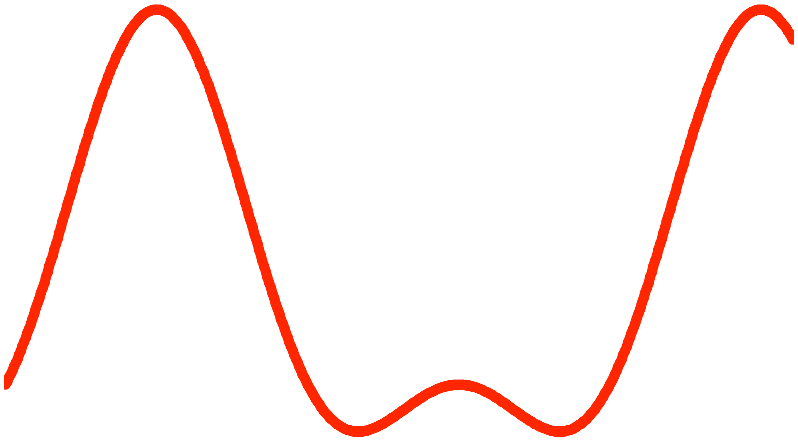
MIPS-FAIMS

Modular Intelligent Power Sources

Operations Manual
Rev 1.1, April 24, 2015



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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.

The FAIMS power supply is capable of developing over 5,000 volts of RF output signal; please use extreme caution when working with this system. 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 all the electrical connections are complete between the FAIMS power supply and your FAIMS device.
3.) Make sure to cover all your connections to protect them from accidental contact.
4.) Place the FAIMS power supply in a position that will provide clearance for its intake fans and air exit openings.
5.) Do not operate this FAIMS power supply until you have read the operating instructions and tuning instructions.
6.) There are no user serviceable parts inside the FAIMS power supply so do not remove the covers.
7.) Only replace fuses with the specifications defined on the rear panel of the MIPS system.
8.) Never operate this system in a combustible gas environment.

Introduction:

The FAIMS power supply consists of two subsystems in separate enclosures. The MIPS controller contains the user interface and the power and signal sources needed to generate and control the FAIMS bisinusoidal waveform. The second enclosure is the FAIMS RF deck; this system contains the RF tuned circuits used to develop the high voltage FAIMS signal. The RF deck connects to the MIPS controller using a 25 pin D connector and to your FAIMS device using specialized connectors on the rear panel.

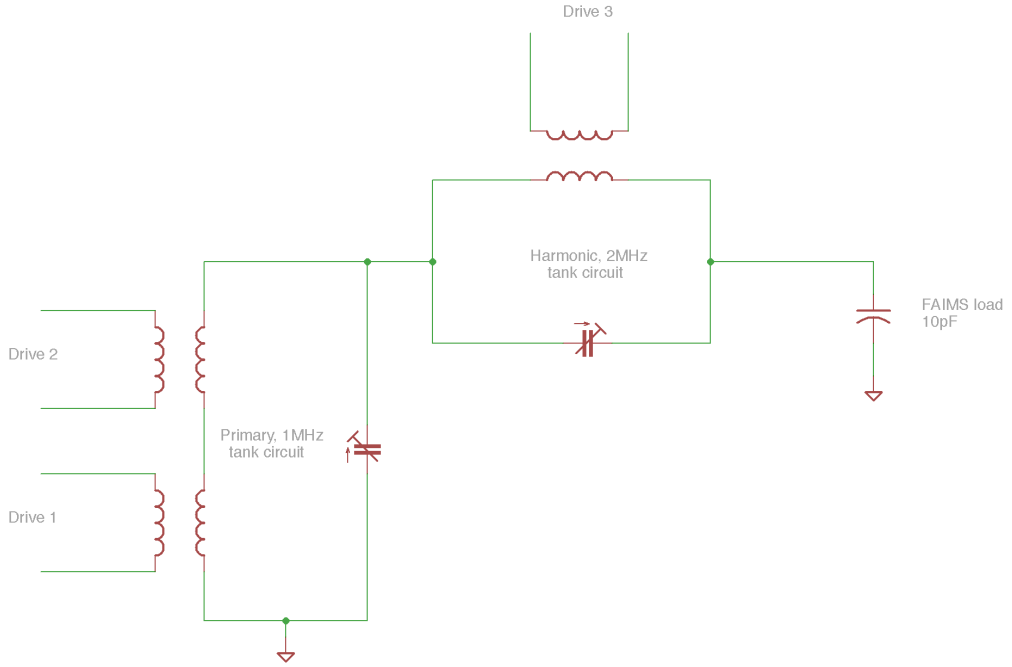


Figure 1, Simplified diagram of the FAIM dual resonate RF driver.

The FAIMS system develops the bisinusoidal waveform using a dual resonate circuit that is contained in the RF deck. Figure 1 shows a simplified circuit diagram of this dual resonate circuit. Two tank circuits are in series one at the primary (~1MHz) frequency and the second at the harmonic (~2MHz) frequency. The primary tank circuit is driven by two separate sets of drive electronics (Drive 1 and Drive2), this is done to enable higher voltage and distribute the power over two coils. The harmonic tank circuit is driven by a single driver (Drive 3). Applying the proper drive levels and frequencies to these three drivers and controlling the phase difference between Drive 3 and the Drive 1 and 2 pair develops the bisinusoidal waveform. The MIPS controller develops all the drive signals and phase control needed to generate and monitor the waveform.

The quality factor or Q of the three coils shown in figure 1 determines the power needed to generate the waveform. The coils were made using Litz wire and air cores to minimize losses and power dissipation. The coil Qs are over 100 in this system resulting in total power dissipation of about 70 watts for a 5.5KV waveform.

The MIPS controller allows you to control all the operating parameters needed to generate the FAIMS waveform and also monitor key system parameters. The MIPS controller also will shut down the system in the event an error condition is detected.

FAIMS waveforms are high voltage and caution should be used with working with this system, only trained and qualified electrical workers can install this system and insure its safe operation.

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 FAIMS module is controlled through five dialog boxes of menus that group control parameters together in a logical fashion. The five menus and the parameters that can be controlled and monitored are discussed below:

FAIMS main menu
Tune menu
Drive Menu
Power menu
DC drive menu

FAIMS main menu

The FAIMS main menu will appear after the MIPS system is powered up and the initialization is complete. This menu will allow you to monitor and control key FAIMS parameters as well as select other FAIMS menu options. The FAIMS system will always start with the waveform generation disabled and this menu will allow enabling the system. Below you will find a description of each parameter:

Enable

This parameter is the global or overall system enable. Turning this parameter on will enable all of the drives that have been enabled through the drive menu. When this parameter is set to on the FAIMS waveform generation will begin.

The FAIMS RF deck contains an emergency off button, pressing this button will turn this enable parameter off and display a warning message.

Drive

This is the global or overall system drive level. This parameter controls the output voltage level and is adjustable from 25% to 100% (or the value defined by max drive level). Each driver has its own drive level control and can be set in the dive menu, this parameter adjust all drive level proportionally. To change the ratio of the drive levels use the drive menu.

RF, KV

This is a display only parameter that shows the output voltage being developed. Both the positive peak and negative peak voltages are displayed. These values are in KV.

Power

This is a display only parameter that shows the total system power that is being dissipated. This value is in watts.

Tune menu

Selecting this option will select the Tune menu and allow you to control parameters used to tune the resonate tank circuits and control the phase difference between the drivers.

Drive menu

The drive menu allows you to enable and disable individual drivers, set there relative drive levels, and monitor there power levels.

Power menu

The power menu allows you to define limits for power dissipation in each of the three coils as well as setting maximum drive level and maximum system run times.

DC drive menu

This menu allows you to control the output DC levels that are added to the FAIMS waveform and its return path.

Save settings

Selecting this option will save the entire FAIMS configuration data to non-volatile memory chip on the FAIMS 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 FAIMS parameters or they will be lost when power is cycled or the system is rebooted.

Restore settings

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

Return to main menu

Selecting this option will return to the MIPS main menu.

Tune menu

The Tune menu allows you to control parameters use to optimize the waveform generation and control the phase difference between driver 3 and the driver 1 and 2

pair. This phase control will control the shape of the FAIMS waveform. Each parameter is defined below and you will find a tuning procedure later in this document.

Frequency

This parameter defines the main operating frequency of the primary tack circuit. The frequency can only be changed when the global enable is off and thus the waveform generation is disabled. This value is in Hz.

Coarse phase

The coarse phase adjustment is used to adjust the phase shift between the primary frequency and the harmonic. This parameter allows eight setting from 0 to 7, each increment is 45 degrees of phase shift.

Fine phase

The fine phase adjustment allow 256 steps of phase adjustment, each step is 2 nS so this allows fine control the phase difference between the primary and harmonic signals.

Pri capacitance

This parameter allows you to control the capacitor value used to resonate the primary frequency tank circuit. The value is adjustable between 0 and 100% where 100% indicate the maximum capacitance.

Har capacitance

This parameter allows you to control the capacitor value used to resonate the harmonic frequency tank circuit. The value is adjustable between 0 and 100% where 100% indicate the maximum capacitance.

Drive Menu

This menu allows you to control the output DC levels that are added to the FAIMS waveform and its return path.

Power Menu

The power menu allows you to define limits for power dissipation in each of the three coils as well as setting maximum drive level and maximum system run times.

Return to FAIMS menu

Selecting this option will return to the FAIMS main menu.

Drive Menu

The drive menu allows you to control and monitor the three coil drivers. Driver 1 and 2 are used for the primary tank circuit while Driver 3 is used for the harmonic tank circuit.

Enable Drv1
Enable Drv2
Enable Drv3

These parameters allow you to enable and disable each driver, before the driver will actually drive the coil both this enable and the global enable on the main FAIMS menu will need to be enabled.

Drv1 level
Drv2 level
Drv3 level

These parameters set the drive level for each coil driver; this range of this value is 25% to 100%. The drive levels on this menu are used to define the relative drives for each coil. The global drive level will then increase all three drives proportionally.

Drv1 power
Drv2 power
Drv3 power

This is a display only parameter and it shows the power level being dissipated for the driver and its coil.

Tune menu

Selecting this option will select the Tune menu and allow you to control parameters used to tune the resonate tank circuits and control the phase difference between the drivers.

Return to FAIMS menu

Selecting this option will return to the FAIMS main menu.

Power menu

The power menu allows the user to define power limits, drive limits, and maximum FAIMS on time limits for the system. These limits are designed to protect the system.

Drv1 power limit
Drv2 power limit
Drv3 power limit

These parameters allow you to define power level limits in watts for each driver and its coil. If this power level is exceeded the FAIMS controller will reduce the global drive level until the power level is under the limit.

Total power limit

This parameter allows you to define the total power level limit in watts for all drivers and coils. If this power level is exceeded the FAIMS controller will reduce the global drive level until the power level is under the limit.

Max drive level

This parameter limits the maximum drive level that can be set with the global drive level on the FAIMS main menu. This provides a level of safety to prevent accidental over voltage to your system.

Max time, hrs

This parameter allows you to define the maximum number of hours that the FAIMS system can be enabled before its automatically disabled. This parameter will prevent the system from remaining on indefinitely if someone walks away and forgets to turn it off.

Return to FAIMS menu

Selecting this option will return to the FAIMS main menu.

DC drive menu

The FAIMS controller provides two DC output voltages that the user can control. The DC bias output is added to the FAIMS bisinusoidal output signal and the DC cv is available on the FAIMS return connection on the rear panel of the FAIMS RF deck. Each of these DC output are adjustable from -250 to 250 volts. Additionally an offset is provided to allow you to define the center of this adjustable range from -250 to 250 volts. This allows you to achieve -500 to 500 volts range on each output.

The DC cv voltage can be scanned from the CV start to CV end voltage values over the duration, in seconds, defined.

DC bias
: Sets the DC bias output DC voltage that is added to the FAIMS bisinusoidal output signal.

DC cv
: Sets the DC cv output DC voltage that is available on the FAIMS return connection on the rear panel of the FAIMS RF deck.

Offset
: This parameter defines the center of the voltage range for the DC bias and DC cv output voltages.

CV start
: The DC cv value can be scanned linearly and this parameter defines the starting voltage for this scanning capability.

CV end
: The DC cv value can be scanned linearly and this parameter defines the ending voltage for this scanning capability.

Duration
: The DC cv value can be scanned linearly and this parameter defines the duration, in seconds, for a scan from the CV start to CV end values.

Scan
: This parameter allows you to turn on and off a scan operation; A scan can also be triggered using the Trig input on the rear panel of the MIPS controller. This trigger input is positive edge sensitive.

Calibrate channel
: This option allows calibration of each output channel and its read back monitor. This is not an option you would normally use and its used at the factory when the system is initially fabricated. The calibration procedure is defined in more detail in the appendix of the MIPS operations manual.

Return to FAIMS menu
: Selecting this option will return to the FAIMS main menu.

Connecting the FAIMS device

The FAIMS device is connected to the FAIMS RF deck using two banana plugs on the rear panel of the chassis. The bisinusoidal waveform with the added DC bias is

available on the red plug located in the center of a 3" round shielded tube. Use care when connecting this signal to your FAIMS device both to shield the system from capacitance changes and electrical break down as well as providing a safe operating environment.

Your system includes supplies to make this connection, these supplies include:

1.) 3" diameter flexible metal tube.
2.) 3 spacers to hold the signal in the center of the tube.
3.) 5 feet of Teflon ¼" tubing that will fit in the center hole of the spacers and protect the signal.
4.) Banana jacks and wire
5.) 2 Hose clamps to hold the flexible metal tube in place on the RF deck and at your FAIMS device.

Its our recommendation that you engineer an connection system at your FAIMS device that is similar to the one on the rear panel of the FAIMS RF deck. This will provide and safe and stable signal connection.

The FAIMS signal return with the DC cv voltage is provided on a black banana plug and should be connected to the FAIMS device return signal plate. This connection can have up to 500 volts of DC and has been decoupled in the RF deck to remove any AC signal.

Tuning the system

The procedure outlined in this section defines how to tune the RF deck after the initial installation and setup of the FAIMS device. This procedure will need to be repeated if you make any significant changes to the system setup.

Throughout the following tuning procedure attach a scope to the monitor output BNC on the FAIMS RF deck front panel.

1.) The first step in tuning a new installation is to resonate both the primary and harmonic tank circuits.
    a. Use the drive menu to enable drive 1 and drive 2 if resonating the primary take circuit or enable drive 3 if resonating the harmonic tank circuit. First resonate the primary tank circuit and then the harmonic. These two will interact a little bit so this needs to be repeated a least one time. The drive levels for each driver should be set at 25% and the global drive level should be set at 25%. Do not enable all three drivers when resonating the tank circuits just the drivers for the tank circuit you are tuning.
    b. Turn on the global enable and adjust the primary capacitance value or harmonic value while monitoring the output on the scope. Adjust the capacitance value until you have seen a peak in the output voltage. Adjust the capacitance value to achieve a peak. This procedure

resonates the tank circuits; complete the primary tank circuit and then the harmonic tank circuit. Repeat this procure at least one time to remove any interaction of the two tank circuits.

c. If you are unable to achieve resonance you will need to change the operating frequency. The system is very sensitive to frequency changes and you should make small changes. The frequency can only be changed when the global enable is off. If the output signal increases as you increase capacitance but does not peak before you reach 100% of the capacitance value you will need to reduce the frequency, try reducing by 1000 Hz and repeating the procedure.

2.) After both tank circuits have been resonated the waveform symmetry will be adjusted.

a. Use the drive menu to enable all three drivers and set the drive level to 25%.
b. Set the global drive level to 25% and set the global enable to on. This will start the system generating the bisinusoidal waveform.
c. Adjust the coarse phase adjustment to generate as good a waveform as possible. The coarse phase adjustment only needs to get you close to the proper shape.
d. Adjust the fine phase control to achieve optimal symmetry.

The symmetry adjustment will not interact with the resonate frequency tuning from step 1 so you should not have to repeat step 1. The symmetry is very sensitive to minor system changes so you may need to adjust the symmetry as the system warms up.

After you have completed the system tuning make sure to save the parameters so the system will startup using the values you have set.

Operation recommendations

This section contains some general recommendations about the operation of the FAIMS power supply system.

1.) The system will automatically startup with the global enable off and the global drive level set to the highest coil drive level found. Its good practice to slowly increase the drive level and monitor the power and voltage. If anything seems out of normal power the system off and investigate.
2.) The drive menu allows you to control the individual coil drivers. Please keep these values low, around 25%. Driver 1 and driver 2 should always be set the same and driver 3 may differ if needed to obtain the desired amplitude relationship.
3.) The system should produce a 5.5KV signal at 1MHz using about 70 watts of total power. If your results are significantly different it could indicate a problem.
4.) When you have the system running at your desired operating point make note of the drive levels and the power levels, both total power and individual

driver power levels. Its good practice to then set the power limits and drive limits 20 to 30% above your operating point. This will allow the monitoring logic to protect the system in the event of a failure of some kind.

5.) The system has a maximum enabled time value that is set at 0.5 hours by default. This value is likely too short, please enter reasonable times but don't disable this feature by entering a ridiculous value like 10,000 hours. It's a good idea to not operate the system unattended until you have some experience with your system and have established system reliability.
6.) If you stop the system by turning off the global enable or pressing emergency stop please reduce the drive level before you re enable the system.
7.) Do not shut the system down by powering off the MIPS box, first turn the global enable off and then power off the MIPS box.
8.) If you turn off the MIPS box leave it off for at least 15 seconds before powering back up.

Troubleshooting the system

The following are a number of systems tests to do with the power turned off. Please insure the power is off and the system is disconnected from the FAIMS device. Also disconnect the cable from the MIPS FAIMS controller to the FAIMS RF head.

Refer to the FAIMS drawing package that came with your system for these measurements.

Perform the following resistance checks at the 25 pin connector on the front of the RF head:

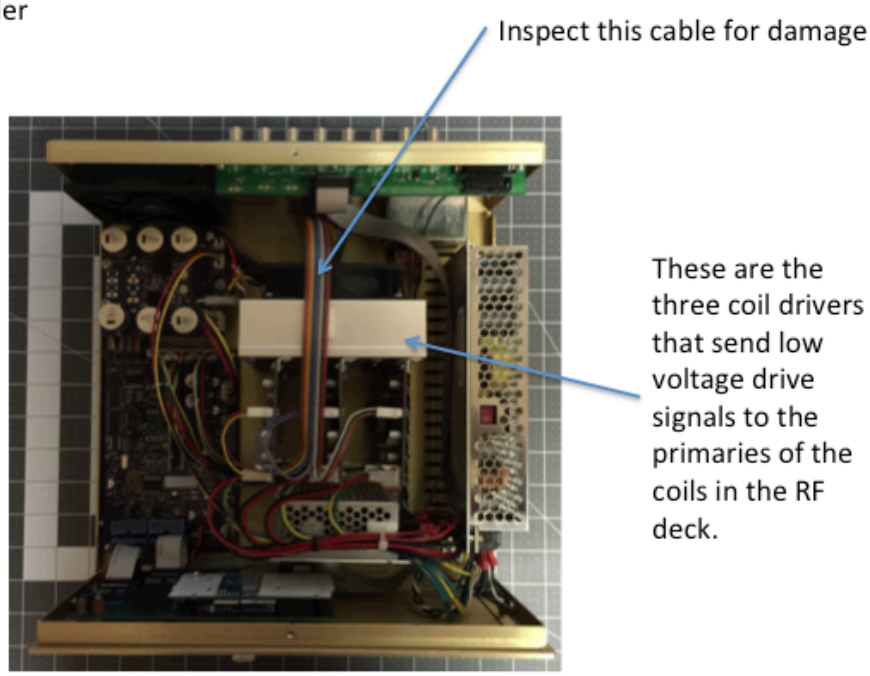
1.) Pins 1 to 2 should read a few ohms. Pin 1 or 2 should show infinite resistance to chassis ground.
2.) Pins 3 to 4 should read a few ohms. Pin 3 or 4 should show infinite resistance to chassis ground.
3.) Pins 5 to 6 should read a few ohms. Pin 5 or 6 should show infinite resistance to chassis ground.
4.) Pin 7 should show low resistance to chassis ground, a few ohms.
5.) Pin 13 should read 470K ohms to the black banana jack on the rear of the RF deck.
6.) Pin 25 should read 470K ohms to the red banana jack on the rear of the RF deck.

You can also remove the cover from the RF deck and inspect for damage. To remove the cover you will need to remove the bottom row of fan filter screws and well as the cover mounting screws. Do not try and run the system with the cover removed due to voltages generated and the fact that the tuning will change with the cover off. You can compare the internal components to the picture that you will find in the drawing package.

Its also a good idea to test the interconnection cable between the RF deck and the MIPS box. Test for continuity between the two connectors. The cable is one to one meaning pin 1 on one end connects to pin 1 on the opposite end. Note and a number of pins are doubled and will ohm as a short to one another. The doubled pins are:
1 and 14
2 and 15
3 and 16
4 and 17
5 and 18
6 and 19
7 and 20
8 and 21

The MIPS FAIMS controller power off tests are visual. Remove the cover and refer to the following figure.

MIPS FAIMS controller



After these tests are complete return the system to operational status by installing the covers and connecting all the cables. Make sure the system is connected to your FAIMS device.

The following tests will be performed with the system power applied, apply power and allow the system to start, you should see the FAIMS main menu in about 10 seconds after power is applied. Perform the following tests:

1.) The +5V and +12V LEDS should be illuminated on the RF deck.
2.) Select the Drive menu and make sure all three driver levels are set to 25%.
3.) Enable driver 1 and disable driver 2 and 3.
4.) Return to the FAIMS main menu.
5.) Set the drive level to 25%.
6.) Enable the system. The RF on LED on the RF deck should illuminate.
7.) Use the monitor output to test for RF, you should see RF at the frequency defined on the tune menu.
8.) Repeat steps 3 through 7 but this time enable only drive 2.
9.) Repeat steps 3 through 7 but this time enable only drive 3. In this case the frequency should be twice the frequency defined on the tune menu.
10.) The peak-to-peak voltage levels should be similar in all the above tests. Also monitor the drive power in each case, this power level should be low, a few watts to 1 watt.
11.) Assuming these test all pass then return to the drive menu and enable all three drivers. Make sure the drive level is 25% for each. Then using the main menu enable the system and set the drive level to 25%. This should

produce a bisinusoidal waveform. The system should now be ready to tune using the procedure defined in this manual.