53A-242 ARBITRARY WAVEFORM GENERATOR CARD

OPERATING MANUAL

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DESCRIPTION

The 53A-242 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, and user-defined, arbitrary waveforms. The ARB Card produces an analog output of +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.

Eighteen programmable sample rates are provided, covering a 5.5-decade range from 10 MHz to 20 Hz. A waveform consisting of up to 8,192 10-bit voltage points can be programmed into the on-card memory. The memory is partitioned into two 4K-word blocks that may be combined to form a single 8K-word block. When partitioned as two 4K blocks, one memory partition may be updated while the other is transmitting.

The waveform in each partition may be of any length, up to 4,096 samples. Each waveform may be independently programmed to repeat from 1 through 99 times, or continuously. The two partitions may also be chained together, and the chained composite of the two waveforms may be programmed to repeat from 1 through 99 times, or continuously.

Breakpoints may be programmed in any nonconsecutive memory locations. A break-point will temporarily pause a waveform until it is retriggered by software or by an external, hardware, TTL trigger.

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. The phase relationship between multiple, synchronized waveforms can then be varied under program control by specifying each individual waveform's starting output-memory location.

Memory locations are easily programmed using a string of numeric ASCII characters which directly specify the output voltage for each sample. An editing capability is provided to allow changing of individual points in the waveform without requiring a complete reloading of memory. To allow high-speed downloading of waveforms from the system controller (calculator or computer) under DMA control, the ARB Card can transfer characters at a 500-kHz rate. Memory loading has an auto-increment capability so that only the starting waveform address is programmed at the beginning of a block-waveform load, further optimizing the speed of waveform updating.

Auxiliary inputs are provided to allow for external-clock input (up to 10 MHz), external waveform trigger, and external-clock/waveform gating. Auxiliary output provide a clock at the programmed sample rate and a synchronization pulse which occurs at the end of each waveform cycle.

CONTROLS AND INDICATORS

Address-Select Switch

The 53A-242 Card has a miniature 10-position switch labeled "ADDRESS" that selects the 53A-242 Card's address (0-9) in the 53/63 System. The switch-cover hinges open allowing the address to be reselected. A screwdriver with a narrow, flat blade should be used to turn the cam-action wiper to the desired address 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 taking. Whenever the 53A-242 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-242 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

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

Function LEDS and Switches

RUN A
This LED is lit when partition A of memory is actively transmitting.

RUN B
This LED is lit when partition B of memory is actively transmitting.

PGM A
This LED is lit when partition A of memory is selected for waveform updating.

PGM B
This LED is lit when partition B of memory is selected for waveform updating.

XTRG
This LED is lit when the external trigger has been armed by the X (eXternal trigger) command (see OPERATION section).

External Clock Enable Switch

The External Clock Enable Switch is located at the front edge of the ARB Card, just below the large Power LED. This 2-position, slide switch allows a user-provided external clock to replace the 10-MHz, internal, sample-rate clock used by the ARB Card. If the switch is in the OFF position, the 53A-242 Card's internal clock is selected; if the switch is in the ON position, External Clock Input is selected.

SPECIFICATIONS

Number of Channels: Single channel.

Amplitude Resolution: 10 bits (1,024 vertical samples).

Memory: Two 4K memory banks that can be chained to 8K (from 2 to 8,192 horizontal samples).

Programming: ASCII characters representing value of output sample in volts.

Memory-Update Capability: Random-access update of any point in waveforms.

Automatic increment of address for sequential memory points.

Waveform-Repeat Capability: Waveforms A and B are independently programmable for a repeat count of 1 through 99 times, or continuous.

Repeated waveforms A and B may be chained; chained-waveform sequence is programmable for a repeat count of 1 through 99 times, or continuous.

Waveform Triggering: Triggering under program control, or with external trigger.

External Trigger Input: Enabled or disabled under program control.

Breakpoint-Capability Memory: Any two points in a waveform, except the first sample point, or any sequential sample points, can be programmed to pause transmission until card is retriggered.

Interrupt Capability: Programmable interrupt at end of transmission, or on breakpoint.

Output Amplitude: +5.11 V dc into a 50-Ohm load, programmable in 10-mV steps; +10.22 V dc into an open impedance, programmable in 20-mV steps.

Output Accuracy

  Dc Accuracy: ±0.5% of full scale.

  Dc Temperature Drift: 0.02% °C of full scale.

  **Settling Time
  (full scale):**   300 ns (to dc accuracy).
  200 ns (to 1.5% accuracy).

<u>Output Current</u>:	100 mA, maximum.
<u>Maximum Output Sample Rate</u>:	10 MHz.
<u>Programmable Sample Rates</u>:	10 MHz, 5 MHz, and 2 MHz.
	1 MHz, 500 kHz, and 200 kHz.
	100 kHz, 50 kHz, and 20 kHz.
	10 kHz, 5 kHz, and 2 kHz.
	1 kHz, 500 Hz, and 200 Hz.
	100 Hz, 50 Hz, and 20 Hz.
<u>Frequency Accuracy</u>:	0.005% (0 °C to 50 °C).
<u>External Clock Input</u>:	User-supplied, 0-Hz to 10-MHz, TTL-compatible signal. Minimum clock duration:
	Clock high - 45 ns. Clock low - 45 ns.
<u>External Trigger Input</u>:	User-supplied, active-low, TTL-compatible pulse. Minimum pulse width: 120 ns.
<u>Auxiliary I/O Capability</u>:	Sample-clock output. End-of-waveform output. External-clock input. External-trigger input. Clock-enable (gate) input.
<u>Auxiliary Outputs</u>:	Advanced Schottky-TTL drive, 40 standard TTL loads.
<u>Auxiliary Inputs</u>:	Advanced Schottky-TTL load, 0.3 standard TTL load.
<u>Power Requirements</u>:	5V and ±15V dc power is provided by the internal Power Supply in the 53/63 Series Card Cage.
<u>Voltage (5-volt Supply)</u>:	4.75 V dc to 5.25 V dc.
<u>Current (5-volt Supply)</u>:	2.0 A, maximum quiescent. 2.1 A, peak.
<u>Voltage: (+/-15-volt Supplies)</u>:	+14.5 V dc to +15.5 V dc. -14.5 V dc to -15.5 V dc.
<u>Current (+/-15-volt Supplies)</u>:	115 mA, maximum quiescent. 140 mA, peak.

NOTE: The 53A-242 Card requires more current than the standard 53A function card. This limits the number and placement of the 53A-242 Cards installed in either the 53A-002, the 53B-003, or the 63A-012 Card Cages.

The limitations are as follows:

53A-002 Card Cage - A total of 18 A of 5-volt current is available to all ten function card slots. Function card slots 0 and 1 are limited to a combined total of 4 A.

53B-003 Card Cage - The total 5-volt current available to all function card slots is 21 A.

63A-012 Card Cage - The total 5-volt current available to the function card slots 1 through 4 is 8.4 A. Function card slot 0 can provide 2.5 A.

To determine if the peak current requirements will be met for a particular application, add 2.1 A for each 53A-242 Card to be installed together with the amperes of 5-volt peak current required for each other function card to be installed. Refer to the limitations described above to verify that the specified total current is not exceeded.

Cooling: Provided by the fan in the 53/63 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., noncondensing.

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 53A-002 or 63A-012 Card Cage, 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: 0.36 kg.   (0.8 lb).

<u>Weight. Shipping</u>:	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:

1.2 kg. (2.6 lb). |
<u>Mounting Position</u>:	Any orientation.
<u>Mounting Location</u>:	Plugs into a function-card slot of the 53A-002 or 63A-012 Card Cage.
<u>I/O Connections</u>:	SMB snap-on connectors; 1 SMB-to-BNC male adapter cable is supplied.
<u>Equipment Supplied</u>:	1 - 53A-242 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# 00000-12420).
1 - Service manual (Part# 00000-22420).

OPERATION

Overview

The 53A-242 Card is programmed by ASCII characters issued from the system controller to the 53/63 System's communications card. The 53A-242 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 card address (0-9) of the function card within the addressed mainframe. The 53A-242 Card's Y 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-242 Card is addressed, the commands listed below may be issued until another function card is addressed.

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

D   (Divide) command programs the basic sample rate of the card.

A and B
    select the A and B partitions of memory, respectively, for voltage programming.

V   (Voltage) command sequentially programs the arbitrary waveform voltages for the selected memory partition. It also programs the end-of-waveform bit, any breakpoints, and optional chaining to the waveform in the other partition.

R   (Repeat) command programs the number of times to repeat the waveform in the selected memory partition, or programs continuous transmission.

C   (Chain) command programs a repeat count or continuous transmission for any chained waveform.

T   (Trigger) command starts actual transmission of the waveforms.

H   (Halt) command may be used to prematurely halt a waveform or as the means to halt a continuous waveform.

X   (eXternal trigger) and I (Interrupt) commands program the external trigger and interrupt modes, respectively.

E   (Edit) command allows random access to any location in the selected memory partition for updating of any point or points in the waveform with a subsequent V command.

A status capability for the experienced programmer, to allow synchronization of real-time waveform updates with actual transmission from the two memory partitions, is described in Application Note 242-2.

Card Commands

Detailed descriptions of the 53A-242 Card's commands, in the order listed above, are as follows:

Command	Description
[n1][n2]D	The D (Divide) command specifies how the main clock rate is to be divided to form the desired output sample rate. The output sample rate is the time between successive output-voltage updates from the ARB Card's memory.

[n1] is a 1-digit decimal number (0, 1, or 2) that specifies division of the main clock rate (10 MHz) by 1, 2, or 5, respectively.

[n2] is a 1-digit decimal number (0 through 5) that specifies how many times the clock rate resulting from [n1] is to be divided by ten.

[n1] and [n2] provide the following possible clock and sample rates:

Command	Clock Rate	Sample Rate
00D	10 MHz	100 ns
01D	1 MHz	1 μs
02D	100 kHz	10 μs
03D	10 kHz	100 μs
04D	1 kHz	1 ms
05D	100 Hz	10 ms
10D	5 MHz	200 ns
11D	500 kHz	2 μs
12D	50 kHz	20 μs
13D	5 kHz	200 μs
14D	500 Hz	2 ms
15D	50 Hz	20 ms
20D	2 MHz	500 ns
21D	200 kHz	5 μs
22D	20 kHz	50 μs
23D	2 kHz	500 μs
24D	200 Hz	5 ms
25D	20 Hz	50 ms

On power-up, the value of the D command is undefined. It should always be programmed to the desired value after power-up.

The value of the D command is not altered by a Halt command sent to the card (see H command), or by an @XH command used to reset the system (see Appendix A).

If External Clock Input has been selected, the ARB Card's 10-MHz internal clock is replaced with the clock appearing at the External Clock Input connector. The sample rate programmed by the D command is then given by the formula shown below:

$$SA = SP \left[FE/(10 . 106) \right]$$

where:
    SA = Actual sample rate in ns, μs or ms
    SP = Sample rate programmed with D command in ns, μs or ms
    FE = Frequency of external clock in Hz (10 MHz, maximum)

Command	Description
A	The A command selects the A memory partition for updating, and resets the A memory pointers. All memory-dependent commands (V, R, T, and E) that follow, affect the A memory partition until the B memory partition is selected.
B	The B command selects the B memory partition for updating, and resets the B memory pointers. All memory-dependent commands (V, R, T, and E) that follow, affect the B memory partition until the A memory partition is selected.

NOTE: Until instructed to select the other memory partition, the 53A-242 Card always operates on the memory partition currently selected.

Command	Description
[pv][m]V	The V (Voltage) command is used to load the selected memory partition with:

1) The desired voltage to be output during a sample period.

2) The memory-programming instructions to be executed at the end of the sample period.

[pv] the programmed voltage, is a 1- to 3-digit number form -511 to +511. When entering [pv], a minus sign must prefix negative values, and a plus sign is optional for positive values. Leading zeros and 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 two digits following the decimal point, then the value is multiplied by 0.01 to give the programmed voltage. The examples below show the resulting programmed voltage for correctly and incorrectly formatted [pv] values.

Examples:	[pv] Entered	Programmed Voltage (V)
Correctly Formatted:		
	.01	0.01
	.10	0.10
	1.00	1.00
Incorrectly Formatted:		
	.001	0.01
	.1	0.10
	.100	1.00
	1	0.01
	1.0	0.10
	10	0.10
	10.	1.00
	100	1.00
	100.	1.00

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 needs to 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, a simple resistance calculation can be used to calculate the output voltage as follows:

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

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

[m] is a 1-digit decimal number (0 through 7) that specifies the memory-programming instructions to be executed at the end of the sample period being programmed. The values of [m] and their associated memory-programming instructions are shown below:

[m]   <u>Memory-Programming Instruction</u>

0   Proceed to the next sample in memory.

1   Chain this memory to the other memory partition (executes the first memory location in the other memory partition next).

2   End of waveform in this memory partition: The sample in the first location in the same memory partition is repeated if the number of times the waveform is to be repeated (R command) has not been reached.

3   Chained end of waveform in this memory partition: The waveform programmed in this memory partition is repeated the number of times specified with the R command; then the first location in the other memory partition is executed.

4   Breakpoint: The ARB Card holds the current voltage output until another trigger command is received.

5   Chained breakpoint: The ARB Card holds the current voltage output until another trigger command is received, and then executes the sample in the first location of the other memory partition.

6   Breakpoint and end of waveform: The ARB Card holds the current voltage output until another trigger command is received. The ARB Card then outputs the voltage programmed in the first location of the current memory partition until the waveform is repeated the number of times specified by the R command.

7   Chained breakpoint and end of waveform: The ARB Card holds the current voltage output until another trigger command is received. When another trigger command is

received, and if the current memory partition has not been repeated the number of times specified by the R command, the next sample executed is the first sample of the current memory partition. When the current memory partition has been repeated the specified number of times, the next sample executed is the first location in the other memory partition.

NOTE: The trigger command used in conjunction with [m] values of 4 through 7 can be either a hardware or software trigger (see the T and X commands).

The values for [pv] and [m] form a single, concatenated number.

Example:

.153V is a valid V command; it programs 0.15 V dc, and sets a chained end of waveform in memory.

Consecutive V commands load into consecutive memory locations. To program a waveform, send an A command or a B command to reset the memory pointers so that programming begins in the first memory location. The memory pointers are automatically incremented by 1 after each V command is issued.

Note that when the ARB Card is halted at a breakpoint, the memory-access circuitry for the halted memory partition continues to operate. If V commands are issued to a breakpoint-halted memory partition, they will be ignored by the card.

Example of a memory load:

    @11A20D00R0.000V1.000V2.000V3.000V4.000V5.002V

The above command is decoded as follows:

The 53A-242 Card is in mainframe 1 and set to card address 1. The A memory partition is being used at a sample rate of 500 ns between samples. The waveform continuously repeats until an H command or an @XH command is sent. A step function is programmed for 0 V, 1 V, 2 V, 3 V, 4 V, and 5 V; and then repeats.

To start the ARB Card outputting the waveform defined above, the system controller would send the command string: @11AT

Mainframe 1, card address 1, is again addressed; the memory pointers are reset; and the A memory partition is then triggered, with output starting at the voltage defined in memory location 0. If no other function cards are addressed between this command

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string and the previous command string used to define the waveform,@11AT can be shortened to simply AT.

On power-up, the contents of memory, as programmed by the V command, are undefined. Once programmed, an H command sent to the card, or an @XH command used to reset the 53/63 System (see Appendix A), will not alter the contents of memory as programmed by the V command.

Command	Description
[n]R	The R (Repeat) command specifies the number of times the selected A or B memory partition is to repeat its stored waveform.

[n] is a 2-digit decimal number, from 00 to 99, that specifies how many times the stored waveform is to repeat. (See the special case using 00R in Example 2).

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 an @XH command or an H command.

Command	Description
[n]C	The C (Chain) command specifies the number of times the chained A and B memory partitions are to repeat.

[n] is a 2-digit decimal number, from 00 to 99, that specifies how many times the waveform contained in the A and B memories is to repeat. (See the special case using 00C in Example 2).

Examples:

1. 46C causes the chained A and B memory sequence to repeat 46 times.

2. 00C causes the chained A and B memory sequence to repeat continuously until the sequence is halted by an @XH command or an H command.

Command	Description

X

The X (eXternal trigger) command enables the ARB Card's external-trigger function. After the X command is issued, 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 H (Halt) command is used to clear the X command.

[n]I

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

[n] is a 1-digit decimal number (0, 1, or 2) 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 V command with [m] = 4, 5, 6, or 7.

2   End-of-transmission interrupts enabled. A single interrupt is generated at the completion of the total programmed waveform regardless of whether the waveform is a single-memory-partition waveform, a chained waveform, or a chained or nonchained waveform with a programmed repeat count.

After an interrupt occurs, it is latched by the ARB Card. The ARB Card will continue to generate the 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 53/63 System, a backplane interrupt will 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.

Command	Description
T	The T (Trigger) command triggers the ARB Card to being outputting the waveform stored in memory. An A or B command must first be sent to reset the memory pointers to the first sample of the waveform; then the T command is sent. After the T command is sent, the programmed waveform is output at the sample rate specified by the D command, and repeated for the number of times specified by the R command.

A T command can be issued only when the ARB Card is not currently outputting a waveform. If, for example, the ARB Card is outputting from the A memory and the user wishes to switch to outputting from the B memory, an H command must first be issued to terminate the ARB Card's output before selecting the B memory and issuing another T command. |
| H | The H (Halt) command is used to terminate the ARB Card's output. When the H command is issued, the waveform being output will stop, and the ARB Card's output voltage will go to zero volts.

Any data previously loaded with the D, V, or I commands will remain unchanged after an H command is issued. If external trigger was selected with the X command, it must be reprogrammed. The repeat count (R command) associated with each memory and the overall chain count (C command) need only be reprogrammed if they were previously programmed for continuous operation. |

Command	Description

Command

[m]E

Description

The E (Edit) command directs a memory location in the waveform sample to be programmed or reprogrammed. The E command is 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 E command.

The E command may also be issued just prior to a T command to cause the ARB Card's output to begin at a memory location other than 0.

[m] is a 1- to 4-digit decimal number, from 0 to 4095, that specifies where in memory to begin editing.

Examples:

1. 4021E1.120V2.300V directs the value in memory location 4021 of the current memory partition to be changed to 1.12 V, and the value in memory location 4022 to be changed to 2.30 V.

2. 500ET causes the ARB Card to begin outputting from memory location 500 in the current memory partition.

INSTALLATION

The 53A-242 Card is a function card and, therefore, may be plugged into 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 plugging 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).

b. There are two ejectors on the card. Make sure the ejector marked "53A-242" is at the top.

NOTE: The 53A-242 Card requires more +5-volt dc current than the standard 53A function card, limiting the number and placement of 53A-242 Cards in the 53A, the 53B, and the 63A Card Cage installations. Refer to the Power Requirements subsection of the Specifications for more information.

APPENDIX A

53/63 SYSTEM COMMANDS

Command   Description

@XY   The @XY (Address) command addresses a function card in the 53/63 System.

               The @ is a delimiter used by the 53/63 System. The X is a mainframe address (0-9)
               defined by the address-select switch on the 53A-171 Control Card in the addressed
               mainframe; the 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 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-242 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-242 Card
               reacts as if an H (Halt) command had been issued to the card (see the H command
               in the OPERATION section) when issued an @XH command. In all cases, an
               addressed function card (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-242 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.

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.

Pin No.	Signal Name	Function
J31	$\overline{\text{EX TRG}}$	External Trigger Input
J41	$\overline{\text{EX CLK}}$	External Clock Input
J511	$\overline{\text{EX HOLD}}$	External Hold Input
J512	$\overline{\text{SYNC}}$	Sync Output
J611	$\overline{\text{SMPCLK}}$	Sample Clock Output
J612	ARB OUTPUT	Arbitrary Waveform Output

External Trigger Input

This input provides the user with 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 120 ns. Actual ARB Card triggering will occur within 1 to120 ns after the falling edge of the external-trigger signal.

External Clock Input

External Clock Input is enabled when the External Clock Enable Switch is set to the ON position (see DESCRIPTION section, Function LEDs and Switches). The input accepts a TTL-compatible signal from 0 Hz to 10 MHz. The clock must be high for a minimum of 45 ns and low for a minimum of 45 ns.

External Hold Input

This input is an asynchronous, TTL, active-low signal; the input disables the sample clock at the next sample output, and holds that output value until the sample time following the removal of the External Hold Input signal. The waveform then continues from the same point where it was when the input went low.

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 ([m] = 2, 3, 6, or 7) in the V command (see OPERATION section). The output will remain low for one sample period, and then return high.

Sample Clock Output

This is a TTL, active-low, output that occurs at each sample update. If the internal-clock source is being used, the output will be a square wave whose period is equal to the sample rate programmed by the D command. When an external-clock source is used, the output will be a square wave whose period is equal to the ARB Card's sample rate unless the D command has been programmed to 00D. If 00D is programmed, the output will have a period and duty cycle equal to the supplied external-clock signal.

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.

APPENDIX C

CALIBRATION PROCEDURE

It is recommended that the 53A-242 Card be calibrated every 12 months in order for the card to meet its published accuracy specifications. Calibration should be carried out in an environment where the temperature is between 21°C and 25°C.

Test Equipment Required

1. 4 1/2-digit voltmeter with a dc accuracy of ±0.05% of reading.

2. 53A-729 SMB-to-BNC Adapter Cable (supplied with 53A-242 Card).

3. BNC-to-banana plug adapter.

Test Setup

Using the SMB-to-BNC adapter cable and the BNC-to-banana plug adapter, connect J612 of the 53A-242 Card to the dc-voltage input of the DMM. During the calibration procedure two potentiometers will be adjusted: the offset potentiometer (R1003) and the gain potentiometer (R1002). The two potentiometers are located at the lower, front edge of the card. The top-most potentiometer is R1002; R1003 is located directly below R1002. See the 53A-242 Card's assembly drawing contained in the 53A-242 Card's service manual for a diagram of the potentiometers' locations.

Calibration Procedure

1. Send the following command string to the 53A-242 Card:

    @XYHA00R00D0.000V0.002VAT

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

    Y = Card address (0-9) selected on 53A-242 Card's address-select switch

    Adjust the offset potentiometer (R1003) so that the DMM reads 0.00 V + 30 mV.

2. Send the following command string to the 53A-242 Card:

    @XYHA00R00D5.000V5.002VAT

    Adjust the gain potentiometer (R1002) so that the DMM reads +10.00 V ±30 mV. Note the exact value of the DMM reading.

3. Send the following command string to the 53A-242 Card:

    @XYHA00R00D-5.000V-5.002VAT

If the DMM reads -10.00 V +30 mV, proceed to step 4. If the error voltage is not within +30 mV of -10.00 V, adjust the offset potentiometer (R1003) to reduce the error to half of its original value; then proceed to step 4. Note the final error voltage for use in step 4.

Example:

If the DMM reads -9.760 V after issuing the command in step 3, adjust R1003 until the DMM reads -9.88 V. The final error voltage is -0.12 V, i.e., -10.00 - (-9.88) = -0.12.

4. Send the following command string to the 53A-242 Card:

@XYHA00R00D5.000V5.002VAT

Calculate the error between the value displayed by the DMM and 10.00 V. If step 3 required no adjustment and the DMM reading is within +30 mV of 10.00V, proceed to step 9. Otherwise, compare the error voltage computed in this step with the error voltage noted in step 3. The offset potentiometer must then be adjusted to make the error voltages measured in steps 3 and 4 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 4. Adjust R1003 for the desired DMM reading. Note the final error voltage in step 4.

Example:

Using the previous example, the error voltage in step 3 (after the adjustment of R1003) was -0.12 V. If the initial voltage measured in step 4 was 9.98 V, the error voltage in step 4 is 0.02 V. (-0.12 + 0.02)/2 = -0.05. R1003 is then adjusted so that the DMM reads 9.93 (9.98 - 0.05). The final error voltage in step 4 is 0.07 V.

5. Send the following command string to the 53A-242 Card:

XYHA00R00D-5.000V-5.002VAT

Calculate the magnitude of the error between the value displayed by the DMM and -10.00 V. If this value has the same magnitude as the final error voltage in step 4, proceed to step 6. Otherwise, use the procedure in step 4 (using the magnitude of error calculated in step 5 rather than the step 3 value) to again adjust the offset potentiometer. Repeat steps 4 and 5 until the magnitudes of the errors at +10.00 V and -10.00V are the same.

6. Send the following command string to the 53A-242 Card:

@XYHA00R00D5.000V5.002VAT

Adjust the gain potentiometer (R1002) until the value displayed on the DMM is +10.00 V +30 mV.

7. Send the following command string to the 53A-242 Card:

@XYHA00R00D-5.000V-5.002VAT

Adjust the gain potentiometer (R1002) until the value displayed on the DMM is -10.00 V
+ 30 mV.

8. Repeat steps 6 and 7 until no further adjustment is necessary.

9. Send the following command string to the 53A-242 Card:

    @XYHA00R00D0.000V0.002VAT

    If the DMM reading is 0.00 V +30 mV, proceed to step 12. If the DMM reading is **greater**
    than +30 mV, adjust the offset potentiometer (R1003) until the DMM reads 0.00 V + 30
    mV.

10. Send the following command string to the 53A-242 Card:

    @XYHA00R00D5.000V5.002VAT

    If the DMM reading is within +30 mV of 10.00 V, proceed to step 11. If it is not, adjust
    the gain potentiometer (R1002) so that the DMM reading is 10.00 V + 30 mV.

11. Send the following command string to the 53A-242 Card:

    @XYHA00R00D-5.000V-5.002VAT

    If the DMM reading is within +30 mV of -10.00 V, proceed to step 12. Otherwise, adjust
    the gain potentiometer (R1002) so that the DMM reading is -10.00 V +30 mV.

12. This step is a final linearity check of the 53A-242 Card. Send each of the commands
    listed below, and then check that the DMM reading is within +30 mV of the listed desired
    voltmeter reading. If any measurement is out of tolerance, adjust the offset
    potentiometer (R1003) by the minimum amount needed to bring the measurement into
    tolerance. If any adjustments are made, the sequence from step 8 through step 12 **must**
    be repeated.

Commands to be Sent	Desired Voltmeter Readings (V)
@XYHA00R00D-5.120V-5.122VAT	-10.24
@XYHA00R00D-5.110V-5.112VAT	-10.22
@XYHA00R00D-5.100V-5.102VAT	-10.20
@XYHA00R00D-5.080V-5.082VAT	-10.16
@XYHA00R00D-5.040V-5.042VAT	-10.08
@XYHA00R00D-4.960V-4.962VAT	-9.92
@XYHA00R00D-4.800V-4.802VAT	-9.60
@XYHA00R00D-4.480V-4.482VAT	-8.96
@XYHA00R00D-3.840V-3.842VAT	-7.68
@XYHA00R00D-2.560V-2.562VAT	-5.12
@XYHA00R00D0.000V0.002VAT	0.00
@XYHA00R00D0.010V0.012VAT	0.02
@XYHA00R00D0.020V0.022VAT	0.04
@XYHA00R00D0.040V0.042VAT	0.08
@XYHA00R00D0.080V0.082VAT	0.16
@XYHA00R00D0.160B0.162VAT	0.32
@XYHA00R00D0.320V0.322VAT	0.64
@XYHA00R00D0.640V0.642VAT	1.28
@XYHA00R00D1.280V1.282VAT	2.56
@XYHA00R00D2.560V2.562VAT	5.12
@XYHA00R00D5.110V5.112VAT	10.22

APPENDIX D

APPLICATION NOTE 242-1

Synthesis of Sinusoidal Waveforms

This application note describes an algorithm for programming the 53A-242 Arbitrary Waveform Generator Card as a sine-wave synthesizer. Input parameters to the algorithm are the sine wave's frequency, peak-to-peak amplitude, dc off-set, and the number of points to be programmed in the 53A-242 Card's memory. A sample BASIC program is provided at the end of this application note to implement the algorithm.

The 53A-242 Card can be programmed for 18 different sampling frequencies while using as many as 8,192 points in the ARB Card's memory. Depending on the value of the desired waveform frequency, the sampling frequency and number of data points used can be adjusted to produce the exact (or almost exact) waveform frequency desired. If the desired frequency cannot be programmed exactly, a minimum error between the desired frequency and the actual frequency programmed can be achieved by using the maximum number of points possible in memory and an intelligently chosen sampling frequency.

The closest possible frequency (or if the frequency is exact, the waveform with the least distortion) can be achieved by selecting a sampling frequency from Table 242-1. However, as the number of sample points increases, the time required to compute the points and load them into the ARB Card's memory often becomes objectionable; and a waveform with fewer sample points must therefore be chosen. Table 242-2 summarizes the trade off between waveform distortion and number of sample points used. The example shown is for a 312.5-Hz sine wave. Distortion is expressed as the maximum level of harmonic and other spurious noise (in dB) below the 312.5-Hz signal, occurring in a bandwidth of dc to 250 kHz.

A typical compromise between waveform accuracy, distortion, and sample-computation time, is to use a waveform constructed with 100 to 300 sample points. The sample BASIC program presented at the end of this application note uses from 120 to 300 points to construct waveforms from 5 Hz to 80 kHz with a resulting maximum frequency error of +0.41% and a distortion of < -40 dB.

Table 242-1

Sampling Frequency Selection

Desired Waveform Frequency Range	Sampling Frequency	53A-242 Card's D Command
1.2212 kHz to 5.000 MHz	10 MHz	00D
610.35 Hz to 1.2212 kHz	5 MHz	10D
244.14 Hz to 610.35 Hz	2 MHz	20D
122.07 Hz to 244.14 Hz	1 MHz	01D
61.035 Hz to 122.07 Hz	500 kHz	11D
24.414 Hz to 61.035 Hz	200 kHz	21D
12.207 Hz to 24.414 Hz	100 kHz	02D
6.1035 Hz to 12.207 Hz	50 kHz	12D
2.4414 Hz to 6.1035 Hz	20 kHz	22D
1.2207 Hz to 2.4414 Hz	10 kHz	03D
610.35 mHz to 1.2207 Hz	5 kHz	13D
244.14 mHz to 610.35 mHz	2 kHz	23D
122.07 mHz to 244.14 mHz	1 kHz	04D
61.035 mHz to 122.07 mHz	500 Hz	14D
24.414 mHz to 61.035 mHz	200 Hz	24D
12.207 mHz to 24.414 mHz	100 Hz	05D
6.1035 mHz to 12.207 mHz	50 Hz	15D
2.4414 mHz to 6.1035 mHz	20 Hz	25D

Table 242-2

Waveform Distortion

Number of Sample Points	Distortion (dB)	THD (%)
6400	< -35.0	0.03
640	< -25.0	0.3
160	< -19.0	1.3
120	< -17.8	1.6
64	< -15.0	3.2

Once a sample rate has been chosen, the algorithm for generating the voltage values for the points in memory is as follows:

$$V_i = V_{dc} + 1/2 V_{ptp} \sin[6.283185 \cdot i \cdot (F_o/F_s)]$$

where:

V_i	=	voltage of ith point in ARB Card's memory, i = 1 to n
V_{dc}	=	dc offset voltage
V_{ptp}	=	peak-to-peak voltage
F_o	=	programmed output frequency
F_s	=	sampling frequency of ARB Card

The number of points to be programmed is determined by dividing the ARB Card's sampling frequency (D command) by the desired frequency.

Sample Program

The sample program shown below is written in Advanced BASIC (BASICA) for an IBM PC. The PC is connected to the CDS card cage using a 53A-903 I/O 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-242 Card has been set to address 9. The address of the 53/63 System's card cage containing the 53A-242 Card is address 1.

The sample program loads the memory of the 53A-242 Card using the preceding algorithm, and triggers the card to output the waveform. The waveform frequency, peak-to-peak voltage, and dc offset are input when the program is run. The 5-Hz to 80-kHz sine wave developed will have a maximum frequency error of +0.41%, and exhibit a distortion of < -40 dB.

Lines 1090 through 1130 define the waveform's frequency and voltage parameters. Lines 1140 through 1460 develop the waveform's voltage points to load into the ARB Card's memory. The CALL statements at lines 1480, 1510, and 1540 transfer the contents of the string variable WRT$ to the 53A-242 Card.

In the program listing, lines which are not preceded by a line number are not part of the BASIC program. They are inserted as comments to explain what is occurring at each numbered line.

.
.
.

1090 INPUT "ENTER SINE WAVE'S FREQUENCY IN HERTZ ",FO
1100 INPUT "ENTER SINE WAVE'S PTP VOLTAGE IN VOLTS ",VPP
1110 INPUT "ENTER SINE WAVE'S DC OFFSET IN VOLTS ",VDC

Define variables for the output waveform's frequency (FO), peak-to-peak voltage (VPP), and dc offset voltage (VDC).

1120 IF FO > 80000 THEN PRINT "FREQUENCY OUT OF LIMITS": GOTO 1550
1130 IF (VDC + 0.5*VPP) > 5.11 OR (VDC - 0.5*VPP) < -5.11 THEN PRINT "OUT-OF-LIMIT VOLTAGE ATTEMPTED": GOTO 1550

Determine if the maximum frequency or output level has been exceeded.

NOTE: The output voltage will equal the programmed voltage only when the ARB Card is driving a 50-Ohm load. See the V command in the OPERATION Section.

1140 PTS = FO*120
1150 IF PTS <= 2E6 AND PTS > 1E6 THEN SR$ = "00D": N=2E6/FO: GOTO 1330
1160 IF PTS <= 1E6 AND PTS > 4E5 THEN SR$ = "10D": N=1E6/FO: GOTO 1330
1170 IF PTS <= 4E5 AND PTS > 2E5 THEN SR$ = "20D": N=4E5/FO: GOTO 1330
1180 IF PTS <= 2E5 AND PTS > 1E5 THEN SR$ = "01D": N=2E5/FO: GOTO 1330
1190 IF PTS <= 1E5 AND PTS > 4E4 THEN SR$ = "11D": N=1E5/FO: GOTO 1330
1200 IF PTS <= 4E4 AND PTS > 2E4 THEN SR$ = "21D": N=4E4/FO: GOTO 1330
1210 IF PTS <= 2E4 AND PTS > 1E4 THEN SR$ = "02D": N=2E4/FO: GOTO 1330
1220 IF PTS <= 1E4 AND PTS > 4E3 THEN SR$ = "12D": N=1E4/FO: GOTO 1330
1230 IF PTS <= 4E3 AND PTS > 2E3 THEN SR$ = "22D": N=4E3/FO: GOTO 1330
1240 IF PTS <= 2E3 AND PTS > 1E3 THEN SR$ = "03D": N=2E3/FO: GOTO 1330
1250 IF PTS <= 1E3 AND PTS > 4E2 THEN SR$ = "13D": N=1E3/FO: GOTO 1330
1260 IF PTS <= 4E2 AND PTS > 2E2 THEN SR$ = "23D": N=4E2/FO: GOTO 1330
1270 IF PTS <= 2E2 AND PTS > 1E2 THEN SR$ = "04D": N=2E2/FO: GOTO 1330
1280 IF PTS <= 1E2 AND PTS > 4E1 THEN SR$ = "14D": N=1E2/FO: GOTO 1330
1290 IF PTS <= 4E1 AND PTS > 2E1 THEN SR$ = "24D": N=4E1/FO: GOTO 1330
1300 IF PTS <= 2E1 AND PTS > 1E1 THEN SR$ = "05D": N=2E1/FO: GOTO1330
1310 IF PTS <= 1E1 AND PTS > 4E0 THEN SR$ = "15D": N=1E1/FO: GOTO 1330
1320 SR$ = "25D": N = 4/FO
1330 J = 1: K = 0
1340 LET N = CINT(N)

The value 120 in line 1140 determines the minimum number of voltage points a waveform will contain. Lines 1150 through 1320 determine the exact number of voltage points and the ARB Card's sampling frequency. N is the number of points to be programmed. The CINT function in line 1340 rounds N to the nearest integer, providing the closest frequency to the desired frequency. The string variable SR$ contains the required command string to program the ARB Card's sampling frequency.

1350 C$ = "@19HA00R" + SR$

C$ is a string used to define setup commands for the 53A-242 Card.

@19 is the @XY (Address) command.
H is the Halt command.
A selects the A memory partition.
00R programs the waveform to repeat continuously.
SR$ contains the D command for the ARB Card's sampling frequency.

```
1360 LET C1 = (6.283185)/N
1370 LET C2 = .5*VPP
```

C1 and C2 are constants used in computing the ARB Card's output-voltage steps. C1 is in radians because the SIN function in line 1390 requires radians rather than degrees.

```
1380 FOR I = 1 TO N
1390 V = VDC + C2*SIN(C1*I)
1400 V% = CINT(V*100)
1410 V$ = STR$(V%)
1420 IF I < N THEN V$ = V$ + "0V": GOTO 1440
1430 IF I = N THEN V$ = V$ + "2V"
```

Compute the Ith output-voltage step, convert the result to an integer, convert the integer to a character string, and append the memory-programming instruction code and an ASCII V.

```
1440 D$(J) = D$(J) + V$: K = K + 1
1450 IF K = 36 THEN K = 0: J = J + 1
1460 NEXT I
```

Append the Ith data point to the D$-array element D$(J). When a D$-array element contains 36 voltage steps, increment the D$-array subscript J. When the FOR-NEXT loop from 1 to N is complete, the D$ array will contain the voltage points to be loaded into the ARB Card's memory.

```
1470 WRT$ = C$
1480 CALL IBWRT(CDS%,WRT$)
1490 FOR I = 1 TO J
```

Output the setup commands to the ARB Card

```
1500 WRT$ = D$(I)
1510 CALL IBWRT(CDS%,WRT$)
1520 NEXT I
```

Output the voltage points to the ARB Card.

```
1530 WRT$ = "AT"
1540 CALL IBWRT(CDS%,WRT$)
1550 END
```

Reset the A memory pointer to the beginning of memory, and trigger the card.

APPENDIX E

APPLICATION NOTE 242-2

Considerations for "On-the-Fly" Updating of the ARB Card's Memory

When the two memory partitions of a 53A-242 Card are chained together, it is often desirable to update one memory partition while the other partition is being output. This application note describes and discusses the factors that must be considered to determine if a given 53A-242 Card/system-controller configuration is suitable for doing "on-the-fly" updating of a memory partition.

Four factors must be considered before using the ARB Card's "on-the-fly" updating capability:

1. The total amount of time it will take the system controller to output the new data to the memory partition.

2. The total time required by the 53/63 System and the ARB Card to accept and process the new output data.

3. The total time available for updating the ARB Card's memory partition.

4. The total time required for the system controller to obtain the status of the ARB Card and branch to the memory-update routine.

For successful "on-the-fly" updating, the above considerations can be reduced to the following inequality:

$$T_A > T_S + T_P + T_{STAT}$$

where: T_A =   Total time available for updating a memory partition

T_S =   Total time required by system controller to output new data

T_P =   Total time required for the ARB Card and 53/63 System to process the new data

T_{STAT} =   Total time required for the system controller to obtain the status of the ARB Card and branch to the memory-update routine

To define T_S, consult the documentation provided by the system controller's manufacturer to determine the system controller's output rate. When determining the system controller's output rate, be aware that controller manufacturers typically specify the output rate for the 2nd to nth output-data bytes. The output time for the first output byte is generally much greater. High- performance system controllers typically provide a 0.3-ms to 2.0-ms transfer time for the first output byte and a 3-us to 5-us transfer time for the 2nd to nth output bytes when multiple bytes are output by a single output statement from the system controller.

Six bytes of data (e.g., -5231V) are normally output to update a single data point. The total time to output K data points, with a single output statement from the system controller, is as follows:

$$T_S = T_{S1} + T_{S2} (6K - 1)$$

where: T_S = Total output time for K data points

T_{S1} = Time for system controller to output first byte

T_{S2} = Time for system controller to output each of the 2nd through nth bytes

K = Number of data points being output

The time required for the 53/63 System and the ARB Card to accept and process each new data point is a function of the communications card installed in the 53/63 System. In the case of a 53A-128 IEEE-488 Communications Card, for example, 7.5 μs are required for the communications card to process a single data byte, and 2.0 μs are required for the ARB Card to process the same data byte. If K data points (six bytes per point) are to be updated in the ARB Card's memory, then the total time needed for the 53/63 System and the ARB Card to process the resulting data transfer is as follows:

$$T_P = 9.5 \text{ μs} \times 6 \times K$$

where: T_P = Total time needed to process K data points

The total time available for updating a memory partition is a function of the number of data points and the sample rate programmed for the memory partition currently being output (i.e., partition B will be updated while partition A is being output). This time is defined as follows:

$$T_A = J \times D$$

where: T_A = Total time available for updating a memory partition

J = Number of data points in the memory partition currently being output

D = Sample rate programmed with D command

T_{STAT} is the time required for the system controller to obtain the status of the ARB Card, determine that the card has switched from one memory partition to the other, and then branch to the memory-update routine. Updating of the ARB Card's memory should begin immediately after the card switches outputting from one memory partition to the other memory partition.

The memory partition currently being output by the ARB Card can be determined at any time by addressing the card (@XY command) and requesting input from the card. A single byte of data will be returned. This byte will not be followed by <CR><LF> characters. If the A partition is currently being output, the byte will be a binary 0 (hex 00). If the B partition is being output by the card, the byte will be a binary 1 (hex 01).

T_{STAT} is defined as follows:

$$T_{STAT} = T_I + T_C + 9.5 \text{ μs}$$

where: T_{STAT} = Time required to obtain status

T_I = Time required for system controller to input one data byte

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T_I = Time required for system controller to input one data byte

T_C = Time required for system controller to determine if ARB Card has switched memory partitions and, if so, branch to the memory-update routine

The 9.5 μs in the above equation is the time required for the ARB Card to output the memory partition's status byte when a 53A-128 IEEE-488 Communications Card is being used in the 53/63 System. To determine T_I and T_C, consult the documentation provided by the system controller's manufacturer. When determining T_I be sure that the time used is the time required to input the first byte, not the 2nd through nth bytes. High-performance system controllers typically require 0.3 to 2.0 ms to input a single data byte. Determining TC will require "blocking out" the system controller's code for detecting when the ARB Card switches memory partitions, and then branching to the memory-update routine. You will need to determine the system controller's execution time for each instruction used.

To successfully update one memory partition while another is being output, the following inequality must be satisfied:

$$T_A > T_S + T_P + T_{STAT} + T_{SF}$$

where: T_{SF} = Safety factor (approximately 15% of $T_S + T_P + T_{STAT}$)

T_S, T_P, and T_{STAT} are as defined above.

T_{SF} is included to allow for inaccuracies in computing the various timing considerations. If the ARB Card should switch from partition A to partition B while B is still being updated, incorrect ARB Card operation will occur.

In summary, to determine if one memory partition can be updated "on-the-fly" while the other memory partition is being output, a detailed analysis must be made of the system controller's input/output data rates, the 53/63 System's and ARB Card's byte-by-byte processing time, and total available update time.