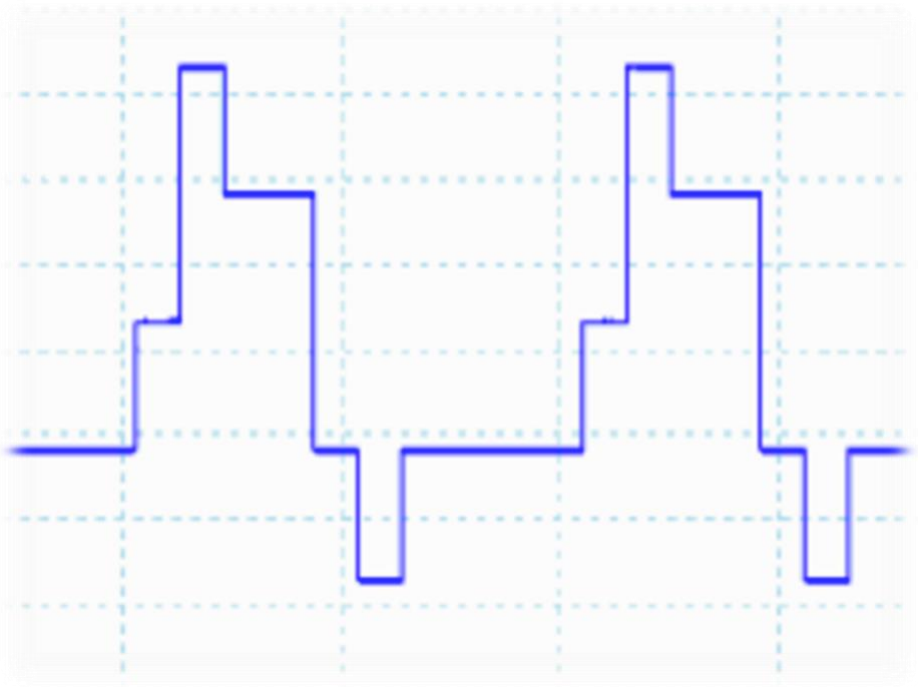
MIPS

Arbitrary Waveform Generator (ARB)
Operation Manual Addendum
Version 4.0 September 2021

(in process, needs review)



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WARNING
TO REDUCE THE RISK OF FIRE OR ELECTRICAL SHOCK DO NOT EXPOSE THIS EQUIPMENT TO RAIN OR MOSITURE.

WARNING
Avoid spilling liquids onto/into the unit.
Do not expose to excessive heat or moisture.
Do not open – there are no user serviceable parts inside.
Do not block the chassis vent slots or the fan inlet.

Only qualified electrical workers are able to install and test this system. Please follow these recommendations:

1.) Never operate the system with the covers removed.
2.) Make sure to cover all your connections to protect them from accidental contact.
3.) Place the MIPS power supply in a position that will provide clearance for its intake fans and air exit openings.
4.) Do not operate this MIPS power supply until you have read the operating instructions and tuning instructions.
5.) There are no user serviceable parts inside the MIPS power supply so do not remove the covers.
6.) Only replace fuses with the specifications defined on the rear panel of the MIPS system.
7.) Never operate this system in a combustible gas environment.

Introduction:

The MIPS arbitrary waveform generator module (ARB) will generate 8 separate ARB output channels. Each channel can be independently programed to generate an arbitrary waveform as needed for your application. A MIPS system can have up to six ARB modules enabling 32 independent ARB outputs. The MIPS ARB system has two main modes of operation, TWAVE and ARB.

TWAVE mode

When in the TWAVE mode the ARB generates 8 repetitive output waveforms each shifted by 45 degrees in phase. Several different waveform types are defined and the user can enter a custom waveform type. In this mode 32 data points are used to define one cycle and the waveform is repeated thus generating a continuous waveform. Multiple ARB modules in one MIPS system support specialized control options used to control multi-pass SLIM separation systems.

ARB mode

When in the ARB mode the system provides classic arbitrary waveform generation capability. The features section below defines the ARB capabilities. This system has been designed to support a generation of pulse sequences. Commands have been developed to simplify definition of these sequences. It is not possible to download raw data to the buffer but this capability will be added in the future.

Features

- 8 output channels
- 8 bit DAC resolution
- Maximum output voltage range +-50V
- Programmable output range (12 bit resolution)
- Programmable output offset (12 bit resolution)
- Auxiliary output channel (12 bit resolution)
- 8000 sample maximum number of samples
- Programmable buffer repeat
- External trigger
- Software trigger
- 1MHz maximum digitization rate, all channels are simultaneous, i.e. all channels operate at 1MHz
- Response time
    - 5V step, rise and fall times ~700nS
    - 20V step, rise and fall times ~1.1uS

Operation:

The MIPS user interface (UI) consists of a multiline color graphics display and a single control knob located on the front panel. The display will show various dialog boxes with parameters you can control and monitor. When a dialog box is displayed you can rotate the control knob to highlight a selection. If you press the knob when a selection is highlighted then the parameter is selected and its value is highlighted. With the parameters value highlighted you can now rotate the control knob to change the parameter. If you rotate the

knob quickly the parameter will change with larger steps allowing you to rapidly move through the adjustable parameters range. When you have finished making changes to a parameter press the button to accept your changes.

The ARB module is controlled through several dialog boxes and menus that group control parameters together in a logical fashion. The menus differ depending on if you have selected the TWAVE or ARB modes. The parameters that can be controlled and monitored are discussed in the following sections.

The ARB TWAVE mode of operation has a number of advanced control features that are described in the Compression Tables section and the Alternate Waveform Capability section discussed in detail later in this document.

The compression tables allow you to define command strings that will synchronize actions between multiple ARB modules in a single MIPS system. Compression tables can be externally triggered to allow synchronization with your system. Here are just a few examples of what can be done with compression tables:

- Change the TWAVE signal amplitude of any module
- Change the TWAVE direction
- Define compression order
- Enter and exit compression mode on any module
- Repeat a loop of operations
- Open and close a gate

The Alternate Waveform Capability allows the ARB to switch between its primary waveform and an alternate waveform via a command or an external signal. Additionally, any ARB module can be programmed to switch to the alternate waveform for a programed length of time and then switch back. When using an external trigger, you can define the trigger's active edge and a delay from when the trigger is received before the alternate waveform is applied.

These two advanced capabilities provide a great deal of flexibility in waveform generation allowing very sophisticated control strategies.

ARB connections

The ARB system has the following connections:

ARB channel outputs are on a D15 male connector on the MIPS rear panel. The signal assignment to the connector is:

D15 pin number	Signal
1	ARB output 1
2	ARB output 2
3	ARB output 3
4	ARB output 4
5	ARB output 5
6	ARB output 6

7	ARB output 7
8	ARB output 8
9-15	Ground

The signal outputs are adjustable from 0 to 100Vp-p output with a programmable offset of +-50V. The offset applies to all outputs and the auxiliary output.

ARB auxiliary output is on a BNC on the rear panel. This output has a range of +-50V and the offset also applies to this signal.

ARB float input is on a BNC on the rear panel. Make sure this input is grounded if not used. The system will have a BNC shorting cap installed when delivered. You may find float inputs for each ARB module in your system if it was configured for independent ARB module power supplies. The float input should not exceed 300 Vrms.

If your system has been configured for external ARB clock option you will find a Clock input and output on the MIPS rear panel. These signals are 0 to 5V TTL logic level signals. The Clock output will always reflect the clock signal running the ARB modules. To accept an external clock all the modules in the MIPS system will need to be set for common clock operation and the clock source set to EXT. The external clock is used to generate the Twave waveforms and the output waveform frequency is the external clock frequency divided by the number of data point per period (32 by default). The maximum external clock frequency allowed is 1.28 MHz.

TWAVE mode

The ARB modules can be controlled using the MIPS front panel control knob and display as well as using the host interface. A number of the advanced modes can only be controlled using the host interface. Additionally, a few setup and trigger options can only be accessed through the MIPS user interface. This section describes the user interface options when the module is in the TWAVE mode. You will find several pages of control options that allow you to monitor and control the behavior of the waveform generation.

Module

The MIPS system supports up to six ARB modules, this parameter allows you to select the module you want to setup. If only one module is present in your system then you will not be able to change this setting.

Mode

This parameter allows you to select TWAVE or ARB modes of operation. This section assumes you are in the TWAVE mode.

Enable

Enable options are ON and OFF. When set to ON the system will generate 8 outputs, each channel shifted 45 degrees from its preceding channel.

Frequency

This option allows you to define the frequency of the output waveforms. This value is entered in Hz.

Amplitude, Vp-p

The DACs are 8 bit and that defines the output resolution. This parameter defines the peak-to-peak output voltage. The full DAC resolution is applied over this peak-to-peak range.

Waveform

The Waveform option allows you to select one of the following waveform types:

SIN	Sine waveform
RAMP	Linear ramp
TRI	Triangle waveform
PULSE	Square wave
ARB	User defined arbitrary waveform

Dir

This parameter defines the direction of the traveling waveform, FWD or REV. Each channel is shifted 45 degrees from the next and this parameter defines the polarity of this phase shift.

ARB waveform

This selection will advance to a new page of options that allows you to define the points that make up the arbitrary waveform. Each point can be defined from -100 to 100, these values are in percent of peak.

Next page

Selecting this option will advance to the next page of options for the TWAVE mode.

Return to main menu

Selecting this option will return to the MIPS main menu.

Below are the options found on the second page of the TWAVE menu option. This second page of options is the same for both TWAVE and ARB modes. Some of these options only apply to the TWAVE mode and are noted below.

Aux Voltage

The ARB system has an auxiliary DC voltage output. This is a static voltage that can be programmed using this parameter. This output range is -50 to 50 volts.

Offset, Volts

All voltage output on the ARB system can be offset using this parameter. This value can be set from -50 to 50 volts. The value set by this parameter is applied to all outputs including the auxiliary output. Please note, the displayed values are not adjusted when the offset is applied. For example if an output is set to 10 volts and you apply a 10 volt offset the output will actually be 20 volts.

Setup

Selecting this option will display the Setup menu that allows you to define sync and direction control options.

Offset A

Offset B

The Offset A and Offset B controls will only appear if your system has two sets of output amplifiers for the ARB module, A and B outputs. Two output amplifiers provide two identical sets (8 signals in each set) of outputs with the ability to control the DC offset of each output set independently of each other.

Sweep

The ARB can sweep the amplitude and frequency of the traveling wave. Selecting this option will display the menu option for the sweep function. This option only applies to the TWAVE mode.

Compressor

Selecting this option will display the compressor menus and options. This selection is only available in the TWAVE mode and only when two or more ARB modules are present in the system. Additionally, the system has to be factory configured for compressor operation. The Compressor section of this manual discusses this capability and the user interface options.

Ramp rate

The Ramp Rate allows you to define a maximum rate of change for the TWAVE output voltage. The units are volts per second. Setting this value to 0 to disable the ramp mode and the values will change as fast as possible.

Save settings

Selecting this option will save the entire ARB configuration data to non-volatile memory chip on the ARB module. You will see a popup menu indicating the status of this save operation. You need to use this option to record any changes you have made to the ARB parameters or they will be lost when power is cycled or the system is rebooted.

Restore settings

This option will reload ARB configuration settings that were saved to non-volatile memory. This function is automatically called when the MIPS system powers up.

First page

Selecting this option will return to the first page of options.

Below are the option found on the Setup menu page.

Sync input

The Sync input behavior depends on the systems mode. In TWAVE mode a Sync input pulse will synchronize the phase of the first channel with the input Sync pulse. In the ARB mode the Sync input act as a trigger and starts the output waveform generation. This option allows you to select an input channel, Q through X, one or more of these TTL input channels will be available on the rear panel of the MIPS system.

Sync level

If a sync input is selected this option allows you to select the active level, while this option provides a number of possibilities only Pos and Neg makes sense for this sync function.

Dir input

This option allows you to define a logic input that can be used to control the TWAVE direction, forward of reverse. This option is only valid in TWAVE mode. This option allows you to select an input channel, Q through X, one or more of these TTL input channels will be available on the rear panel of the MIPS system.

Dir level

If a direction input is selected this option allows you to select the active level, while this option provides a number of possibilities only High and Low makes sense for this direction function.

Return

Selecting this option will return to the previous menu.

Selecting the Sweep option will display a dialog box with the following parameters that allow you to define frequency and voltage sweep of the Twave signals. This sweep operation is linear with time and the values will be returned to their original setting after the sweep is complete.

Start freq
Stop freq
These parameters define the start and stop Twave frequency in Hz for the sweep function. You can define a frequency sweep in any direction you wish, high frequency to low or low to high. If the start and stop frequency match then no frequency changes will be made during a sweep function.
Start Vp-p
Stop Vp-p
These parameters define the start and stop voltages to be applied during a sweep function. The ARB module will linearly sweep the Twave output peak to peak voltage between the start and stop values defined by these options.
Sweep time, Sec
This parameter defines the duration of a sweep in seconds.
Trig input
This option allows you to define a logic input that can be used to trigger the start of a sweep. This option is only valid in TWAVE mode. This option allows you to select an input channel, Q through X, one or more of these TTL input channels will be available on the rear panel of the MIPS system.
Trig level
If a Trig input is defined this option allows you to select the active level, while this option provides a number of possibilities only Pos and Neg makes sense for this sync function and define the active edge for the external trigger to start the sweep.
Return
Selecting this option will return to the previous menu.

ARB mode

In the ARB mode you will find three pages of control options that allows you to monitor and control the behavior of the waveform generation.

Module
The MIPS system supports up to two ARB modules, this parameter allows you to select the modules you want to setup. If only one module is present in your system then you will not be able to change this setting.
Mode
This parameter allows you to select TWAVE or ARB modes of operation.
Enable
Enable options are ON and OFF. When set to ON the system will generate 8 outputs, each channel shifted 45 degrees from its preceding channel.
Frequency

This option allows you to define the frequency of the output waveforms. This value is entered in Hz.

Amplitude, Vp-p

The DACs are 8 bit and that defines the output resolution. This parameter defines the peak-to-peak output voltage. The full DAC resolution is applied over this peak-to-peak range.

Buf length

This option defines the length of the buffer used to generate a waveform. The maximum length is 8000 and the minimum is 100. This parameter should be set when the waveform is not being generated and it should be set before the waveform is defined.

Num buf

This parameter defines how many times the buffer is sent for each trigger or start command. If this parameter is set to zero then the waveform will repeat forever once it has been started.

Set all channels

This option will set all channels to the value selected, please note this will overwrite all values in the DAC buffer! The range of this value is -100 to 100 percent.

Set channel range

Selecting this option will advance to the new page of options that allows you to define values in the output buffer.

Next page

Selecting this option will advance to the next page of options for the ARB mode.

Return to main menu

Selecting this option will return to the MIPS main menu.

When the Next page option is selected in the ARB mode you will see the same set of option described for the second page of option in the TWAVE mode. Please refer to the TWAVE section to see a description of the options.

When the Set channel range option is selected in the ARB mode you will see the following set of options that will allow you to define a waveform. Please note this is not a very convenient way to define a waveform, using the host computer interface is a lot more efficient. Additionally, waveform memory is not saved when power is lost to the system.

The philosophy of defining an arbitrary waveform is to first set all values to their base or default value and then define all the buffer ranges that differ from this default.

Set channel

This parameter allows you to set the channel number you intend to define; valid range is 1 through 8.

Set start index

This value defines the starting index of the range you intend to define. Valid range is 0 to less than Buf length.

Set stop index

This value defines the stopping index of the range you intend to define. Make sure this value is larger than the start index and less that Buf length – 1.

Set channel level

This parameter defines the output level you will define over the range set with start and stop index. The range for this parameter is -100 to 100 percent.

Set channel range

Selecting this function will use all the above parameters to define a segment of the waveform buffer.

First page

Selecting this option will return to the first page of options.

Compressor

The compressor function is designed to operate two or more ARB modules in TWAVE mode in a synchronized fashion to enable compressing the ion mobility separation. This requires a Twave structure with two separate sections that accept independent Twave signals. The compressor logic further supports looping structures that can contain a compression section or just simple looping structures. Below are the user interface parameters that control the compressor function:

Mode

The mode input allows you to select Normal or Compress. In Normal mode the two ARB modules run with the same clock and are synchronized. In the Compress mode Twave module 2's clock is gated off for a defined number of cycles. A Twave cycle is one waveform period and represents one full set of signal rotations. The number of cycles that are gated off is defined by Order. For an Order of 2, one cycle is gated off, for 3 two cycles are gated off, etc. This is a static mode of operation and does not depend on any of the timing parameters and only control module 2 outputs.

Order

This option allows you to define the Order as discussed in the Mode option above. Note, setting the Order to 1 is the same as setting the Mode to Normal.

Compression table

This is a display only parameter and will display the current compression table. The table can exceed the available space on this display and if this is the case you will only see the initial part of the table, the full table is stored internally. The table can only be defined using the host interface and the table syntax is defined later in this document.

Trig delay, mS

In multi-pass mode the system start is triggered, this trigger can be an external trigger or manual trigger. This parameter allows you to define a delay in milliseconds from the trigger to the start of the multi-pass timing.

Compress t, mS

A compressed cycle consists of a period of time operating with compressed timing followed by a period of time operating with normal timing. These two times sum to define the time for one full compressed cycle. This parameter allows you to define the time in milliseconds for the compressed segment of this cycle.

Normal t, mS

A compressed cycle consists of a period of time operating with compressed timing followed by a period of time operating with normal timing. These two times sum to define the time for one full compressed cycle. This parameter allows you to define the time in milliseconds for the normal segment of this cycle.

Non Comp t, mS

Multi-pass operation can include non-compressed cycles around the structure. This parameter allows you to define the time in milliseconds for a non-compressed cycle.

Next page

This selection allows you to advance to the second page of compressor options.

Return to ARB menu

Selecting this option will return to the ARB options menu and exit the compressor menu.

Below are the commands found on the second page of the compressor parameters:

Trig input

The multi-pass mode must be triggered to start the cycle. This option allows you to select an input channel for the trigger signal. The inputs are TTL level connections on the rear panel of MIPS. In addition to selecting the input channel you must select the active edge for the trigger using the following option.

Trig level

This option allows you to select the input trigger edge you with to use to trigger the system. A number of options are provided but POS and NEG make the most sense for triggering from an external source.

Switch output

For multi-pass devices an ion switch is required to release the ions to the detector. This selection allows you to define an output TTL signal to be used to control the ion switch. In addition to selecting the output you also need to select the active level, high or low, using the option below. This switch can be controlled with the compression table gate commands, G and g.

Switch level

This option allows you to select the active level of the ion switch output, high or low.

Switch state

The option allows you to manually open of close the ion switch, useful for system testing.

Cramp

Cramp is compression order ramping. This parameter defines the final compression order at the end of the ramp function. This parameter can be positive or negative and the sign defines the direction of the ramp. The initial compression order is defined by the Order parameter. This ramp function starts when the compression mode is entered.

Cramp order

The Cramp order defines the change in compression order that will happen at the end of each cycle during a compression ramp.

Force trigger

This option allows you to force a manual trigger to start the multi-pass timing.

First page

This selection returns to the first page of compressor options.

Return to ARB menu

Selecting this option will return to the ARB options menu and exit the compressor menu.

Compression tables

The Twave mode compressor logic supports multi-pass operations that can contain any arbitrary combination of compression passes and non-compression passes. The compressor mode can only be enabled when two or more ARB modules are in your system; module number 2 is always configured for the compress region. The user can define the multi-pass operation using the compressor table capability.

The multi-pass compressor control table is designed to allow control of the Twave parameters and synchronize parameter changes with the operation of the compressor. The table is a simple string of characters with all commands being a single character. The table also contains parameters and these are always whole number parameters and they follow the command character. There are two types of commands, state change commands and twave parameter commands.

Cycles vs Modes. Something that can be very confusing is the difference between a cycle and a mode. An ARB module can be in compression mode and this is very different that a compression cycle. A compression cycle is a sequence of events and mode changes that are used to compress ions using a properly design Twave board. A compressed cycle consists of a period of time operating with compressed timing (or in compression mode) followed by a period of time operating with normal timing (or in normal mode). These two times sum to define the time for one full compressed cycle. These two times can be defined using the MIPS UI or they can be set using the compression table. The compression table allows you to define a cycle and/or set ARB modes. It is possible to create a compression cycle in a compression table without ever using the compression cycle command.

State change commands stop the execution of the table until the state has completed, for example a C or compression command will stop the table execution until a full compression cycle has finished.

Twave parameter commands execute immediately and change controlling parameters such as voltages and timing parameters.

State change commands

- N Normal non-compressed Twave cycle
- C Compression cycle
- D Delay, holds current state and stops the command execution until the delay has expired

Twave parameter commands

- S Controls the output switch state, 1 and 0 for open and close
- O Compression order or ratio
- V Twave module 1 peak to peak waveform voltage
- v Twave module 2 peak to peak waveform voltage
- F Twave frequency
- c Compression time in mS
- n Normal time in mS, a compression cycle is the sum of c and n
- t Non compression cycle time

s Stop the twave clock, Note this command stops the common clock so only the ARB modules using the common clock will be affected.

r Restart the twave clock, Note this command restarts the common clock so only the ARB modules using the common clock will be affected.

o Defines gate open time in mS

g Time in mS from start of table to gate open. This gate is defined through the MIPS UI using the switch selection menu option. This menu option defines the digital output used for the gate.

G Time in mS from start of table to gate close. This gate is defined through the MIPS UI using the switch selection menu option. This menu option defines the digital output used for the gate.

K Sets the Cramp value

K Sets Cramp order

W Selects waveform type for ARB master channel, (1=Sin,2=Ramp,3=Triangle,4=Pulse,5=ARB)

w Selects waveform type for ARB compressor channel, (1=Sin,2=Ramp,3=Triangle,4=Pulse,5=ARB)

[Start of a loop

] End of a loop

M This is a mode command that defines the behavior of the compressor. There are three valid modes, 0, 1, and 2. Mode 0 is the normal mode and Twave 1 and 2 amplitude controls set respective output pulse voltages in all states. Mode 1 allows the Twave channel 1 amplitude to define the normal mode amplitude on Twave channel 2. Mode 2 behaves as Mode 1 with the addition that Twave 2 voltage will define Twave 1 voltage in the compress state.

L Twave module 3 peak to peak waveform voltage

l Twave module 4 peak to peak waveform voltage

B Twave module 1 ramp rate in volts per sec, 0 to disable

b Twave module 2 ramp rate in volts per sec, 0 to disable

E Twave module 3 ramp rate in volts per sec, 0 to disable

e Twave module 4 ramp rate in volts per sec, 0 to disable

m This command sets the compression mode of any valid module. m1C will set module 1 to compression mode and m1N will set module 1 to normal mode.

J This command sets the compression order for any valid module. J210 will set the compression order to 10 for module 2.

H Used to halt execution of the table and wait for a trigger, followed by the DIO name, upper case for positive edge trigger or lower case of negative edge trigger. HT will wait for a positive edge on the T digital input.

Compression table commands are case sensitive. Below are a number of compression table examples that illustrate the capability.

Both of the following tables show 2 compression cycles followed by 2 normal cycles. Note that the repeat or count parameter follows the command and it is assumed to be 1 if not defined.

CCNN
C2N2

The following table shows changing parameters before defining twave states. In this case the compression time is set to 200mS, the twave channel 2 pulse voltage it set to 30 volts and the order is set to 5 then a compression cycle is executed. When the compression cycle finishes the twave channel 2 voltage is set to 50 then another compression cycle is executed followed by 2 normal cycles.

c200v30O5Cv50CN2

This final example shows how the looping capability works. In this example the commands enclosed by the […] are repeated the number of times defined by the number that follows the], in this case 10.

C[NCCN]10N

The compressor multi-pass table can only be defined through the host interface. This table is lost when power is cycled on the MIPS system. The following commands support table reporting and definition:

GARBCTBL will return the current table.
SARBCTBL, <table string> will define the table.

The table is not checked for syntax and invalid entries are simply ignored when the table is processed.

Clocks

The ARB modules use a clock to generate the waveforms. This clock can be provided by the ARB module or the ARB module can use a clock generated by the MIPS controller, this is called the common clock. If you need to synchronize multiple ARBs you will likely want to use the common clock. The following command allows you to define the clock configuration to want to use:

SARBCCLK,module,TRUE or FALSE

module = 1,2,3,4,5 or 6, selected the ARB module to want to set.
TRUE signals the ARB to use the common clock.
FALSE signals the ARB to use the on-board clock.

The clock settings will be lost when power is cycled unless the settings are saved. There are two ways to save the settings.

1.) Use the MIPS UI and select the ARB module and then select the Save option.
2.) You can issue the SAVEM,ARB command to save all the ARB modules setting.

When the MIPS system powers up with multiple ARB they will not be synchronized even if they are running on a common clock. The ARB modules can be synchronized by issuing the ARBSYNC command or by using an external pulse. Each ARB module that you wish to synchronize with an external trigger will need the Sync signal defined using the MIPS UI. While it is possible to define different trigger inputs for each ARB module you are required to use the same signal for all modules you wish to synchronize or you will get unpredictable results.

Points per period

The ARB module, in Twave mode, generates waveforms using 32 points to define one cycle of a waveform or one waveform period. This results in an upper frequency limit of 40KHz on each ARB output channel for the module due to the maximum digitization rate of 1.28MHz. This number of 32 points per period (PPP) can be changed by the user. The range for this value is 8 to 128. It is recommended that this value be in multiple of 8 to allow optimal phase shifting of the waveforms for each output channel. The upper frequency limit will change with this PPP value. The upper frequency limit is defined as 1.28MHz / PPP.

The following commands allow you to read and set the PPP value.

GARBPPP,module

This command will return the current PPP value for the ARB module selected.

SARBPPP,module,PPP

This command will set the selected ARB module to the used defined PPP value. Please note you will need to reboot the MIPS system after changing this value. If you need to change multiple modules you can reboot after all the changes are complete.

ARB Alternate Waveform Capability

ARB firmware version 2.1 and later, support the ARB alternate waveform capability; additionally MIPS controller firmware rev 1.167 or later is required. This feature is only available in the Twave mode of the ARB module. This capability allows the user to switch the ARB output from its conventional Twave waveforms to an alternate set of waveforms. This switching can be done by issuing a command from the host-controlling computer or the ARB can be setup to accept and control logic signal.

The alternate waveform capability is controlled through host commands with the controlling computer. There are no MIPS controller UI menus to control these functions. The full list of commands is included below.

When the ARB receives a command or signal to switch to the alternate waveform the ARB will finish the current primary waveform cycle and then switch to the alternate waveform. Switching back to the primary waveform also happens at the completion of one cycle, this is true even if the alternate waveform is a set for fixed voltages. This cycle time is defined by the ARB frequency, for example if the frequency is 10KHz the cycle time is 100uS.

The default alternate waveform is the compression waveform. The compression waveform holds the final value after one cycle of the primary ARB Twave waveform. The following alternate waveform types are supported:

COMP

This is the default value and defines the compression waveform. This waveform holds the final value of the primary waveform. This waveform is used in the compression capability.

REV

This option will define the alternate waveform the same as the primary waveform but traveling in the reverse direction. This is done by reversing the phase shift of the 8 output channels to reverse the waveform's direction of travel.

ARB

This option will apply the user defined arbitrary waveform as the alternate waveform.

FIX

This option allows the user to apply a fixed output voltage on each of the 8 electrodes. The user can define each of the electrode voltages as a percentage of the current peak to peak output voltage.

CUR

This option allows the user to apply the current main waveform as the alternate waveform, in this case the main waveform and the alternate waveform are the same. This option is used when you would like to change the amplitude only and keep the waveform the same. This option requires ARB firmware 2.21 and MIPS firmware 1.227.

When the alternate waveform is selected it will use the current output voltage peak to peak setting. Host commands allow the user to enable an alternate waveform range (peak to peak output voltage). If enabled this alternate waveform range is automatically applied when the waveform switches.

The user has a number of options on how to enable the alternate waveform. A host command can be sent to switch to the alternate waveform. The system can also be configured to use a MIPS digital input to switch to the alternate waveform. Finally, the user can define a digital input to trigger the application of the alternate waveform, after a user defined delay, for a user defined length of time.

Examples:

1.) The following is a simple example using commands to enable and disable an alternate waveform on ARB module 1:

The following commands configure the ARB as the alternate waveform and also enable the separate voltage range of 15 Vp-p.

SALTWFM,1,ARB
SALTHWD,1,FALSE
SALTRENA,1,TRUE
SALTRNG,1,15

The command SALTENA,1,TRUE will start the generation of the alternate waveform and SALTENA,1,FALSE will stop and return to the original waveform.

2.) In this example ARB module 1 is configured to generate an alternate waveform and used an external signal to enable its generation. In this case the external signal is a logic gate and when the signal is high the alternate waveform will be generated.

The following commands configure the system to generate the ARB alternate waveform when a gate signal is received on input R. All ARB modules share

the same input gate control so if you are setting up multiple modules you only need to issue the SALTHWD command one time.

SARBHISR,1,TRUE
SARBCMPLN,1,2
SALTRENA,1,TRUE
SALTRNG,1,15
SALTWFM,1,ARB
SALTTRG,1,R
SALTHWD,1,TRUE
SALTTMODE,1,LEVEL

To disable the alternate waveform generation, issue the following commands.

SALTTRG,1,NA
SALTHWD,1,FALSE

3.) This final example will trigger the generation of the alternate waveform using an external input and the user can adjust both a trigger delay and a duration for the application of the alternate waveform. While all ARB modules share the same trigger and gate signal each ARB can be configure with different parameters for the use of this signal.

The following commands configure the system to generate the ARB alternate waveform when a trigger signal is received on input R. All ARB modules share the same input gate/trigger control so if you are setting up multiple modules you only need to issue the SALTHWD command one time.

SARBHISR,1,TRUE
SARBCMPLN,1,2
SALTRNG,1,15
SALTRENA,1,TRUE
SALTWFM,1,ARB
SALTTRG,1,R
SALTHWD,1,TRUE

The following command selects the rising edge of the input trigger, NEG can be used to trigger on the falling edge.

SALTTMODE,1,POS

The following command sets the trigger delay to 1.5 mS

SALTDLY,1,1.5

The following command defines the width of the waveform, or application time, as 3.5 mS.

SALTPLY,1,3.5

To disable the generation of the waveform, issue the following commands.

SALTHWD,1,FALSE
SALTRENA,1,FALSE
SALTTRG,1,NA

Alternate waveform MIPS commands:

SALTENA,*module*,*value*

This command will enable the alternate waveform. The waveform will remain enabled until this command is issued again to disable the alternate waveform.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

value is TRUE to enable the alternate waveform and FALSE to disable.

GALTENA,*module*

This command returns the alternate waveform enable status.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

value is TRUE to enable the alternate waveform and FALSE to disable.

Returns:

TRUE if the alternate waveform is enabled, FALSE if disabled.

SALTTRG,*module*,*value*

This command enables MIPS to send a trigger signal to the ARB modules. All ARB modules use the same trigger signal. While it is possible to enable inputs on all ARB modules you should only issue this command to one module. The last module number configured will take precedence. Note this command enables the MIPS ARB module driver to send the digital signal to all the connected ARB modules. Individual ARB module will need to be configured to use this signal. This allows you to define the module or modules you would like to use this feature.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

value is Q thru W or NA. Q thru W will define a digital input on MIPS to use for the trigger, NA will disable the signal generation on the selected module. The digital signal is active high, so when logic one is applied the alternate waveform will be applied assuming the hardware input is enabled.

GALTTRG,*module*

This command returns the external input configuration for the selected module.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

Returns:

The selected digital input, Q thru W or NA if not selected.

SALTHWD,*module*,*value*

This command will enable or disable the selected ARB module's use of the external trigger hardware signal sent by MIPS. If enabled the signal from MIPS will be used to switch to the alternate waveform.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

value is TRUE to enable the alternate waveform external trigger and FALSE to disable.

GALTHWD,*module*

This command returns the status of the selected ARB module's external trigger.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

Returns:

TRUE if the alternate waveform external trigger is enabled, FALSE if disabled.

SALTTMODE,*module*,*mode*

This command defines the external trigger mode for the select ARB module. This mode selection allows the alternate waveform to be selected via a logic level or applied due to edge detection.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

mode is LEVEL, POS, or NEG. If LEVEL then the alternate waveform is applied when the input is logic level 1 or high. If POS then the alternate waveform will be applied after a user defined delay for a user defined length of time.

GALTTMODE,*module*

This command returns the external trigger mode for the select ARB module.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

Returns:

The current trigger more, LEVEL, POS or NEG.

SALTWFM,*module*,*type*

This command defines the alternate waveform type.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

type defines the desired alternate waveform, COMP = compression waveform, REV = the reverse direction of the current primary waveform, ARB = the user defined arbitrary waveform, FIX = a fixed voltage profile, CUR = current main waveform.

GALTWFM,*module*

This command returns the selected waveform type for the selected module.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

Returns:

The selected alternate waveform type, COMP, REV, ARB, or FIX.

SALTFVAL,*module*,*channel*,*value*

This command allows the user to define the output voltage for the fixed alternate waveform type.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

channel defines the alternate waveform channel 0 thru 7. The channel represents the Twave output channel or electrode number.

value is the output value to be applied to the selected channel. This value is in percentage with a range of +- 100. This is the percentage of the peak range. Note the range is a peak to peak value so if the range is 100 volts peak to peak and the fixed output is set to 100% then the output voltage will be 50 volts, -100% will result in -50 volts.

GALTFVAL,*module,channel*

This command returns the output voltage percentage for the selected module and channel.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

channel defines the alternate waveform channel 0 thru 7. The channel represents the Twave output channel or electrode number.

Returns:

The selected module and channel's output percentage of the peak voltage range.

SALTDLY,*module*,*delay*

This command allows the user to define a trigger delay when in edge trigger mode. The delay in milliseconds is applied after the edge is detected before the alternate waveform is applied.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

delay defines the delay in milliseconds after the edge is detected before the alternate waveform is applied.

GALTDLY,*module*

This command returns the trigger delay.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

Returns:

Trigger delay in milliseconds.

SALTPLY,*module*,*duration*

This command defines duration in milliseconds for the application of the alternate waveform. This duration is used when an alternate waveform is triggered in edge mode. After the trigger delay the alternate waveform is applied for this user defined duration.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

duration defines the duration milliseconds for the application of the alternate waveform.

GALTPLY,*module*

This command returns the alternate waveform duration time in milliseconds.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

Returns:

Alternate waveform duration in milliseconds.

SALTRENA,*module*,*value*

This command allows the user to enable an alternate range to be used when in alternate waveform mode. When enabled (TRUE) the alternate range is used, when disabled (FALSE) the modules range is used.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

value is TRUE to enable the alternate waveform range and FALSE to disable.

GALTRENA,*module*

This command returns the state of the alternate waveform alternate range mode.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

Returns:

TRUE if the alternate range is enabled, FALSE if disabled.

SALTRNG,*module*,*value*

This command allows the user to define the alternate waveform alternate range.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

value is the alternate range in volts peak to peak.

GALTRNG,*module*

This command returns the alternate waveform alternate range value in volts peak to peak.

Where:

module is the ARB module number in your MIPS system, 1 thru the maximum number of modules in your system.

Returns:

Alternate range in volts peak to peak.

CARBADLY,add,mask

This command allows you to use the Level Detection Module (LDM) to control the delay time when you have the alternate waveform generator configured to trigger after a delay. The LDM is an option that can be installed in your MIPS system and must be configured to detected a change and have the lookup table defined. Please read the LDM documentation for details. This command enables MIPS to respond to change detection events from the LDM. The parameter add is the hex address of the LDM (32 is default address) and mask is a hex bit mask that signals the ARB module to update based on the LDM's lookup table results. Bits 0 thru 5 correspond to ARB modules 1 thru 6.

CARBADUR, ,add,mask

This command allows you to use the Level Detection Module (LDM) to control the duration time when you have the alternate waveform generator configured to trigger for a defined duration. The LDM is an option that can be installed in your MIPS system and must be configured to detected a change and have the lookup table defined. Please read the LDM documentation for details. This command enables MIPS to respond to change detection events from the LDM. The parameter add is the hex address of the LDM (32 is default address) and mask is a hex bit mask that signals the ARB module to update based on the LDM's lookup table results. Bits 0 thru 5 correspond to ARB modules 1 thru 6.

Frequency and amplitude sweep capability

The frequency and amplitude sweep function allows the user to define a starting and stopping frequency and amplitude as well as a sweep time in seconds. When instructed to start the sweep the MIPS system will linearly sweep the Twave output frequencies and Twave peak-to-peak output voltages.

There are two ARB sweep systems implemented in a MIPS ARB based system. One controlled by the MIPS controller and a second sweep system controlled by the processor in the ARB module. This second system supports much faster sweep rates. The MIPS controller-based sweep system will only allow sweeping on ARB modules 1 and 2 while the ARB based solution is implemented on all ARB modules.

Sweeps can be started using a command or an external trigger signal.

The commands to support this function are implemented through the host interface and there is a MIPS user interface to define sweep parameters as well as defining a trigger for the ARB based sweep function. The details of the host commands are provided later in this document.

ARB modules can be configured to use a command clock, this is often done when you need to keep multiple ARB modules synchronized. When using a command clock only MIPS level sweeping can be used to generate a frequency sweep, additionally MIPS level sweeping will only function for ARB modules 1 and 2.

The following example show how to configure the system for both MIPS and ARB level sweeping.

The following command setups the sweep frequency and voltage range and a lot the sweep duration. These commands are the same for both MIPS and ARB based sweeps. If you do not want to sweep a parameter, for example keep the frequency fixed then set the start and stop parameters to the same value. If you intend to weep multiple modules you need to enter these parameters for each module, this example configures module 1.

Start and stop frequency of 1000 to 10000Hz
STWSSTRT,1,1000
STWSSTP,1,10000
Starting and stopping voltage of 10 to 20 volts
STWSSTRTV,1,10
STWSSTPV,1,20
Sweep time of 5.5 seconds
STWSTM,1,5.5

1.) This example will start a MIPS based sweep on ARB module 1.

This command sets the common clock for ARB module 1.
SARBCCLK,1,TRUE
This command starts a MIPS based sweep, in this case ARB module 1. You can also select 2 for ARB module 2 or 3 to trigger both modules 1 and 2. This sweep mode can only control ARB modules 1 and 2. Also its important to note that the frequency sweeps settings need to be the same for both ARB module 1 and 2 when using MIPS based frequency sweeping.

STWSGO,1
It also possible to use any external trigger to start a MIPS based sweep. This is done using the delayed trigger capability in MIPS. The following commands will enable the external triggering of the sweep.
SDTRIGINP,R,POS
SDTRIGDLY,0
SDTRIGRPT,1
SDTRIGMOD,SWEEP
SDTRIGENA,TRUE
You can disable the external trigger with the following command.
SDTRIGENA,FALSE

2.) In this example we start a sweep using the ARB based control of the sweep.
This command sets the internal clock for ARB module 1. This is required to use ARB based sweeping.
SARBCCLK,1,FALSE
This command will start a sweep on ARB module 1. Any ARB module can be used in the ARB based sweep mode.
SARBSGO,1
You can externally trigger an ARB based sweep using the trigger selection that you will find on the MIPS system located on the Sweep page of the ARB UI interface. You can assign different triggers for different modules and you can select multiple modules to use the same trigger is you wish.

Host commands

The ARB modules have two modes of operation TWAVE and ARB. These host commands have been grouped into categories that apply to the various mode as well as defining general commands that apply to both modes.

General or common commands

SARBMODE,<Module>,<TWAVE or ARB>
Defines the selected modules mode, valid options are TWAVE or ARB. Valid module range is 1 to 2.

GARBMODE,<Module>
Returns the selected module's current mode. Valid module range is 1 to 2.

SWFREQ,<Module>,<Value>
Sets the ARB digitization frequency for the selected module, all ARB channels run at this frequency, 1000000 maximum in ARB mode and 40000 maximum in TWAVE mode.

GWFREQ,<Module>
Returns the selected module's current digitization frequency. Note that this frequency may not match the requested frequency; the frequency will be set as close as possible to the requested value.

SWFVRNG,<Module>,<Value>
This parameter defines the selected modules the peak-to-peak output voltage for a full range DAC signal. If a channel has a DAC output defined from -100 to

100 then the actual output will be the value defined by this command. The range of Value is 0 to 100.

GWFVRNG,<Module>

Returns the selected module's current peak-to-peak voltage setting.

SWFVAUX,<Module>,<Value>

This parameter defines the selected module's auxiliary output channel voltage value; valid range is -50 to 50 volts.

GWFVAUX,<Module>

Returns the selected module's current auxiliary output voltage value.

SWFVOFF,<Module>,<Value>

This parameter defines the selected module's offset output voltage value; valid range is -50 to 50 volts. This offset voltage is applied to all ARB channels and the auxiliary output channel. Note, the MIPS system does not adjust the reporting or setting functions to account for this value, its up to the user to keep track of the offset.

GWFVOFF,<Module>

Returns the selected module's current offset output voltage value.

SWFDIS,<Module>

This command will stop the waveform generation for the selected module.

SWFENA,<Module>

This command will start the waveform generation for the selected module; this is a software waveform trigger command.

TWAVE mode specific commands

SWFDIR,<Module>,<FWD or REV>

This commands sets the Twave direction to forward (FWD) or reverse (REV) for the selected module. Forward and reverse define the direction of the phase shift from one ARB channel output to the next. In forward mode the phase is advanced 45 degrees from one to the next and in negative mode the phase is adjusted by -45 degrees.

GWFDIR,<Module>

This command returns the Twave direction (FWD or REV) for the selected module.

SWFARB,<Module>,<Values…>

This command allows you to define the 32 points of an arbitrary waveform for the selected module. 32 values must be entered after the module number. These values range from -100 to 100 percent of the peak voltage.

GWFARB,<Module>

This command returns the arbitrary waveform for the selected module. This command will return 32 comma-separated values.

SWFTYP,<Module>,<SIN, RAMP, TRI,PULSE, or ARB>

The arbitrary waveform generator has a number of predefined waveforms in addition to one you can define. This command allows you to select a waveform for the selected module number.

GWFTYP,<Module>

This command returns the selected waveform for the selected module number.

SWFVRAMP, <Module>,<Value>

This command sets the selected ARB modules ramp rate in volts per second. This ramp rate affects the Twave output voltage of all 8 channels. This will cause all voltage change request to ramp to the new values using this ramp rate. Set this value to 0 to disable this function and cause the voltage to change as fast as possible.

GWFVRAMP, <Module>

This command returns the selected ARB modules ramp rate in volts per second.

SARBOFFA,<Module>,<Value>

This command is only valid if your system has two sets of output amplifiers on the selected ARB module. In this case you will have A and B sets of Twave outputs. This command will set an offset voltage that will only apply to the output set A. The offset value range is limited to +- 10 volts.

GARBOFFA,<Module>

This command returns the output set A offset value for the selected module. This command is only valid if your system has two sets of output amplifiers on the selected ARB module.

SARBOFFB,<Module>,<Value>

This command is only valid if your system has two sets of output amplifiers on the selected ARB module. In this case you will have A and B sets of Twave outputs. This command will set an offset voltage that will only apply to the output set B. The offset value range is limited to +- 10 volts.

GARBOFFB,<Module>

This command returns the output set B offset value for the selected module. This command is only valid if your system has two sets of output amplifiers on the selected ARB module.

ARBSYNC

This command will send a synchronization signal to all the ARB modules in your system.

SARBREVA,<Module>,<Value>

This command allows you to define an Aux output voltage to be generated when the selected ARB module is in the reverse direction. Value is the Aux voltage to be applied with a range of -50 to 50 volts.

CLRARBRV,<Module>

This command will clear the Aux output voltage defined for rev direction application. When cleared the Aux voltage will not change when the Twave direction is reversed.

Compression TWAVE commands

SARBCTBL,<Table string>

GARBCTBL

Sets and returns the compressor multi-pass command table as described earlier in this document.

SARBCMODE,<Normal | Compress)

GARBCMODE

Sets and returns the current compressor mode, valid modes are Normal, and Compress.

SARBCORDER,<Order>

GARBCORDER

Sets and returns the compression order, 0 through 255. Note compression of 1 is the same as normal.

SARBCTD,<Time in mS>

GARBCTD

In multi-pass mode the system start is triggered, this trigger can be an external trigger or manual trigger. This parameter allows you to define a delay in milliseconds from the trigger to the start of the multi-pass timing.

SARBCTC,<Time in mS>

GARBCTC

A compressed cycle consists of a period of time operating with compressed timing followed by a period of time operating with normal timing. These two times sum to define the time for one full compressed cycle. This parameter allows you to define the time in milliseconds for the compressed segment of this cycle.

SARBCTN,<Time in mS>

GARBCTN

A compressed cycle consists of a period of time operating with compressed timing followed by a period of time operating with normal timing. These two times sum to define the time for one full compressed cycle. This parameter allows you to define the time in milliseconds for the normal segment of this cycle.

SARBCTNC,<Time in mS>

GARBCTNC

Multi-pass operation can include non-compressed cycles around the structure. This parameter allows you to define the time in milliseconds for a non-compressed cycle.

TARBTRG

The command will cause a multi-pass trigger. The MIPS system can also be setup to accept an external trigger. The compressor menu options allow you to select a trigger input and active edge.

SARBCSW,<Open | Close>

GARBCSW

Sets and returns the switch status, valid states are Open and Close.

Sweep function TWAVE commands

STWSSTRT,<Module>,<Frequency>

GTWSSTRT,<Module>

Sets and returns the frequency sweep starting frequency for the selected ARB module. The frequency is defined in Hz.

STWSSTP,<Module>,<Frequency>

GTWSSTP,<Module>

Sets and returns the frequency sweep stopping frequency for the selected ARB module. The frequency is defined in Hz.

STWSSTRTV,<Module>,<Voltage>

GTWSSTRTV,<Module>

Sets and returns the voltage sweep starting voltage for the selected ARB module. This value is defined in volts peak to peak.

STWSSTPV,<Module>,<Voltage>

GTWSSTPV,<Module>

Sets and returns the voltage sweep stopping voltage for the selected ARB module. This value is defined in volts peak to peak.

STWSTM,<Module>,<Time>

GTWSTM,<Module>

Sets and returns the sweep time for the selected ARB module. This value is defined in seconds and represents the total time of the sweep operation.

STWSGO,<Module>

This command will start a sweep operation for the selected module (this is the MIPS controller sweep mode). If the module number is set to 3 then this command will start the sweep on both modules at the same time.

STWSHLT,<Module>

This command will stop a sweep operation that is in progress for the selected module (this is the MIPS controller sweep mode). If the module number is set to 3 then this command will stop the sweep on both modules at the same time.

GTWSTA,<Module>

This command will return the sweep status for the selected module(this is the MIPS controller sweep mode). This function will return one of the following messages depending on the system status:

IDLE
STARTING
STOPPING
SWEEPING

SARBSGO,<Module>

This command will start a sweep operation for the selected module (this is the ARB module sweep mode).

SARBSHLY,<Module>

This command will stop a sweep operation that is in progress for the selected module (this is the ARB module sweep mode)

GARBSTA,<Module>

This command will return the sweep status for the selected module (this is the ARB module sweep mode). This function will return one of the following messages depending on the system status:

IDLE
STARTING
STOPPING
SWEEPING

ARB mode specific commands

SARBBUF,<Module>,<Value>

Defines the waveform buffer length for the selected module, valid range is 100 to 8000.

GARBBUF,<Module>

Returns the current waveform buffer length for the selected module.

SARBNUM,<Module>,<Value>

This command sets the number of times the waveform buffer will be repeated for each trigger or enable command for the selected module. Setting to 0 will cause the waveform to repeat forever.

GARBNUM,<Module>

Returns the current number of buffers value for the selected module.

SARBCHS,<Module>,<Value>

This command will set all channels (1 through 8) to the value defined for the selected module. The value range is -100 to 100 percent. This is basically a clear command used to initialize all channels in the buffer.

SARBCH,<Module>,<Channel>,<Value>

This command will set one channel (defined by Channel) to the value defined for the selected module. The value range is -100 to 100 percent. This is basically a clear command used to initialize one channel in the buffer.

SACHRNG,<Module>,<Channel>,<Start>,<Stop>,<Value>

This command will set a specific range to a user defined value.

Where:

Module = selected module, 1 or 2
Channel = Channel number to define, 1 through 8
Start = starting index, 0 to less then buffer length
Stop = stopping index, greater then Start and less than buffer length
Value = channel value, -100 to 100 percent

System configuration commands

SARBCCLK,<Module>,<TRUE | FALSE>

This command enables a common clock for the ARB module defined by Module. If this is set to TRUE then the on-module clock is not used and the MIPS controller or external clock input generates the clock for the selected ARB module.

SARBCMP,<TRUE | FALSE>

The command enables the compressor mode of operation if set to TRUE. ARB module 2 is always used for compression.

SARBCOFF,<Flag>

Setting this flag to TRUE will enable a common offset for all ARB modules in your MIPS system.

SARBADD,<Module>,<Address>

This command allows you to define the TWI address used by the MIPS controller to talk to the ARB module. The ARB module's TWI address must match for the system to operate. This is a factory setup option and should not be set by the user. Address is the TWI address, base 10.

SARBDBRD,<Module>,<Flags>

This flag is used to set an ARB module for dual output amplifier operation with independent offset control for each set of outputs.

GARBVER,<Module>

Returns the ARB firmware version number.

GARBPPP,<Module>

This command will return the number of points used to define a waveform in the ARB Twave mode of operation. The default value is 32.

SARBPPP,<Module>,<PPP>

This command allows you to define the number of points in used to define a waveform period in the Twave mode. The default value is 32. Module selects the module number you wish to define and PPP is your desired number of point per waveform period. PPP valid range is 8 to 128. The MIPS system will need to be rebooted after this value is changed. All modules should be set to the same value but this is not a requirement.

SARBEXT,<Module>,<Source>

If the module is in common clock mode this option will select MIPS or EXT as the clock source. You must have the external ARB clock in and out connectors to use the EXT option.

System advanced configuration commands

The following commands are documented here for completeness but we do not recommend the user issue any of these commands. These are used for factory setup for advanced control functions.

The MIPS controller communicates with the ARB module using a I2C interface as well as two hardware lines used to signal actions. These commands are used to define how the ARB module will react to signals on these control lines.

SARBCPEX,<Module>,<TRUE | FALSE>

This command enables the compressor hardware control line. If TRUE the ARB module will compress mode when this signal is active.

SARBHISR,<Module>,<TRUE | FALSE>

This command signals the ARB module to process the compression control hardware signal using an interrupt service routine vs polling. TRUE enables the interrupt mode.

SARBSYNLN,<Module>,<1 | 2>

This command allows you to define which hardware line is used for the ARB module sync signal, 1 or 2. The default is 1.

SARBCMPLN,<Module>,<1 | 2>

This command allows you to define which hardware line is used for the ARB module compression signal, 1 or 2. The default is 2.

It is possible to use the same hardware line for sync and compression. The sync signal is a narrow pulse while the compression signal is a level change. The firmware is designed to detect this difference. The compression control line is also used to trigger the alternate waveforms if properly enabled.

Waveform definition discussion and examples

This section aims to describe the method used to define waveforms in the ARB mode. This system was designed to generate arbitrary pulse sequences for mass spectrometer applications and this waveform definition mode is optimized for this type of application.

Waveform definition consists of a couple basic steps; first initialize the channel(s) buffer to its resting or common value, next define all the pulse regions that are different than the resting value, below is an example using the host commands but could also be done using the MIPS front panel.

SARBMODE,1,ARB

SWFREQ,1,1000000
SARBCHS,1,0
SACHRNG,1,1,2,4,50

This set of commands will place the system in ARB mode, set all channels to 0 and then define a pulse on channel 1 from index 2 to 4 at 50% of peak level. This will generate a 2 uS wide positive pulse. If the range is set to 100 Vp-p then the output will be 25 volts peak. Play or trigger the waveform using the following command.

SWFENA,1

Storing the waveform setup commands in a file and using the MIPS apps to send the information to the ARB module is a very effective way to setup the ARB module.

Waveform output amplitude

The output waveform amplitude setting can be confusing due to the options provided. This section describes how to define a desired output voltage from an ARB channel. Below are guidelines that should help you define an output voltage.

- The DAC channels of the ARB are set in percent of peak-to-peak level. -100 to 100 is full-scale output.
- The output range command defines the peak-to-peak voltage for a -100 to 100% DAC output.
- The offset voltage command defines a voltage added to all DAC channels and the auxiliary channel.

References

This document provides an overview of the MIPS ARB system that has been designed to support general ARB applications as well and SLIM Traveling Wave (Twave) systems. SLIM Twave applications are complex and the best way to fully understand these systems is through published literature. Below are three publications that will help describe the details of these systems. All of the Twave research performed at PNNL uses our MIPS systems. Most of the work has been done with Twave pulse drivers. This document describes the ARB solution that provides all the capabilities of the pulse system plus the ability to use different waveform types and even define your own unique waveforms.

The Squeezing of Ion Populations and Peaks in Traveling Wave Ion Mobility Separations and Structures for Lossless Ion Manipulations using Compression Ratio Ion Mobility Programming (CRIMP)
Sandilya VB Garimella, Ahmed M Hamid, Liulin Deng, Yehia M Ibrahim, Ian K Webb, Erin Shammel Baker, Spencer A Prost, Randolph V Norheim, Gordon A Anderson, Richard D Smith
Analytical Chemistry 2016

Ultra-High Resolution Ion Mobility Separations Utilizing Traveling Waves in a 13 m Serpentine Path Length Structures for Lossless Ion Manipulations Module

Liulin Deng, Yehia M Ibrahim, Ahmed M Hamid, Sandilya VB Garimella, Ian K Webb, Xueyun Zheng, Spencer A Prost, Jeremy A Sandoval, Randolph V Norheim, Gordon A Anderson, Aleksey V Tolmachev, Erin S Baker, Richard D Smith
Analytical Chemistry 88 (18), 8957-8964 1 2016

Achieving High Resolution Ion Mobility Separations Using Traveling Waves in Compact Multiturn Structures for Lossless Ion Manipulations
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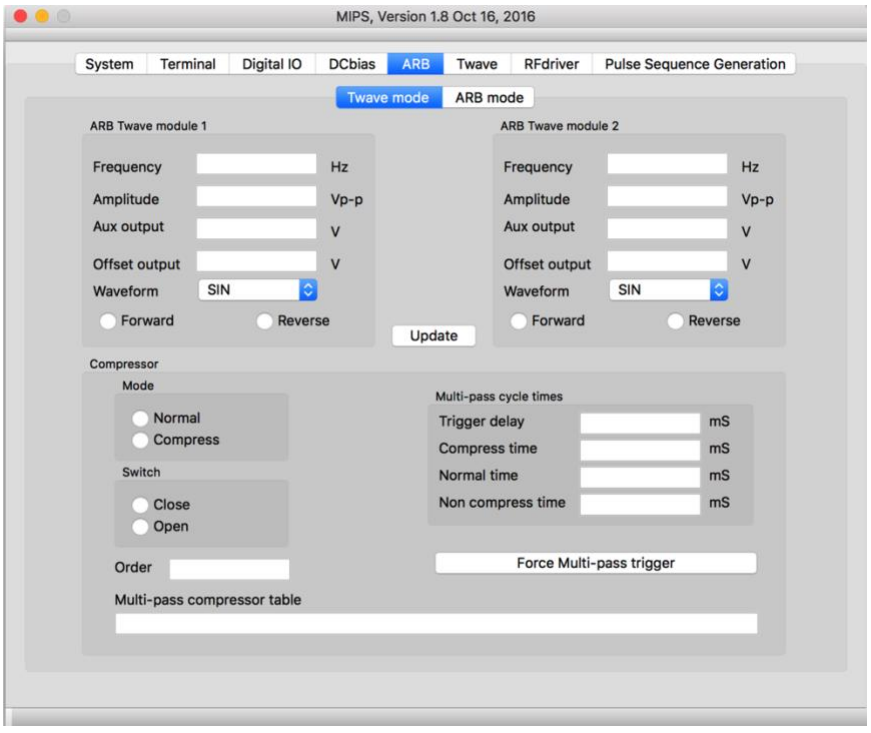
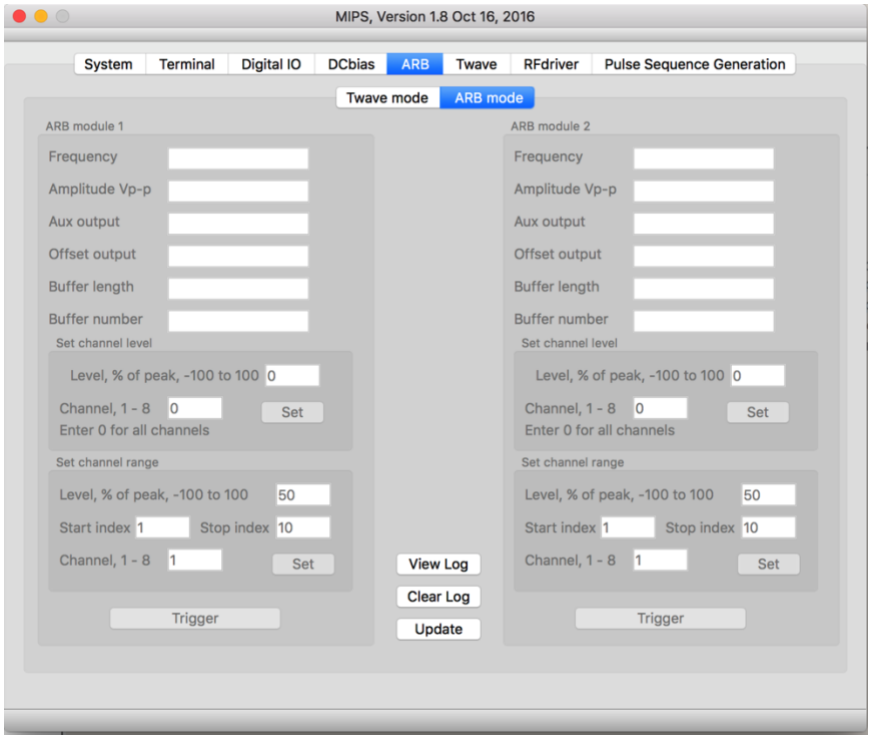
Analytical Chemistry 88 (18), 8949-8956

MIPS host application

We have developed a MIPS host application that will run on a windows PC or an Apple MAC computer. This application communicates through the USB interface or using TCP/IP sockets if your system has a WiFi or Ethernet interface. This application is located on our google drive at this link
https://drive.google.com/open?id=0B3IchPRNYqYIUmxHYXlkbzBrXzQ

This application will also allow you to upgrade the MIPS firmware when new versions are available. You will find example screen shots below that show the ARB interface provided by the MIPS app.





Warrantee

GAA Custom Electronics, LLC warrantees the MIPS system to be free from defects in materials and workmanship and will repair or replace the unit for a period of one year. This warrantee assumes the system is operated in compliance with the procedures and recommendation outlines in this document. GAA Custom Electronics, LLC will also provide free phone support and firmware bug fixes for up to one year. The addition of new features is not covered in this warrantee.