_3D_4D_5$, followed by <CR><LF> characters.

Digit	Value	Status
D_1	1	if ARB is triggered and additional waveform points remain to be output.
	0	if ARB is awaiting a new trigger.
D_2	1	if ARB output is halted at a breakpoint.
	0	if output is not halted at a breakpoint.
D_3	1	if input buffer not empty.
	0	if input buffer empty.
D_4D_5		The digits D_4D_5 are an error code indicating any programming errors detected by the card since the last time status was requested or a K (Kill) command was received by the card. Only the first error detected is reported.

ERROR CODES:

D4D5	ERROR DESCRIPTION
00	NO ERROR
10	UNKNOWN COMMAND RECEIVED
11	FLOATING POINT ERROR
12	PERIOD COMMAND ERROR
14	REPEAT COMMAND IS OUT OF RANGE
15	REPEAT COMMAND INCORRECT CHARACTER
16	INVALID INTERRUPT COMMAND
17	DIVIDE COMMAND IS OUT OF RANGE
18	EXTERNAL TRIGGER COMMAND IS INVALID
19	EXTERNAL CLOCK COMMAND IS INVALID
20	LOW PASS FILTER COMMAND IS INVALID
21	W COMMAND VOLTAGE IS OUT OF RANGE
22	W COMMAND VOLTAGE IS INCORRECTLY FORMATTED
23	INCORRECT VOLTAGE ; W COMMAND
24	B COMMAND VOLTAGE IS OUT OF RANGE
25	B COMMAND VOLTAGE IS INCORRECTLY FORMATTED
26	INCORRECT VOLTAGE ; B COMMAND
27	V COMMAND VOLTAGE IS OUT OF RANGE

D4D5	ERROR DESCRIPTION
28	V COMMAND VOLTAGE IS INCORRECTLY FORMATTED
29	INCORRECT VOLTAGE ; V COMMAND
30	Z COMMAND VOLTAGE IS OUT OF RANGE
31	Z COMMAND VOLTAGE IS INCORRECTLY FORMATTED
32	INCORRECT VOLTAGE ; Z COMMAND

The ? command can be used to determine when the waveform generator has completed processing all the setup commands in its input buffer. This is done by issuing a trigger command at the end of a setup sequence and then polling the status of the card until a triggered condition is reported.

CAUTION:

If the ? command is included in a string of commands, it bypasses all other (buffered) commands. This means that the status returned to the system controller is the card status at the time the input request from the system controller is received by the card, and will not reflect other unprocessed commands in the string. To improve overall system throughput, it is recommended that multiple ? commands not be sent.

NOTE: The ? command sent by the system controller prior to requesting input from the card can also be omitted if desired. All input requests assume a ? has been sent.

Command	Description
K	The K (Kill) command returns the card to its power-up state, with all parameters at the default settings:

Sampling Frequency	25 MHz
Voltage Waveform	0 V dc waveform
Repeat Count	Continuous
External Trigger	Disabled
Interrupt	Disabled
Low Pass Filter	Disabled
Memory Edit Address	0
Error Status	Cleared
Output State	Not triggered
Clock Source	Internal
Period	40 ns

The contents of memory are changed so that a value of 0 V dc is programmed in the first two locations with an end-of-waveform indication in the second. The remainder of memory is undefined. A one millisecond delay is required before issuing any additional commands.

INSTALLATION

The 53A-243 Card is a function card; therefore it may be installed in any blue card slot. Setting the Address Select switch defines the card's programming address. To avoid confusion, it is recommended that the slot number and the programming address be the same.

CAUTION:

To avoid installing the card in backwards, observe the following:

a. Match the keyed slot on the card to the key in the backplane connector. The component side should be to the right for a 53 Series Chassis and to the top for a 63 Series Chassis.

b. There are two ejectors on the card. Make sure the ejector marked "53A-243" is at the top for a 53 Series Chassis and to the left for a 63 Series Chassis.

CAUTION:

The 53A-243 Card requires more +5 volt dc current than a standard 53A function card, limiting the number and placement of 53A-243 Cards in 53/63 Card Cage installations. Refer to the Power Requirements subsection of the Specifications for more information.

CAUTION:

The 53A-243 Card is a piece of electronic equipment and therefore has some susceptibility to electrostatic damage (ESD). ESD precautions must be taken whenever the module is handled.

APPENDIX A

53/63 SYSTEM COMMANDS

Command	Description
@XY	The @XY (Address) command addresses a function card in the 53A/63A System. @ is a delimiter used by the 53/63 Series System. X is a mainframe address (0-9) defined by the address-select switch on the 53A-171 Control Card in the addressed mainframe. Y is a function-card address (0-9) defined by the address-select switch on the function card. Once a mainframe/function-card combination is addressed, it remains addressed until the 53/63 Series System detects a new @ character.
@XS	The @XS (Status) command provides the interrupt status of all function cards within the mainframe defined by X. The mainframe backplane interrupt status of all function cards in the addressed mainframe is latched into the 53A-171 Control Card when the @XS command is issued. All function cards in all mainframes become unaddressed after the @XS command. The 53A-171 Control Card Operating Manual describes the @XS command in detail. The @XS command allows the interrupt status of the 53A-243 Card to be read as programmed by the I (Interrupt) command.
@XH	The @XH (Halt) command halts all function cards within the mainframe defined by X. The command does not affect function cards in other mainframes. How a function card reacts to the @XH command depends on the card. The 53A-243 Card's operation depends on the setting of the Halt Switch. If the Halt Switch is on, the 53A-243 Card becomes unaddressed and responds as if a K (Kill) command had been issued to the card (see the K command in the OPERATION section). If the Halt Switch is off, the card, if addressed (Power LED out), becomes unaddressed (Power LED lit).
STOP	The STOP command is not a string of ASCII characters. The command is hard-wired from the system controller (calculator or computer) to the 53/63 System's communications card in each mainframe. When the system controller issues a STOP command, each function card, including the 53A-243 Card, reacts as if it received the @XH command described above. How the system controller executes the STOP command depends on the communications card used. With the 53A-128 IEEE-488 Card, for example, a STOP command is executed when the system controller asserts the IEEE-488 bus line IFC (Interface Clear) true.

APPENDIX B

INPUT/OUTPUT CONNECTIONS

Snap-on SMB connectors are used for both input and output connections. One 53A-729 SMB-to-BNC Adapter Cable is provided with the card. Additional 53A-729 Adapter Cables may be ordered.

The input/output connectors, from top to bottom, are as follows:

Signal Name	Function
EX TRG*	External Trigger Input
SYNC*	Sync Output
EX CLK*	External Clock Input
ARB OUTPUT	Arbitrary Waveform Output

ARB OUTPUT (Arbitrary Waveform Output)

This is the analog output of the arbitrary waveform generator. This output can drive a load of 50 Ohms at ±5.11 V or a high-impedance load at ±10.22 V.

EX TRG* (External Trigger Input)

This input provides external-triggering capability if the input is enabled by the X (eXternal trigger) command (see OPERATION section). The input requires a TTL-compatible active-low signal. The ARB Card is triggered on the falling edge of the input signal. The minimum pulse width is 80 ns. Actual ARB Card triggering will occur within 1 to 80 ns after the falling edge of the external-trigger signal.

EX CLK* (External Clock Input)

The External Clock Input is enabled when the External Clock Function is enabled with the C command (see Operation section). The input accepts a TTL-compatible signal from 0 Hz to 25 MHz. The clock must be high for a minimum of 14 ns and low for a minimum of 17 ns.

SYNC* (Sync Output)

This is a TTL active-low output that provides a pulse which is synchronous with the beginning of the analog-output step that completes the waveform programmed by the user. Sync Output repeats each time the program completes the waveform defined by the end-of-waveform argument (the W or Z command - see Operation section). The output will remain low for one sample period, and then return to high.

APPENDIX C

CALIBRATION PROCEDURE

The 53A-243 Card must be calibrated every 12 months in order for the card to meet its published accuracy specifications. Calibrate the card in an environment where the temperature is between 21°C and 25°C.

Test Equipment Required

1. 4½ digit voltmeter (DMM) with a dc accuracy of ±0.05% of reading.
2. 53A-729 SMB-to-BNC Adapter Cable (supplied with 53A-243 Card).
3. BNC-to-banana plug adapter.
4. Precision 50 ohm load (BNC).

Test Setup

Using the SMB-to-BNC adapter cable, the 50 ohm load, and the BNC-to-banana plug adapter, connect the ARB output of the 53A-243 Card to the dc voltage input of the DMM. During the calibration procedure two potentiometers will be adjusted: the offset potentiometer (R714) and the gain potentiometer (R713). The two potentiometers are located at the lower front edge of the card. The top-most potentiometer is R701; R702 is located directly below R701. See the 53A-243 Card's Assembly Drawing contained in the 53A-243 Card's Service Manual for the potentiometers' locations.

Calibration Procedure

1) Send the following command string to the 53A-243 Card:

@XYQRD5.00V5.00WT

where: X = Mainframe address (0-9) selected on 53A-171 Control Card in addressed mainframe

Y = Card address (0-9) selected on 53A-243 Card's address-select switch

Adjust the offset potentiometer (R714) so that the DMM reads 5.00 V ±5 mV.

2) Send the following command string to the 53A-243 Card:

@XYQRD0.00V0.00WT

Adjust the gain potentiometer (R713) so that the DMM reads 0.00 V ±5 mV.

3) Repeat steps 1 and 2 until both are within 5 mV. Note the exact value of the DMM reading in step 1.

4) Send the following command string to the 53A-243 Card:

@XYQRD-5.00V-5.00WT

If the DMM reads -5.00 V ±15 mV, proceed to step 5. If the error voltage is not within ±15 mV of -5.00 V, adjust the gain potentiometer (R713) to reduce the error to half of its original value; then proceed to step 5. Note the final error voltage for use in step 5.

Example: If the DMM reads -4.880 V after issuing the command in step 4, adjust R701 until the DMM reads -4.97 V. The final error voltage is -0.06 V, i.e., -5.00 - (-4.94) = -0.06.

5) Send the following command string to the 53A-243 Card:

@XYQRD5.00V5.00WT

Calculate the error between the value displayed by the DMM and 5.00 V. If step 4 required no adjustment and the DMM reading is within ±15 mV of 5.00V, proceed to step 10. Otherwise, compare the error voltage computed in this step with the error voltage noted in step 4. The offset potentiometer must then be adjusted to make the error voltages measured in steps 4 and 5 equal. To do this, calculate the sum of the two errors, divide the result by two, and add this quantity to the DMM reading obtained in step 5. Adjust R714 for the desired DMM reading. Note the final error voltage in step 5.

Example: Using the previous example, the error voltage in step 4 (after the adjustment of R714) was -0.06 V. If the initial voltage measured in step 4 was 4.99 V, the error voltage in step 4 is 0.01 V. (-0.06 + 0.01)/2 = -0.025. R714 is then adjusted so that the DMM reads 4.965 (4.99 - 0.025). The final error voltage in step 5 is 0.035 V.

6) Send the following command string to the 53A-243 Card:

@XYQRD-5.00V-5.00WT

Calculate the magnitude of the error between the value displayed by the DMM and -5.00 V. If this value has the same magnitude as the final error voltage in step 5, proceed to step 7. Otherwise, use the procedure in step 5 (using the magnitude of error calculated in step 6 rather than the step 4 value) to again adjust the gain potentiometer. Repeat steps 5 and 6 until the magnitudes of the errors at +5.00 V and -5.00V are the same.

7) Send the following command string to the 53A-243 Card:

@XYQRD5.00V5.00WT

Adjust the offset potentiometer (R714) until the value displayed on the DMM is +5.00 V ±15 mV.

8) Send the following command string to the 53A-243 Card:

@XYQRD-5.00V-5.00WT

Adjust the gain potentiometer (R713) until the value displayed on the DMM is -5.00 V ±15 mV.

9) Repeat steps 7 and 8 until no further adjustment is necessary.

10) Send the following command string to the 53A-243 Card:

@XYQRD0.00V0.00WT

If the DMM reading is 0.00 V ±15 mV, proceed to step 13. If the DMM reading is greater than ±15 mV, adjust the offset potentiometer (R701) until the DMM reads 0.00 V ±15 mV.

11) Send the following command string to the 53A-243 Card:

@XYQRD5.00V5.00WT

If the DMM reading is within ±15 mV of 5.00 V, proceed to step 12. If it is not, adjust the offset potentiometer (R714) so that the DMM reading is 5.00 V ±15 mV.

12) Remove the 50 ohm load and reconnect the cables, then send the following command string to the 53A-243 Card:

@XYQRD-5.00V-5.00WT

If the DMM reading is within ±15 mV of -10.00 V, proceed to step 13. Otherwise, adjust the gain potentiometer (R713) so that the DMM reading is -10.00 V ±15 mV.

13) This step is a final linearity check of the 53A-243 Card. Send each of the commands listed below, and then check that the DMM reading is within ±15 mV of the desired voltmeter reading listed. If any measurement is out of tolerance, adjust the offset potentiometer (R714) by the minimum amount needed to bring the measurement into tolerance. If any adjustments are made, the sequence from step 9 through step 13 must be repeated. Reinstall the 50 ohm load and connect the cables.

Commands to be Sent	Desired Voltmeter Readings (V)
@XYQRD-5.12V-5.12WT	-5.12
@XYQRD-5.11V-5.11WT	-5.11
@XYQRD-5.10V-5.10WT	-5.10
@XYQRD-5.08V-5.08WT	-5.08
@XYQRD-5.04V-5.04WT	-5.04
@XYQRD-4.96V-4.96WT	-4.96
@XYQRD-4.80V-4.80WT	-4.80
@XYQRD-4.48V-4.48WT	-4.48
@XYQRD-3.84V-3.84WT	-3.84
@XYQRD-2.56V-2.56WT	-2.56
@XYQRD0.00V0.00WT	0.00
@XYQRD0.01V0.01WT	0.01
@XYQRD0.02V0.02WT	0.02
@XYQRD0.04V0.04WT	0.04
@XYQRD0.08V0.08WT	0.08
@XYQRD0.16V0.16WT	0.16
@XYQRD0.32V0.32WT	0.32
@XYQRD0.64V0.64WT	0.64
@XYQRD1.28V1.28WT	1.28
@XYQRD2.56V2.56WT	2.56
@XYQRD5.11V5.11WT	5.11

13. Remove the 50 ohm load and verify that the following table's measurements are met to an accuracy of ±50 mV.

Commands to be Sent	Desired Voltmeter Readings (V)
@XYQRD-5.12V-5.12WT	-10.24
@XYQRD-5.11V-5.11WT	-10.22
@XYQRD-5.10V-5.10WT	-10.20
@XYQRD-5.08V-5.08WT	-10.16
@XYQRD-5.04V-5.04WT	-10.08
@XYQRD-4.96V-4.96WT	-9.92
@XYQRD-4.80V-4.80WT	-9.60
@XYQRD-4.48V-4.48WT	-8.96
@XYQRD-3.84V-3.84WT	-7.68
@XYQRD-2.56V-2.56WT	-5.12
@XYQRD0.00V0.00WT	0.00
@XYQRD0.01V0.01WT	0.02
@XYQRD0.02V0.02WT	0.04
@XYQRD0.04V0.04WT	0.08
@XYQRD0.08V0.08WT	0.16
@XYQRD0.16V0.16WT	0.32
@XYQRD0.32V0.32WT	0.64
@XYQRD0.64V0.64WT	1.28
@XYQRD1.28V1.28WT	2.56
@XYQRD2.56V2.56WT	5.12
@XYQRD5.11V5.11WT	10.22

APPENDIX D

ADVANCED PROGRAM CAPABILITIES

The following two commands provide additional capabilities for the more experienced programmer.

Command	Description
[n]D	The D (Divide) command specifies the number of main clock divisions (or periods) in the output sample rate. The output sample rate is the time between successive output-voltage updates from the ARB Card's memory (40 ns per division for internal clock). [n] is a 0 to 8-digit decimal number from 0 to 16,777,215 that specifies the number of divisions of the main clock rate. A 1D, 0D, or a D command all specify a 40 ns (25 MHz) clock rate. The command 123D sets a clock rate of 123 * 40 ns (equal to 4.92 microsecond) sample clock period (203.25203252 KHz sample clock). On power-up, the value of the D command is set to 1 (a 40 ns or 25 MHz rate if internal clock is selected). The value of the D command is not altered by a Q (Quit) command sent to the card, but is reset to the power-up value by a K (Kill) command or a STOP command to the card (see Appendix A).
#[n][m][b,..b_n]	The # (binary) command places the card in binary mode to load voltage waveform data points at a much faster rate than is possible with the V command. [n] is the binary address the memory pointer is to be set to. It is a 2-byte number, high byte first, with a value from $(00000000)(00000000)_B$ to $(00011111)(11111111)_B$, or 0 to 16383 decimal. [m] is the number of binary bytes (2 bytes per voltage) in binary that the card will receive from the user. The value of [m] is in two bytes, high byte first. The voltage data (b ..... b_n) is sent in binary as a string of two byte binary values, high order byte first, following the two byte value of [m]. The sixteen bit data (bits 15 to 0) are in the format of 10 bits of voltage data in the lowest ten bits (bits 9 to 0 where zero is the least significant bit) of the data. Bit ten is set if the voltage sample is the last sample in the waveform. Bit eleven is set if the output is to be programmed for a breakpoint. The 10-bit value is a two's complement binary value from 0000000000 to 1111111111 and programs a value of -5.12 V to +5.11 V into a 50 ohm load. A value of 0 V is 1000000000.

Use the following algorithm to determine the two 8-bit bytes for a particular voltage:

Value = (Voltage * 100) + 512
Low Byte = Value - INT(Value/256) * 256
High Byte = INT(Value/256) + 4 (if end of wave) + 8 (if breakpoint)

Example:

A voltage of 3.00 V, with an end of waveform would give a value of 812; a low byte of 812 - 768 or 44 decimal, and a high byte value of 3 + 4 or 7 decimal. A value of 1.00 volt without an end of waveform would require a low byte of 100 and a high byte of two.

Binary values may be sent in many programming languages by building a string with a CHR$ function. The argument of the CHR$ function is a decimal value of 0 to 255 or a hexadecimal value of 00 to FF to provide any 8-bit binary value.

To program a 2-point waveform of 1.0 V followed by 3.0 V with an end of waveform, the following string would be built and transmitted to the card:

```
VOLT$="#"+CHR$(0)+CHR$(0)+CHR$(0)+CHR$(4)+CHR$(2)+CHR$(100)+CHR$(7)+CHR$(44)
```

The first character # defines a binary command. The following two bytes define the start address for the memory pointer (in this case zero). The next two bytes, 0 and 4 define 4 bytes (2 words) to be transmitted, and the last 4 values defined the two voltage samples as described earlier in the example.

The 53/63 System has a "binary" mode which the card uses when executing this command. Certain 8-bit values have special meaning to the 53/63 System; for example, the 8-bit binary value corresponding to a "@" character controls addressing of cards in the 53/63 System. When a "#" character is sent to the 53A-243 Card, the card puts the 53/63 System in the binary mode, during which time any special character will lose its meaning to the system.

CAUTION:

The 53A-243 Card will not allow the 53/63 System to exit the binary mode until the specified number of bytes is received. Failure to send the specified number of bytes will interfere with proper addressing of other cards in the system.

APPENDIX E

SAMPLE PROGRAMS FOR THE 53A-243

The sample programs below are written in Advanced BASIC (BASICA) for an IBM PC. The programs will familiarize the user with the card commands and provide examples of typical applications for the 53A-243 Card.

The PC is connected to the CDS 53/63 Series Card Cage using a 53A-903 Card installed in the PC. The 53A-903 I/O Card provides an IEEE-488 interface between the PC and the CDS Card Cage. The 53A-243 Card has been set to address 11. The address of the 53/63 Card Cage containing the 53A-243 Card is address 1.

For these programs, PCX is a variable containing the IEEE-488 address of the CDS 53/63 Series Card Cage and GPIB0 is a variable containing the IEEE-488 address of the 53A-903 I/O card. The 53A-903 commands used in this program are:

IBFIND, IBINIT1, IBINIT2, IBLOAD
: These commands load and initialize the software drivers for the 53A-903 card in the PC. The drivers are loaded from the software disk supplied with the 53A-903.

IBSIC
: Resets the IEEE-488 interface, setting the interface IFC line true for 100 microseconds.

IBTMO
: Defines the PC timeout for I/O operations to the 53A-903.

IBWRT
: Writes the contents of a string variable to the 53/63 Series Card Cage.

IBRD
: Reads data bytes from the 53/63 Series Card Cage and stores them in string variables. Note that the variable must first be filled with space characters equal to the maximum number of data bytes to be read.

Sample BASIC Programs

In these program listings, lines which are indented and not preceded by a line number are not part of the BASIC program. They are inserted here as comments to explain what the program is doing at each numbered line. Note that although some of the BASIC lines appear to take more than one line, they are continuous when entered in the program.

NOTE: Lines 10 through 140 are included in the program to initialize the 53A-903 IEEE-488 interface card in the PC.

Example 1

This program selects a 53A-243 card in card cage address 1 and card address 1. The Q command halts any program currently running and sets the memory pointer of the ARB's memory to the first location in memory to prepare for programming. The 5.00V loads the first memory location with a voltage sample of five volts. The following command, -5.00W, programs the next position in memory as the last voltage sample in the waveform and sets its voltage to a negative five volts. The R command causes the waveform to run continuously

until a Q or K command is received or a backplane STOP command is sent. The D command selects the sample clock rate at 80 nanoseconds per sample. Finally the T command triggers the card. The card now will output a 6.25 MHZ square wave of ten volts peak to peak into a fifty ohm load.

```
10  CLEAR,60000!
        BASIC declarations.

20  IBINIT1 = 60000!

15  IBINIT2 = IBINIT1 + 3

40  BLOAD "bib.m",IBINIT1

50  CALL    IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,
    IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,
    IBWRTF)

60  CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,IBRD,
    IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,IBWRTIA,
    IBSTA%,IBERR%,IBCNT%)

70  WRT$ = SPACE$(255)
        Write data buffer.

80  BDNAME$ = SPACE$(7)
        Board or device name buffer.

90  BDNAME$ = "CDS"

100 CALL IBFIND (BDNAME$,CDS%)
        Find the IEEE devices.

110 BDNAME$ = "GPIB0"

120 CALL IBFIND (BDNAME$,GPIB0%)
        Find the IEEE controller.

115 TIMEOUT%

140 CALL IBTMO(CDS%,TIMEOUT%)
        Disable the PC TIMEOUT function for I/O operations to the 53A-903.

150 WRT$ = "@11Q5.00V-5.00WR2DT"

160 CALL IBWRT(CDS%,WRT$)
```

Example 2

This example is the same as the previous example, except that it uses the period command to set the sample rate to the same 80 nanoseconds per sample as the previous example.

```
.
.
.

150  WRT$ = "@11Q5.00V-5.00WR80E-9PT"

160  CALL IBWRT(CDS%,WRT$)
```

Example 3

By varying the sample rate and the number of samples in the waveform it is possible to output different frequencies. This example uses two samples at five volts and two samples at negative five volts at the forty nanosecond sample rate, giving a square wave with ten volt peak to peak output into a fifty ohm load, as in the previous two examples, but at a frequency of 4.166 MHZ.

```
.
.
.

150  WRT$ = "@11Q5.00V5.00V5.00V-5.00V-5.00V-5.00WRDT"

160  CALL IBWRT(CDS%,WRT$)
```

Example 4

This program outputs a two volt peak to peak triangle wave into a fifty ohm load at a frequency of 62.5 KHZ. The low pass filter is turned on by the L command to smooth out the voltage samples.

Lines 10 through 140 MUST be included in your program to initialize the 53A-903 IEEE-488 interface card in the PC.

```
10   CLEAR,60000!
          BASIC declarations.

20   IBINIT1 = 60000!

15   IBINIT2 = IBINIT1 + 3

40   BLOAD "BIB.M",IBINIT1
```

```
50  CALL    IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,
    IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,
    IBWRTF)

60  CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,IBRD,
    IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,IBWRTIA,
    IBSTA%,IBERR%,IBCNT%)

70  WRT$ = SPACE$(255)
        Write data buffer.

80  BDNAME$ = SPACE$(7)
        Board or device name buffer.

90  BDNAME$ = "CDS"

100 CALL IBFIND (BDNAME$,CDS%)
        Find the IEEE devices.

110 BDNAME$ = "GPIB0"

115 CALL IBFIND (BDNAME$,GPIB0%)
        Find the IEEE-488 controller.

120 TIMEOUT%

130 CALL IBTMO(CDS%,TIMEOUT%)
        Disable the PC TIMEOUT function for I/O operations to the 53A-903.

140 WRT$ = "@11Q"

150 CALL IBWRT(CDS%,WRT$)

160 FOR I = 1 TO 9
        Lines 160 - 200 set up and output voltage samples from 0.01 to 0.09 volts.

170 VOLT$ = ".0"+STR$(I)

180 VOLT$ = VOLT$+"V"

190 CALL IBWRT(CDS%,VOLT$)

200 NEXT I

210 FOR I = 10 TO 99
        Lines 210 - 250 set up and output voltage samples from 0.1 to 0.99 volts.

220 VOLT$ = "."+STR$(I)

215 VOLT$ = VOLT$+"V"

240 CALL IBWRT(CDS%,VOLT$)
```

```
250  NEXT I

260  WRT$ = "1.00V"
         Lines 260 and 270 output a 1 volt sample.

270  CALL IBWRT(CDS%,WRT$)

280  FOR I = 99 TO 10 STEP -1
         Lines 280 - 310 set up and output voltage samples from 0.99 to 0.1 volts.

290  VOLT$ = "."+STR$(I)+"V"

150  CALL IBWRT(CDS%,VOLT$)

310  NEXT I

320  FOR I = 9 TO 1 STEP -1

315  VOLT$ = ".0"+STR$(I)+"V"

340  CALL IBWRT(CDS%,VOLT$)

350  NEXT I

360  WRT$ = ".00V"
         Lines 360 and 370 output a zero volt sample.

370  CALL IBWRT(CDS%,WRT$)

380  FOR I = 1 TO 9
         Lines 380 - 410 set up and output voltage samples from -0.1 to -0.09 volts.

390  VOLT$ = "-.0"+STR$(I)+"V"

400  CALL IBWRT(CDS%,VOLT$)

410  NEXT I

420  FOR I = 10 TO 99
         Lines 420 - 450 set up and output voltage samples from -0.1 to -0.99 volts.

415  VOLT$ = "-."+STR$(I)+"V"

440  CALL IBWRT(CDS%,VOLT$)

450  NEXT I

460  WRT$ = "-1.00V"
         Lines 460 and 470 set up and output a -1 volt sample.

470  CALL IBWRT(CDS%,WRT$)
```

```
480  FOR I = 99 TO 10 STEP -1
```
Lines 480 - 510 set up and output voltage samples from -0.99 to -0.1 volts.

```
490  VOLT$ = "-."+STR$(I)+"V"

500  CALL IBWRT(CDS%,VOLT$)

510  NEXT I

520  FOR I = 9 TO 1 STEP -1

515  VOLT$ = "-.0"+STR$(I)+"V"
```
Lines 515 - 550 set up and output voltage samples from -0.09 to -0.01 volts.

```
540  CALL IBWRT(CDS%,VOLT$)

550  NEXT I

560  VOLT$ = "0.00W"
```
Lines 560 and 570 output a zero volt sample and set it as the last sample in the waveform.

```
570  CALL IBWRT(CDS%,VOLT$)

580  WRT$ = "RDLT"
```
Lines 580 and 590 set the card to repeat continuously at the 40 ns sample rate, with the 4 MHz low pass filter on, and trigger set to External Hardware trigger.

```
590  CALL IBWRT(CDS%,WRT$)

600  END
```

Example 5

The following sample program demonstrates how to set up a sine wave generator program. Lines 10 through 140 MUST be included in your program to initialize the 53A-903 IEEE-488 interface card in the PC.

```
10   CLEAR,60000!
```
BASIC declarations.

```
20   IBINIT1 = 60000!

15   IBINIT2 = IBINIT1 + 3

40   BLOAD "BIB.M",IBINIT1

50   CALL  IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,
     IBONL,IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,
     IBEOT,IBRDF,IBWRTF,IBTRAP)
```

```
60  CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,IBRD,
    IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,IBWRTIA,
    IBSTA%,IBERR%,IBCNT%)

70  WRT$ = SPACE$(255)
        Write data buffer.

80  BDNAME$ = SPACE$(7)
        Board or device name buffer

90  BDNAME$ = "CDS"

100 CALL IBFIND (BDNAME$,CDS%)
        Find the IEEE-488 devices.

110 BDNAME$ = "GPIB0"

120 CALL IBFIND (BDNAME$,GPIB0%)
        Find the IEEE-488 controller.

130 TIMEOUT%

140 CALL IBTMO(CDS%,TIMEOUT%)
        Disable the PC TIMEOUT function for I/O operations for the 53A-903.

150 WRT$ = "@11Q"

151 CALL IBWRT(CDS%,WRT$)
        Lines 150 and 151 send a Q (Quit) command to the 53A-243 Card that resets the
        memory pointer and halts any output that is currently running.

160 CLS:

170 PRINT "53A-243 SINEWAVE GENERATOR"

210 INPUT "ENTER FREQUENCY DESIRED IN HERTZ. (UP TO 250000)",FOR
        Lines 210 - 215 set a frequency (F0), the peak-to-peak voltage (VPP), and a dc
        voltage offset (VDC).

211 IF FOR = 0 THEN FOR = 250000!

220 INPUT "ENTER SINE WAVE'S PTP VOLTAGE IN VOLTS ",VPP

221 IF VPP = 0 THEN VPP = 2

215 INPUT "ENTER SINE WAVE'S DC OFFSET IN VOLTS ",VDC


240 IF FOR > 250000! THEN PRINT "FREQUENCY OUT OF LIMITS":GOTO 210
        Sets an upper limit of 250 KHz to allow a minimum of 100 voltage samples in a
        sinewave.
```

```
250 IF (VDC + .5*VPP) > 5.11 OR (VDC - .5*VPP) < -5.11 THEN PRINT "OUT OF LIMITS
    VOLTAGE ATTEMPTED":GOTO 210
```

Checks to make sure that the voltage limits of +5.11 to -5.11 volts have not been exceeded by the dc voltage offset.

```
251 WRT$ = "@11QR"
```

Resets the card and sets repeat count to continuous.

```
252 CALL IBWRT(CDS%,WRT$)

260 WFPRD = 1/FOR
```

Finds the period of the waveform.

```
270 N = 0

276 IF FOR <100 THEN N=980
```

Lines 276 - 278 set a base number of points for the low frequency sinewave to shorten the calculation time.

```
277 IF FOR <10 THEN N=9800

278 IF FOR <1 THEN N=98000!

280 N = N+1

290 PTS = (WFPRD/N) * 25000000#

150 IF PTS > 1000 THEN GOTO 280
```

Limits the maximum size of the waveform to 1000 voltage samples to limit load time.

```
310 PTS = CINT(PTS)

320 WRT$ = STR$(N)
```

Lines 320 - 340 set the calculated sample clock rate.

```
315 CALL IBWRT(CDS%,WRT$)

340 WRT$ = "D"

350 CALL IBWRT(CDS%,WRT$)

360 J = 1: K = 0

370 C1 = (6.283185)/PTS
```

C1 and C2 are constants. C1 is the angle in radians per voltage point; C2 is the peak value of the sinewave.

```
380 C2 = (.5*VPP)

390 DIM D$(1000)
```

Dimensions an array.

```
400  FOR I = 1 TO PTS
```

Lines 400 - 415 calculate the voltage of each voltage sample of the sinewave.

```
410  V! = VDC + C2*SIN(C1*I)

420  V = CINT(V!*100)

415  V = V/100

600  IF V < 0 THEN WRT$ = "-0.00V" ELSE WRT$ = "+0.00V"
```

Lines 600 - 690 take the voltage calculated and put it in the format required by the 53A-243 Card.

```
610  V = ABS(V)

620  A = INT(V)

640  MID$(WRT$,2,1) = RIGHT$(STR$(A),1)

650  V = V-A

660  V% = INT(V * 100)

670  IF V% < 10 THEN MID$(WRT$,5,1) = RIGHT$(STR$(V%),1) ELSE MID$(WRT$,4,2) =
     RIGHT$(STR$(V%),2)

690  D$(I) = WRT$

691  IF I = PTS THEN D$(I) = LEFT$(D$(I),5) + "WT"
```

Lines 691 and 715 set an End of Waveform bit and trigger the card on the last voltage sample.

```
730  CALL IBWRT(CDS%,D$(I))

740  NEXT I

741  WRT$="L"
```

Lines 741 and 742 turn on the low pass filter to reduce DAC switching noise.

```
742  CALL IBWRT(CDS%,WRT$)

750  END
```

SERVICE MANUAL

53A-243

25 MHZ ARBITRARY WAVEFORM GENERATOR CARD

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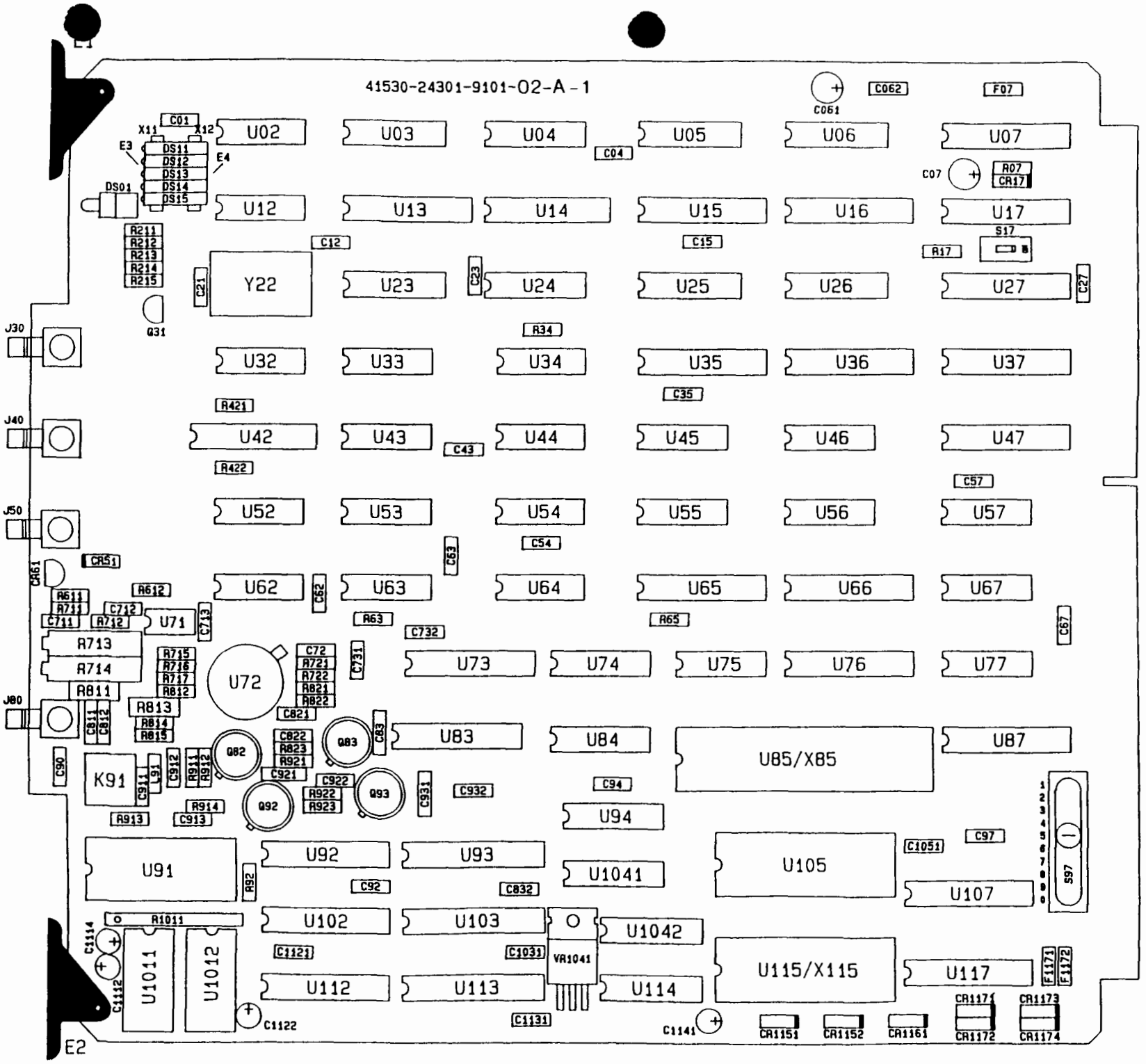
REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
	53A-729	1	ADAPTER CABLE BNC MALE TO SMB SNAP-ON PLUG	0026	53A-729
	53A-729-10	1	10 FT CABLE LENGTH	0026	53A-729-10
C01,04,062,1031,1051,12,15,21,23 27,35,43,54,57,62,63,67,72,732 822,922,932,97	20128-10005	23	CAP FXD CER .01UF 20% 50VDCW	0106	1C25Z5U103M050B
C061,07	22022-68008	2	CAP FXD TA 68UF 20% 6VDCW	0106	199D686X06R3DA1
C1112,1114,1122,1141	22022-10008	4	CAP FXD TA 10UF 10-20% 20-25VDCW	0106	199D106X9025CA1
C1121,1131,711,712,713,731,821 832,911,92,94	20128-10006	11	CAP FXD CER .1UF 20% 50VDCW	0058	C322C104M5U5CA
C811	21528-20003	1	CAP FXD MICA 200PF 5% 500VDCW	0012	DM-15-201J
C812	21528-50003	1	CAP FXD MICA 500PF 5% 500VDCW	0012	DM15-501J-500VDCW
C83,921,931	21528-10002	3	CAP FXD MICA 10PF 5% 100VDCW	0012	DM15-100D
C90,913	20128-47006	2	CAP FXD CER .47UF 20% 50VDCW	0075	RPE123Z5U474M50V
C912	21528-33003	1	CAP FXD MICA 330PF 5% 100VDCW	0025	CD7CA331J03
CR1151,1152,1161,1171,1172,1173 1174	32000-04001	7	DIODE SILICON 50V 1A 5%	0357	1N4001
CR17	32000-04148	1	DIODE SILICON 75V 1A 5%	0078	1N4148
CR61	32000-18069	1	DIODE REF 1.23V 100PPM 5MA	0055	ICL8069DCZR
DS01	32000-00103	1	DIODE LIGHT EMITTING RED 50MA	0039	550-0103
DS11,12,13,14,15	32000-02003	5	DIODE LIGHT EMITTING RED WITH RESISTOR 0	0039	547-2003
E1	40401-00243	1	STAMP 53A-243 STYLE B BLUE	0026	40401-00243
E2	40401-10067	1	STAMP ARB STYLE D BLUE	0026	40401-10067

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
E3	45050-03313	1	DCL LED 5 POSITION DRW 00000-01104	0026	45050-03313
E4	45050-03240	1	DCL LED 5POS BLK DRW 00000 -00470	0026	45050-03240
F07,1172	42202-52001	2	FUSE SUB-MIN 2AMP	0061	251002
F1171	42202-52101	1	FUSE SUB-MIN 1AMP	0061	251001
J30,40,50,80	45002-51053	4	CONNECTOR SMB RT. ANGLE PC BD MOUNT	0287	R114665
K91	83500-20013	1	RELAY DPDP HIGH ISOLATION	0299	MMS204
L91	27051-47007	1	INDUCTOR 4.7 UH 10%	0037	IRF-1 4.7UH 10%
PCB1	41530-24301	1	P.C. BOARD VERSION 4L 9101	0498	41530-24301
Q31	51100-03646	1	TRANSISTOR NPN HIGH SPEED SWITCH	0074	MPS3646
Q82,93	51100-05583	2	TRANSISTOR HIGH SPEED PNP	0074	2N5583
Q83,92	51100-05943	2	TRANSISTOR HIGH SPEED NPN	0074	2N5943
R07,17,65	10117-10005	3	10K RES COMP 1-4W 5%	0087	R25J-10K-5%
R1011	12008-56003	1	560 OHM RES NETWORK 5% 1.5W 9-PKG	0037	CSC10A-01-561J
R211	10117-68004	1	6.8K RES COMP 1-4W 5%	0087	R25J-6.8K-5%
R212	10117-51004	1	5.1K RES COMP 1-4W 5%	0087	R25J-5.1K-5%
R213,421,422	10117-33004	3	3.3K RES COMP 1-4W 5%	0087	R25J-3.3K-5%
R214	10117-39004	1	3.9K RES COMP 1-4W 5%	0087	R25J-3.9K-5%
R215	10117-47003	1	470 OHM RES COMP 1-4W 5%	0087	R25J-470-5%
R34	10117-51003	1	510 OHM RES COMP 1-4W 5%	0087	R25J-510-5%
R611,612,823,922	10117-10004	4	1K RES COMP 1-4W 5%	0087	R25J-1K-5%
R63	10117-33003	1	330 OHM RES COMP 1-4W 5%	0087	R25J-330-5%
R711	10117-22004	1	2.2K RES COMP 1-4W 5%	0087	R25J-2.2K-5%
R712	10117-15003	1	150 OHM RES COMP 1-4W 5%	0087	R25J-150-5%

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
R713	15117-50003	1	500 OHM RES VAR CER 22TRN 1W 100PPM	0105	43P-501
R714	15117-20003	1	200 OHM RES VAR CER 22TRN 1W 100PPM	0105	43P-201
R715	14024-20003	1	200 OHM RES FILM 1-4W 1% 100PPM	0035	RN55D2000F
R716	14024-64903	1	649 OHM RES FILM 1-4W 1% 100PPM	0035	RN55D6490F
R717	14024-71503	1	715 OHM RES FILM 1-4W 1% 100PPM	0035	RN55D7150F
R721,822	10117-33002	2	33 OHM RES COMP 1-4W 5%	0087	R25J-33-5%
R722,821,921,923	10117-51002	4	51 OHM RES COMP 1-4W 5%	0087	R25J-51-5%
R811,813	14044-24902	2	24.9 OHM RES FILM 1-4W .1%	0037	CMF60-24R9BT2
R812	14024-61902	1	61.9 OHM RES FILM 1-4W 1%	0035	RN55D61R9F
R814	14024-40202	1	40.2 OHM RES FILM 1-4W 1% 100PPM	0035	RN55D40R2F
R815	14024-10002	1	10 OHM RES FILM 1-4W 1% 100PPM	0035	RN55D10R0F
R911,912	14027-40201	2	4.02 OHM RES FILM 1-4W 1% 150PPM	0037	CMF-55 4.02 1% T-0
R913,92	14024-16904	2	1.69K RES FILM 1-4W 1% 100PPM	0035	RN55D1691F
R914	14024-49902	1	49.9 OHM RES FILM 1-4W 1% 100PPM	0035	RN55D49R9F
S17	42050-10101	1	SWITCH DIP 1POS SPST	0093	JS-8794-01
S97	42050-10010	1	SWITCH 10POS.	0101	C42315-A61-A11
U02	73304-07474	1	IC HCMOS DUAL D-TYPE FLIP-FLOP	0107	74HC74
U03,04,05,23,24,25	71205-74161	6	IC TTL ALS SYNCH 4-BIT COUNTER TI ONLY	0107	SN74ALS161BN
U06,1041,1042,114,26,94	71203-74161	6	IC TTL AS SYNCH 4-BIT COUNTER	0107	SN74AS161N
U07	79814-00267	1	PAL PROGRAMMED EP310-2 REV A 53A-243	0000	

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
U1011,1012	79920-44750	2	IC HYBRID DELAY LINE 5-NS INC 50-NS MAX	0205	0447-0050-10
U102,92	73002-74374	2	IC TTL AS OCTAL D-TYPE FLIP-FLOP	0107	74AS374
U103,113,93	79805-04188	3	IC CMOS 16K X 4 SRAM 20NS	0331	P4C188-20PC
U105	79805-58256	1	IC CMOS 32K X 8 SRAM 120NS	0387	UM62256A-12L
U107	73306-74244	1	IC HCMOS OCTAL BUFFER NON-INVERTING	0107	74HC244
U112,73,83	73310-74244	3	IC TTL LS OCTAL BUFFER NON-INVERTING	0107	74LS244N
U115	79813-00142	1	PROGRAMMED PROM U115 53A-243	0000	
U117,13,14,15,35,36	73004-74273	6	IC HCMOS OCTAL D-TYPE FLIP-FLOP	0107	74HC273
U12,55,63	76603-07410	3	IC TTL AS 3-INPUT NAND GATE	0107	74AS10
U16,47	73005-74564	2	IC HCT OCTAL TRISTATE LATCH	0107	74HCT564
U17,87	73310-74240	2	IC TTL LS OCTAL BUFFER	0107	74LS240
U27,37	73309-74240	2	IC HCT OCTAL BUFFER INVERTING	0088	74HCT240
U32,77	76603-07400	2	IC TTL AS 2-INPUT NAND GATE	0107	74AS00
U33,67	77204-07408	2	IC TTL AS QUAD 2-INPUT AND GATE	0107	74AS08
U34,75	77825-07432	2	IC TTL ALS QUAD 2-INPUT OR GATE	0107	74ALS32
U42	73312-74240	1	IC TTL AS OCTAL BUFFER	0107	74AS240
U43,44,52,53,54	73006-07474	5	IC TTL AS DUAL D-TYPE FLIP-FLOP	0107	74AS74
U45	77820-07432	1	IC TTL S QUAD 2-INPUT OR GATE	0107	74S32
U46	77203-07408	1	IC TTL ALS QUAD 2-INPUT AND GATE	0107	74ALS08
U56,57	73300-07406	2	IC TTL HEX INVERTER BUFFER-DRIVER	0107	7406

REFERENCE DESIGNATOR	CDS PART NUMBER	QTY.	PART DESCRIPTION	MFG. NUM.	MFG. PART NUMBER
U62	73001-07474	1	IC TTL LS DUAL D-TYPE EDGE TRIG FLIP-FLOP	0107	74LS74A
U64	77815-07432	1	IC TTL LS QUAD 2-INPUT OR GATE	0107	74LS32
U65	76510-74804	1	IC TTL AS HEX 2-INPUT NAND DRIVER	0107	74AS804
U66	79814-00268	1	PAL PROGRAMMED EP310-2 REV A 53A-243	0000	
U71	61000-00007	1	OP AMP BIPOLAR ULTRA LOW DRIFT	0082	OP07EP
U72	61000-00220	1	OP AMP WIDEBAND	0253	CLC220AI
U74,84	79004-74138	2	IC TTL AS 3-TO-8 DECODER	0107	74AS138
U76	73309-74245	1	IC HCT OCTAL BUS TRANSCEIVER	0107	74HCT245
U85	79825-84000	1	IC NMOS Z80 CPU 6 MHZ	0117	Z0840006 PSC
U91	20100-01012	1	D-A CONVERTER 12 BIT 30 NS	0415	TDC1012N7C2
VR1041	52000-00336	1	VOLTAGE REGULATOR NEGATIVE 3 TERM ADJUSTABLE	0078	LM337T
VR51	32000-05231	1	DIODE ZENER 5.1V .5W 5%	0107	1N5231
X11,12	45001-05100	2	CONNECTOR SIP 5 PIN	0032	CAS-05VSC-12B
X115	45012-28128	1	SOCKET 28-PIN DIP MACHINED	0089	ICA-286-S-TG30
X85	45012-40128	1	SOCKET 40-PIN DIP MACHINED	0089	ICA-406-S-TG30
Y22	89499-25000	1	CRYSTAL OSC 25.000MHZ 50PPM	0037	XO-43A-25.0000


41530-24301-9101-02-A-1
C01
X11
X12
E3
E4
DS11
DS12
DS13
DS14
DS15
DS01
R211
R212
R213
R214
R215
Q31
C12
Y22
C21
C23
C15
C04
C061
C062
F07
C07
R07
CR17
S17
R17
C27
J30
J40
J50
J80
R34
R421
R422
C35
C43
C57
C54
C63
CR51
CR61
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U77
U83
U84
U85/X85
U87
Q82
Q83
C822
R823
R921
C921
C922
R922
R923
Q92
Q93
C83
C931
C932
C94
U94
C90
K91
C911
L91
C912
R911
R912
R913
R914
C913
U91
U92
U93
U1041
U105
C1051
C97
U107
S97
C92
C832
A92
R1011
U102
U103
U1042
C1121
C1031
VR1041
U112
U113
U114
U115/X115
U117
F1171
F1172
C1114
C1112
U1011
U1012
C1122
C1131
C1141
CR1151
CR1152
CR1161
CR1171
CR1172
CR1173
CR1174
E2

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