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MACIE Acquisition Control

SOFTWARE MANUAL

Revision 5.2

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Markury Scientific, Inc.

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1 Introduction

The MACIE Software is a 64 bit, cross-platform software package for the Multi-purpose ASIC Control & Interface Electronics (MACIE) to enable the operation of an H1RG, H2RG and H4RG sensor chip assembly and other scientific imaging sensors using the SIDECAR ASIC and the WFIRST ACADIA ASIC.

The software package consists of two GUI applications and one MACIE library. The first one, MACIE SIDECAR Acquisition Control (MSAC) is a specific application for operating the MACIE controlled system with the SIDECAR ASIC when running H1RG, H2RG and H4RG SCAs using the Teledyne HxRG assembly code. The second one, MACIE Acquisition Control (MAC), is a generic application for operating all the MACIE controlled systems with either SIDECAR ASIC or ACADIA ASIC. The MACIE library is a dynamic link library which provides a list of API functions for customized software application to communicate with the MACIE card system.

The MACIE software v5.1 or later also supports Multi-MACIE and Multi-ASIC operation (note: this required custom MACIE firmware, please contact Markury Scientific for further information)

The MACIE software package, which is implemented using Qt language, provides the Cameralink, USB and Gigabit Ethernet communication interfaces to operate the MACIE system on windows and Linux platforms.

This document describes how to set up and operate the MACIE software applications (MSAC and MAC). For the MACIE library, please refer to the separate document called MACIE Programmer's Guide.

2 Major Functions

In the current release, the following functionalities are provided in the MAC and MSAC applications and MACIE library:

- MACIE Communication Interfaces: detecting all the available interfaces: CameraLink Serial Port, USB and GigE
- Initialization: loading the firmware and register configuration files for the MACIE, SIDECAR / ACADIA and SCAs to power up and set up the system for operation
- Configuration: modifying the register settings on the MACIE, SIDECAR / ACADIA and SCAs.
- Image Acquisition: capturing the image data through the science interfaces and save them to disk
- MACIE Test Pattern: reading the test pattern image generated by the MACIE card to verify the science data interface
- Power Control: enabling and setting up the ASIC power supplies
- Telemetry: measuring voltage and current of all MACIE provided supplies.

The available MACIE Interfaces and the supported SCA operation modes for each interface are shown in the table below:

Application	Camlink	GigE	USB
MSAC	H2RG fast mode, and all slow modes	All slow modes & fast modes	All slow modes & fast modes
MAC	All slow modes, (fast mode possible but not tested, may require dcf file adjustment by user)	All slow modes & fast modes	All slow modes & fast modes
MACIE Library	All slow modes, (fast mode possible but not tested, may require dcf file adjustment by user)	All slow modes & fast modes	All slow modes & fast modes

Please note that the maximum Gigabit Ethernet data rate is about 100 MB/s, and the maximum USB data rate is about 50MB/s for USB 2.0 (MACIE v1.0 and v1.1) and about 340MB/s for USB 3.0 (MACIE v1.2 and higher). The lower data rate may not be fast enough to transfer the image data for the nominal HxRG fast mode operation. However, due to the large FIFO buffer in the MACIE card (256MB), it is still possible to collect a number of fast-mode images even if the backend GigE or USB bandwidth is insufficient to sustain continuous image capture.

3 Delivery Package

The MACIE software package contains:

- Windows: a binary installer called MACIE_Installer.exe for the following software:
    - MSAC and MAC GUI applications
    - MACIE library – MACIE.dll and MACIE.h
    - Documents - Software Manual, Programming Guide and Release Note
    - C++ sample code – Example for application to use MACIE library
    - MACIE Tool – MACIE Configuration Tool for upgrading the MACIE firmware, and USB driver
- Linux: archived macie_vx.x_ubuntu.tar.gz and archived macie_vx.x_centos.tar.gz for the following software on Ubuntu and CentOs distributions separately:
    - MSAC and MAC GUI applications
    - MACIE library – MACIE.so and MACIE.h
    - C++ sample code – Example for application to use MACIE library
    - Documents – Software Manual, Programming Guide and Release Note

4 Operational Requirements

The following hardware and software platforms are required for operating the MAC or MSAC software:

- Windows 7/10, Linux Ubuntu 16.04 (kernel 3.3 or later), or CentOs 7.3 or later; 64 bit platform.

  Note: The Linux version of the MACIE software has been tested on Ubuntu (all interfaces) and CentOs (only GigE). It may or may not work on other Linux distributions.

- 5V power supply (not needed if powered through USB, and current doesn't exceed USB capabilities)

- Matrox Solios frame grabber and MIL LITE software package: If the Camera Link interface is intended to be used, a Matrox Solios frame grabber must be installed in the PC. Correspondingly, the mil-lite-10.20_517-installer64 needs to be installed. If any other version has to be used, please contact Markury Scientific to discuss possible options.

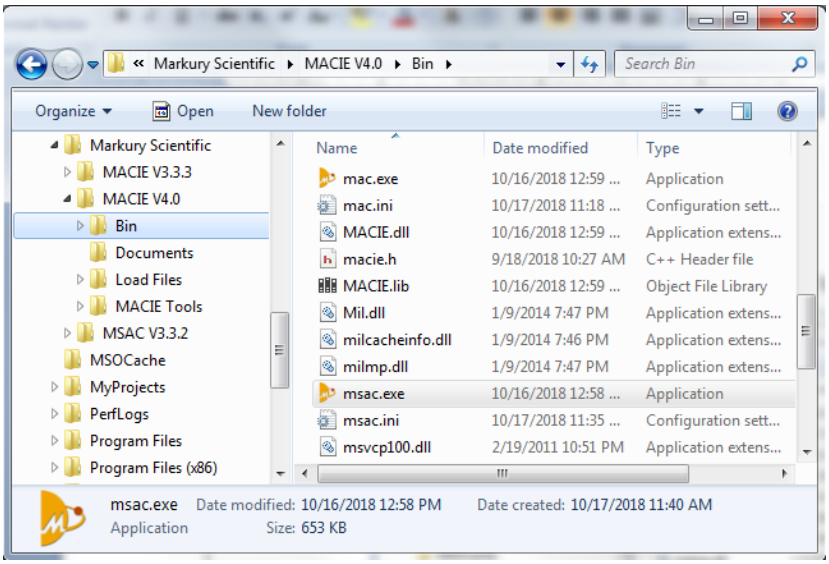
  Please note *that the Matrox MIL LITE software package has specific version requirements for Ubuntu and RedHat. For example: MIL LITE 10.0 R1 is for Ubuntu 12.04; MIL LITE 10.0 R2 is for Ubuntu 14.0 or 16.04. The details are provided at http://www.matrox.com/en/. The current release for Linux was compiled with MIL LITE 10.20 R3, build 517, and is not guaranteed to work with other versions of MIL_LITE (CameraLink operation only).*

- Compatible MACIE FPGA firmware version: It is recommended to upgrade the firmware with the latest release (depending on the given ASIC and mode of operation) which is located in \MACIE Tool\MACIE Configuration Tool\Firmware\

5 Software Installation

5.1 Windows Installation

Installing the MACIE software package on Windows is straight forward. Run the binary installer MACIE_Installer.exe which will install the applications, load files and documents to the destination directory. By default, the MACIE software is installed in C:\Markury Scientific\MACIE Vx.x\, and the links for the MAC and MSAC applications, documents are created in the Startup menu:

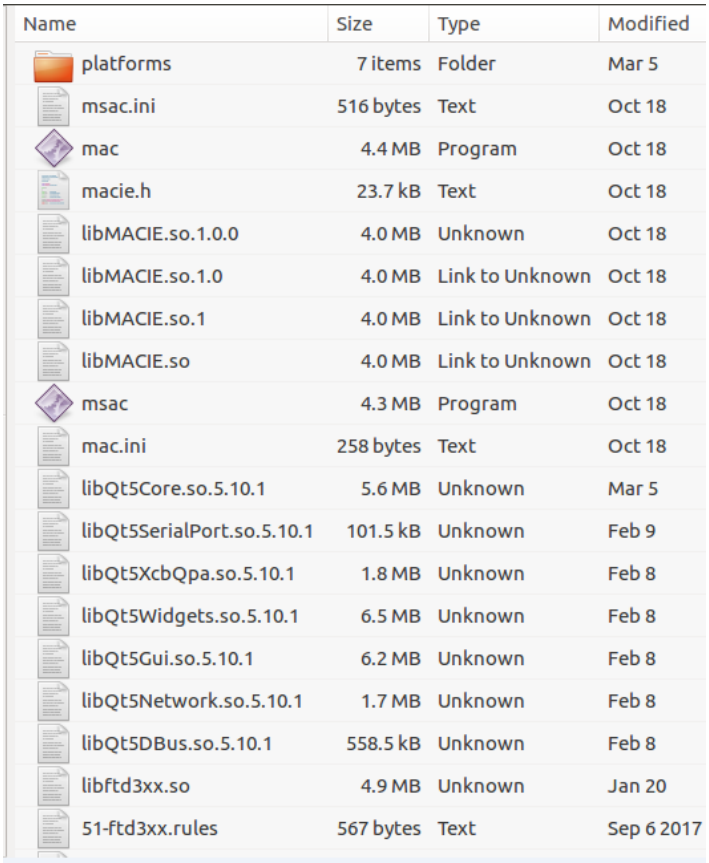


- Bin: containing:
  - MSAC application and msac.ini file, MAC application and mac.ini file
  - MACIE libray and macie.h file
  - Ds9 image viewer and all the dependency libraries
- Load Files: containing MAC load file folder and MSAC load file folder
- MACIE Tool: containing MACIE Configuration Tool and USB driver. Inside the MACIE configuration Tool, the latest versions of MACIE FPGA firmware for SIDECAR and ACADIA ASIC in both LVDS mode and CMOS mode can be found.
- Documents: containing the MACIE software and hardware manuals
- Sample Code: containing a .cpp file for the examples of calling MACIE library API functions.
- MaintenanceTool.exe: an uninstaller for uninstalling the MACIE software.

Note: Usually, the USB driver does not need to be installed manually. Windows will automatically install the correct drivers once the MACIE card is plugged into the PC. However, manual installation may be needed if Windows cannot locate the correct drivers automatically (e.g. no internet connection, or similar). Specifically, Windows may install an incorrect driver, and it is required that the user manually installs the driver located in the MACIE Tool/USB directory (i.e execute the .exe file in that folder). See also Section 0 below: USB Driver Verification.

5.2 Linux Installation

1) Copy the archive macie_vx.x_xxxx.tar.gz to the destination directory and untar it using the shell command (tar -xvzf MACIE_Vx.x_xxxx.tar.gz) to install the applications and dependency libraries to the destination directory, shown in the picture below:



Name	Size	Type	Modified
platforms	7 items	Folder	Mar 5
msac.ini	516 bytes	Text	Oct 18
mac	4.4 MB	Program	Oct 18
macie.h	23.7 kB	Text	Oct 18
libMACIE.so.1.0.0	4.0 MB	Unknown	Oct 18
libMACIE.so.1.0	4.0 MB	Link to Unknown	Oct 18
libMACIE.so.1	4.0 MB	Link to Unknown	Oct 18
libMACIE.so	4.0 MB	Link to Unknown	Oct 18
msac	4.3 MB	Program	Oct 18
mac.ini	258 bytes	Text	Oct 18
libQt5Core.so.5.10.1	5.6 MB	Unknown	Mar 5
libQt5SerialPort.so.5.10.1	101.5 kB	Unknown	Feb 9
libQt5XcbQpa.so.5.10.1	1.8 MB	Unknown	Feb 8
libQt5Widgets.so.5.10.1	6.5 MB	Unknown	Feb 8
libQt5Gui.so.5.10.1	6.2 MB	Unknown	Feb 8
libQt5Network.so.5.10.1	1.7 MB	Unknown	Feb 8
libQt5DBus.so.5.10.1	558.5 kB	Unknown	Feb 8
libftd3xx.so	4.9 MB	Unknown	Jan 20
51-ftd3xx.rules	567 bytes	Text	Sep 6 2017

2) In order to support the USB interface, execute the following shell commands to copy the 51-ftd3xx.rules from the software package to the system directory:

```
sudo cp 51-ftd3xx.rules /etc/udev/rules.d
sudo udevadm control --reload-rules
```

3) In order for the MACIE software to locate the dependency libraries, either modify the system dynamic link configuration or define the shell variable `LD_LIBRARY_PATH` to include the directory where the dependency libraries are installed. For example:

```
export LD_LIBRARY_PATH=~/MACIE_InstallationPath
```

It is optional to add the MACIE_InstallationPath to the system path so the system can find the executables.

```
export PATH=$PATH:~/MACIE_InstallationPath
```

It is recommended to set the environment variables by adding these two commands to ~/.bashrc file.

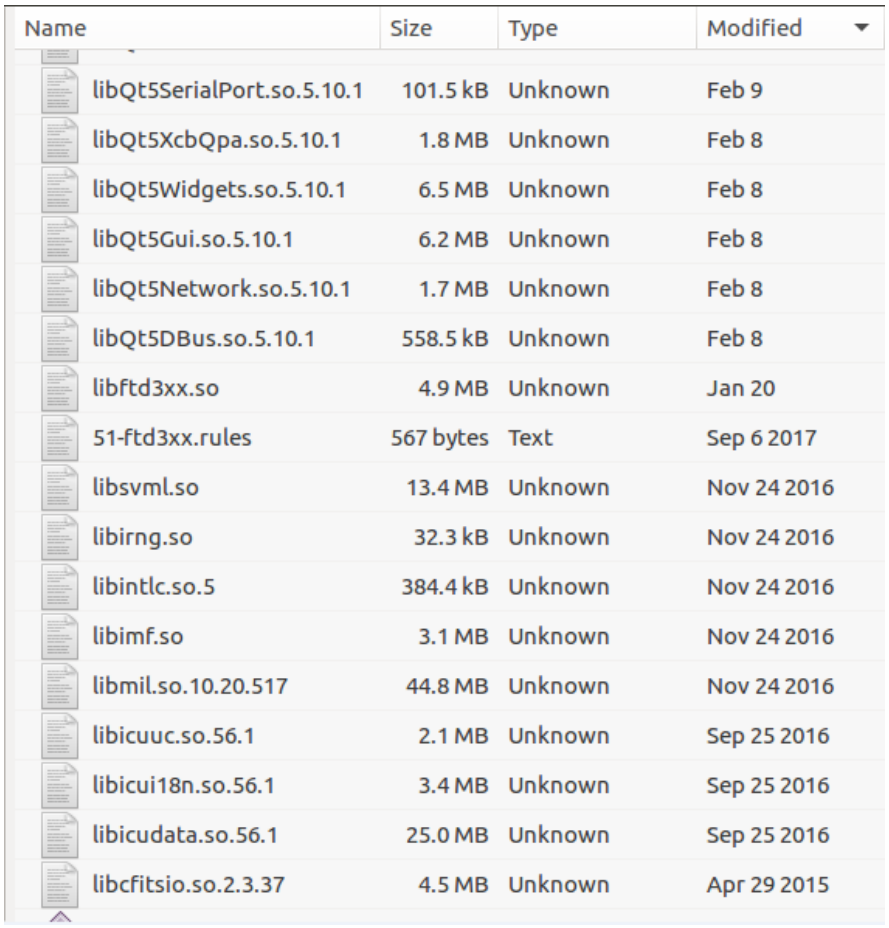
4) Create symbolic links for the shared libraries:

Option 1: execute shell command “ldconfig –nN .” to create the symbolic links for all the libraries:

ldconfig –nN .

Option 2: execute shell command “ln –s” to create the symbolic link for each library file one by one, for example:

ln –s libQt5Core.so.5.10.1 libQt5Core.so.5



Name	Size	Type	Modified
libQt5SerialPort.so.5.10.1	101.5 kB	Unknown	Feb 9
libQt5XcbQpa.so.5.10.1	1.8 MB	Unknown	Feb 8
libQt5Widgets.so.5.10.1	6.5 MB	Unknown	Feb 8
libQt5Gui.so.5.10.1	6.2 MB	Unknown	Feb 8
libQt5Network.so.5.10.1	1.7 MB	Unknown	Feb 8
libQt5DBus.so.5.10.1	558.5 kB	Unknown	Feb 8
libftd3xx.so	4.9 MB	Unknown	Jan 20
51-ftd3xx.rules	567 bytes	Text	Sep 6 2017
libsvml.so	13.4 MB	Unknown	Nov 24 2016
libirng.so	32.3 kB	Unknown	Nov 24 2016
libintlc.so.5	384.4 kB	Unknown	Nov 24 2016
libimf.so	3.1 MB	Unknown	Nov 24 2016
libmil.so.10.20.517	44.8 MB	Unknown	Nov 24 2016
libicuuc.so.56.1	2.1 MB	Unknown	Sep 25 2016
libicui18n.so.56.1	3.4 MB	Unknown	Sep 25 2016
libicudata.so.56.1	25.0 MB	Unknown	Sep 25 2016
libcfitsio.so.2.3.37	4.5 MB	Unknown	Apr 29 2015

5) If the Camera Link interface is used, please make sure the MIL LITE libraries are able to be located by the MACIE software. If an error occurs that indicates a MIL related shared library loading error, either modify the system dynamic linker configuration or define the shell variable `LD_LIBRARY_PATH` to include the directory where the library is installed. For example:

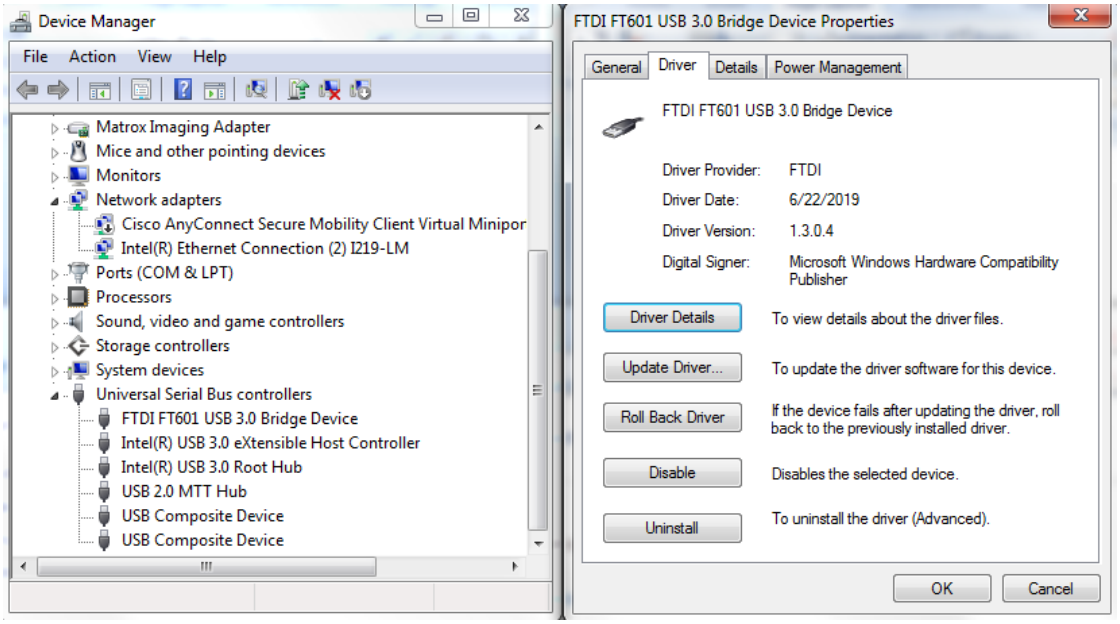
Set the environment variable by adding the following commands to the ~/.bashrc file:

export LD_LIBRARY_PATH=/opt/matrox_imaging/mil/lib

6 PC Configuration Steps

USB Driver Verification: Check if the USB driver version on the PC is same as the distribution provided in the MACIE package (MACIE Tools\USB folder). If it is not same or not available, manually install it using WHQLCertified_vxxx_Installer.exe for Windows; and using the shell commands to copy 51-ftd3xx.rules to /etc/udev/rules.d for Linux (see the Software Installation section for detail)

IMPORTANT: some versions of the FTDI USB driver are not compatible with the MACIE card (specifically Windows v1.3.0.2)This driver version must not be used.



GigE Socket Receiving Buffer: On older versions of the Linux platform (for example: Ubuntu older than 16.04), configure the socket receiving buffer (`SO_RCVBUF`) to 134MB or more.

Open the */proc/sys/net/core/rmem_max* file to make this change.

Or open file */etc/sysctl.conf* and add the following line:

net.core.rmem_max=134000000

Firewall Configuration for GigE on Centos: If the firewall active zone is configured as "public", which prevents the MACIE GigE port being accessed by the MACIE software, configure the firewall for trusting the MACIE GigE port (1900 shown in the MACIE Hardware Manual). For example:

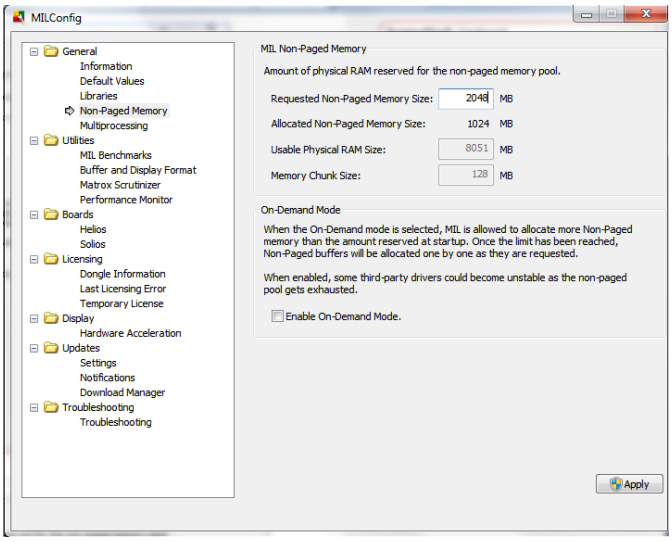
use shell command "sudo firewall-cmd --get-active-zones" to query the active zones as follows:

public

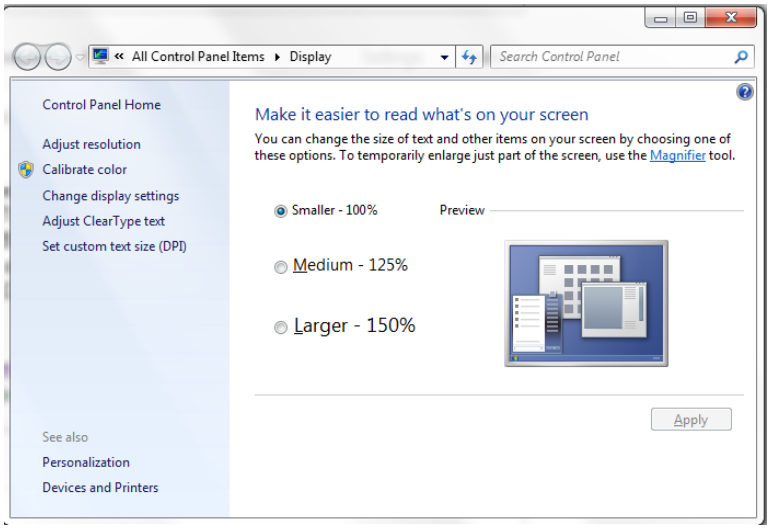
interfaces: eth0

then use shell command "firewall-cmd --zone=trusted --change-interface=eth0" to set the zone to "trusted"

MIL None-Paged Memory: If the Camera Link interface is selected for the image acquisition, configure the MIL None-Paged Memory on both Windows and Linux to 2048 MB or more. Make this change by using the MIL Config tool in the Matrox Imaging Library Control Center:



Windows Font Size: it is recommended to set the windows font size scaling as 100%:



Linux Keyboard Input Configuration: If the software especially running on the virtual box becomes unresponsive, for example: preventing ds9 from displaying quickly, not allowing user to type into terminals, or inhibiting boot times, it might because ibus-ui-daemon taking up all available processing power. In this case, user can try to disable ibus language: under System Setting > Language Support, switch Keyboard Input Support to "none" rather than "ibus".

7 Software Operation

First, turn on the 5V power supply and wait for at least one green LED and one blue LED to be visible on the side of the MACIE card. Then, start the MAC or MSAC applications as followings:

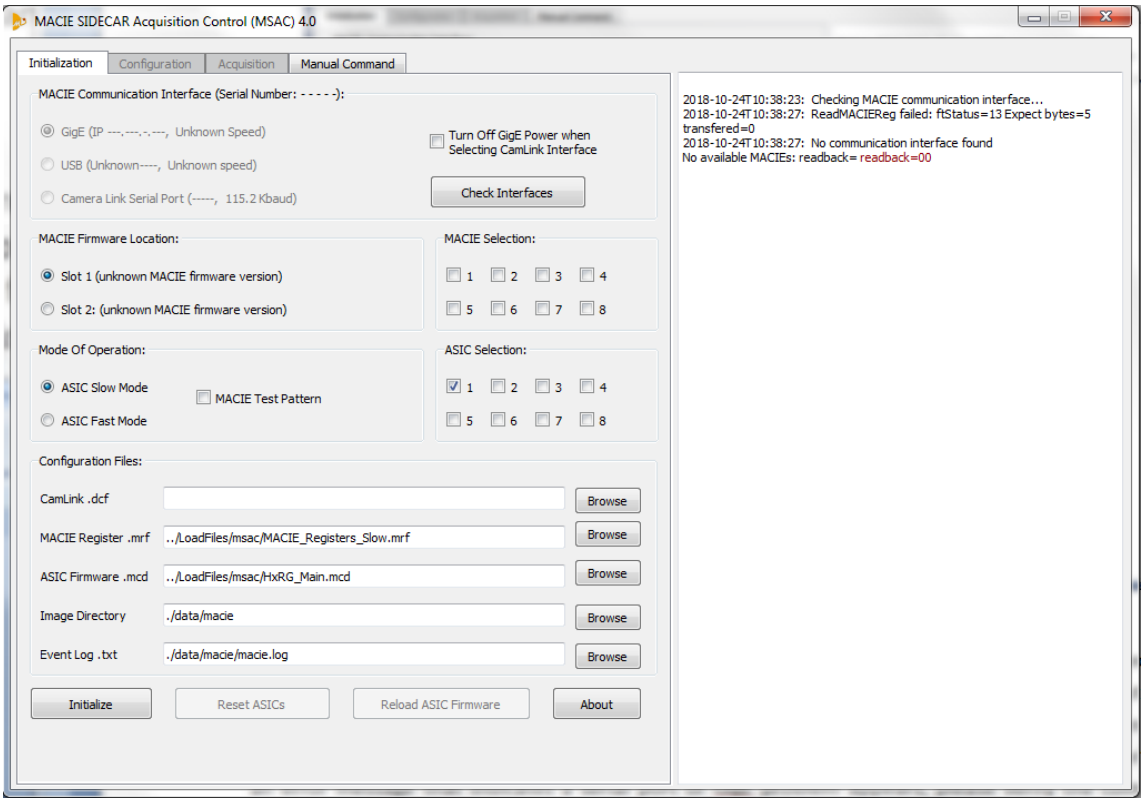
On Windows: Select MSAC or MAC application from Startup menu or double click the file MSAC.exe or MAC.exe in the Bin folder.

On Linux: Execute the following shell commands:

user@workstation: ~/MACIE/linuxbin/debug$ ./msac (or ./mac)

7.1.1 MSAC

The MSAC is a specific application supporting the MACIE controlled system with the SIDECAR ASIC and H1RG, H2RG and H4RG SCAs when running HxRG firmware. It provides the Camera Link serial port, USB and GigE interfaces for the operation. If the software starts properly, the GUI will look like the following picture:



If an error occurs that indicates some libraries are missing, please follow the on-screen instructions to install the missing libraries or updates. In case of QT library loading errors under Linux, please see the Software Installation section to resolve the library path issues. If the xcb related plugin loading error occurs, please make sure the symbolic link for the shared library libQt5XcbQpa.so.5.10.1 is created.

7.1.2 Initialization

Once the software has started, it searches for all the connected MACIE cards and reports the status. If a MACIE card is found, the corresponding interface radio buttons will be activated, the MACIE card serial number, USB and GigE data rate, and the FPGA firmware version will also be reported on the GUI. If an error message that indicates a serial port / GigE / USB problem appears, please verify the communication interface using the MACIE Configuration Tool (see MACIE Configuration Tool manual for details).

In addition, the software reads the msac.ini file and applies the settings to the SCA operation mode, and its corresponding MACIE register file, SIDECAR firmware on the GUI. If the MACIE register load file and the SIDECAR firmware don't appear on the GUI, it is likely that the msac.ini file was not found by the software. In this case, the msac.ini file can be copied from the delivery package, or the load file paths on the GUI can be selected directly using the Browse buttons.

Check Interfaces: When pressing this button, the software will refresh the interface status, in case there has been a change to the GigE, USB and Camera Link interfaces.

SCA Operation Mode: When switching between the ASIC slow mode and ASIC fast mode, the software will repopulate the corresponding MACIE register file and SIDECAR firmware, as well as the Camera Link configuration file from the msac.ini file on the GUI.

In addition to the SCA readout, the software provides the MACIE Test Pattern readout which can be applied for fast mode and slow mode. The MACIE test pattern, which only requires the MACIE card (SIDECAR and SCA are not required) is for verifying the MACIE science data interface operation.

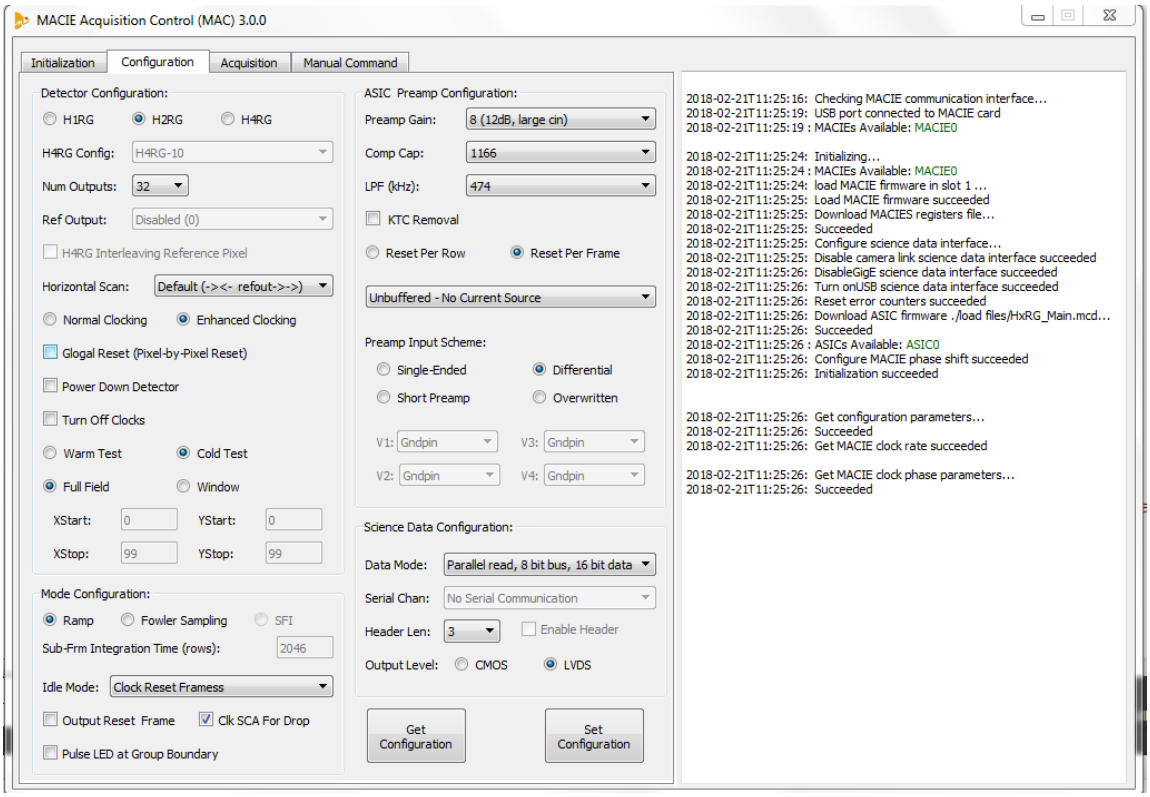
Initialize*:* When pressing this button, the software will load the MACIE FPGA firmware in the selected slot and initializes the MACIE, ASIC and SCA. If the initialization succeeds, the log window will display a success message, and the Configuration tab and Image Acquisition tab will be activated. If it fails, further system checking or debugging may be needed.

MACIE and ASIC selection: In the current release, only a single MACIE card and a single ASIC are supported for operation. It is recommended to only select ASIC 1 and MACIE 1.

Reset ASICs: Reset all the ASICs and wipe out the loaded SIDECAR firmware. After executing this function, it is required to re-initialize the system and reload the SIDECAR firmware.

Reloading ASIC mcd File: Reloads the SIDECAR firmware and overwrite the user configuration on the GUI.

7.1.3 Configuration

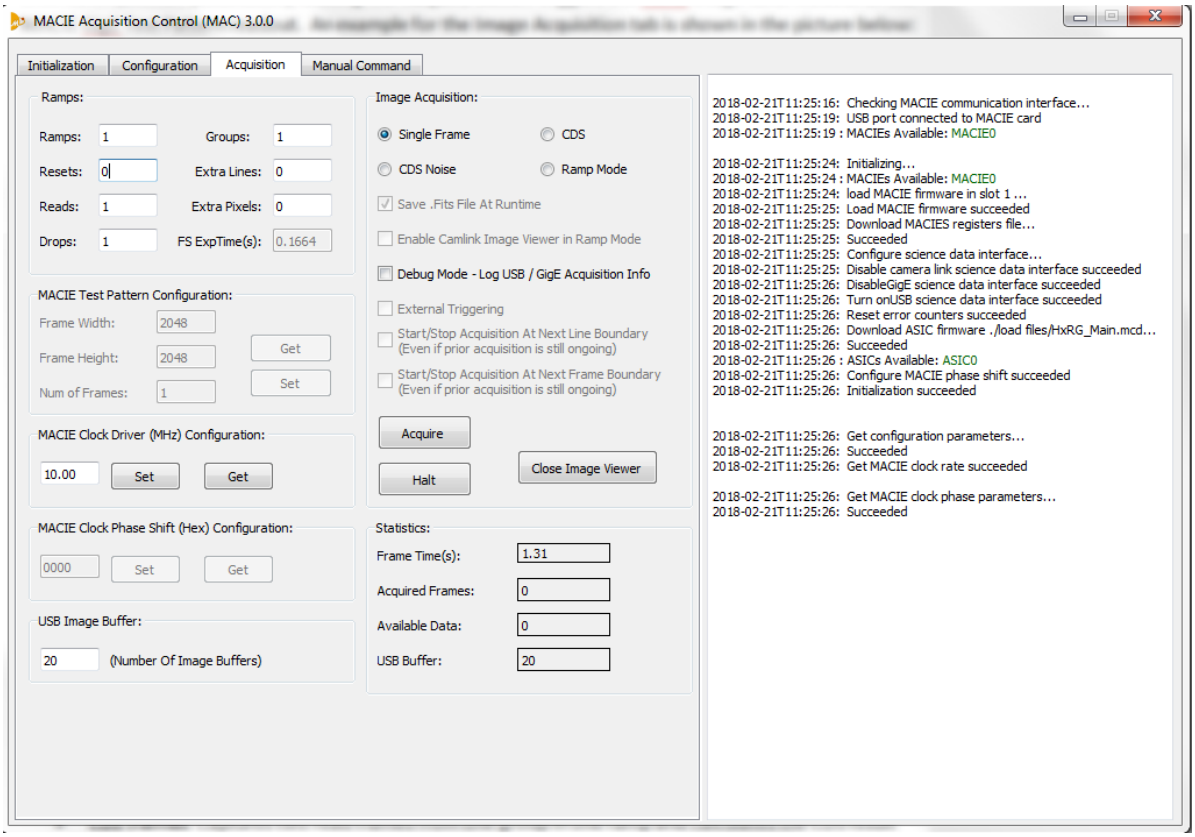


Set Configuration: On this tab, the configuration settings for the SIDECAR ASIC and SCA are provided. Select the settings and click the ***Set Configuration*** button to write the new settings to the MACIE, SIDECAR and SCA.

Get Configuration: click this button to read the current configuration settings from the SIDECAR ASIC and update the GUI accordingly.

7.1.4 Image Acquisition

Based on the operation mode selected on the initialization tab, either **HxRG Ramp Configuration** or **MACIE Test Pattern configuration** is activated.



Acquisition Mode:

- Single Frame: readout one read frame
- CDS: read out two read frames from one group of one ramp and calculate the CDS result.
- CDS noise: read out two ramps with two read frames in each ramp. Then calculate the CDS noise result based on these four frames (spatial CDS noise, which is the difference of 2 CDS frames).
- Ramp Mode: readout the detector image ramps or the MACIE Test Pattern sequence.

Acquire: Write the SIDECAR ASIC register to triggers the image readout, and transfer the image data from the MACIE card to the PC. After capturing the image data, the software saves the image data to disk:

When using the Camera Link interface, the software always saves the image data to a tif file at runtime. It is optional to generate the fits files at runtime. If the Camera Link interface is selected for fast mode operation, especially in the case of acquiring a long ramp, it is recommended to unselect the "Generate Fits File at Runtime" to avoid a potential buffer overflow problem.

For the other interfaces, the software will always save the image data to fits files.

Halt: When a ramp acquisition is started, clicking this button stops the image readout and forces the detector to return to the idle clocking loop. It will tell the MACIE to stop sending out test pattern data, if test pattern mode is activated.

Close Image Viewer: closes all the runtime image viewers launched for the single frame, CDS result or CDS noise result.

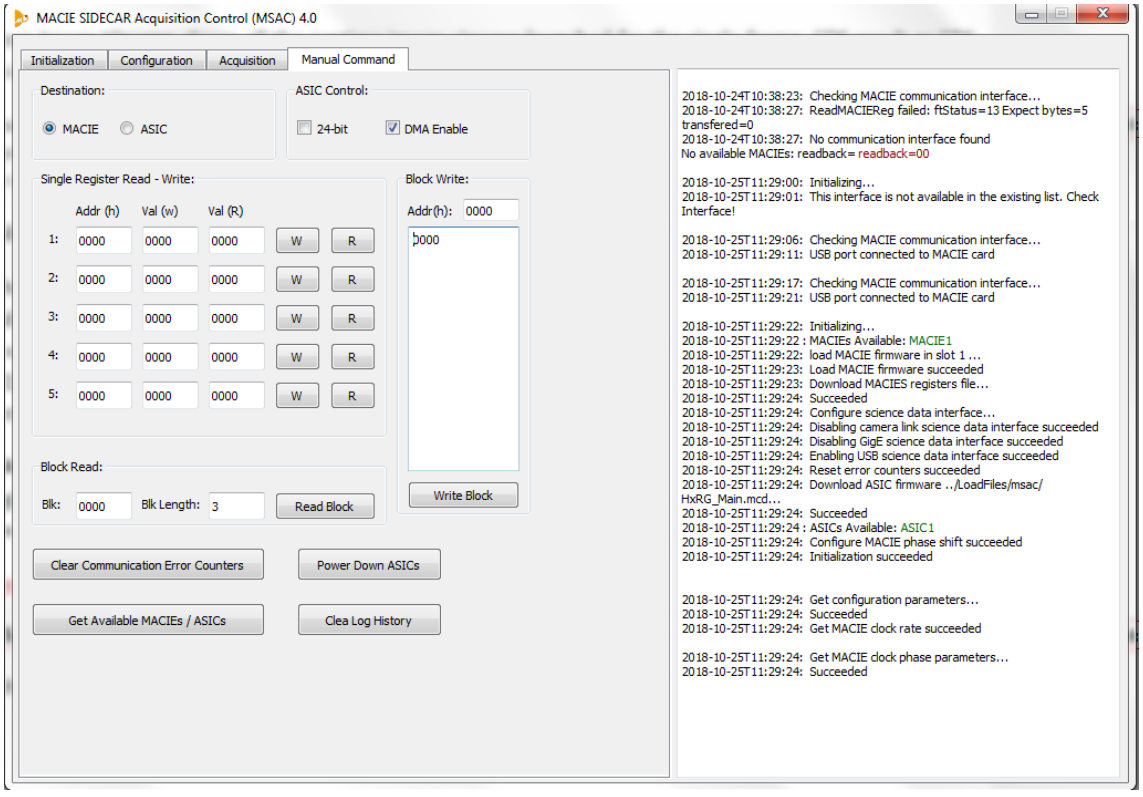
Phase shift configuration: This feature is typically used for the fast mode operation to avoid science data transmission errors. For a specific SIDECAR or SCA at different operating temperature, the phase shift may need to be adjusted by the user.

Follow the sequence below to configure the phase shift:

After acquiring an image ramp, check if the ASIC1 LED on the MAICE card is slowly flashing red (about 1Hz) which indicates some transmission errors. If so, change the Camera Link phase (any value between 0x80 and 0x1ff is valid in addition to the default setting of 0), reset the error counters (button in GUI) to clear the blinking LED, and acquire a new image ramp. If the LED starts flashing red again, repeat this configuration sequence until no transmission error occurs anymore (no more flashing red LED).

MACIE Clock Driver: Provides the master clock for SIDECAR and detector operation. Based on the MACIE register file load, the default MACIE clock speed is displayed on the GUI. In order to decrease or increase the ASCI and detector readout speeds, change the clock setting on the GUI and click the Set button.

7.1.5 Manual Command



Register Read / Write: On this tab, a number of manual read and write operations can be performed. On the left side, there is list of 5 rows, each containing an address field, and data field for write, a data field for read, and two buttons to initiate a read or write operation (W and R). By entering the desired destination address, and pressing the R button, the software will read the corresponding register from the MACIE (result displayed in the Data(R) field). Furthermore, by entering a data value into the Data (W) field, and

pressing the W button, corresponding register is being written. Since the MAICE card, the ACE card, and the SIDECAR ASICs all have their independent 16-bit register space, the hardware destination has to be specified in addition to the register address. This is accomplished by using the "Destination" radio buttons and check boxes in the right half of the window. Here, either the MAICE card or ASIC can be selected.

Block Read/Write: Besides single register read/write operations, a block write or block read operation can be performed. To write a block of data to the LTE, enter the address in the edit field under "Block Trnsfr", and then enter the list of desired data words to be written in the table below. To write the block, press the "Write Block" button. Reading a data block is accomplished by entering the address in the edit field on the lower left, then specifying the length of the block (edit field marked as "Length", and the pressing the "Read Block" button.

Get Available MACIE / ASICs: When this button is pressed, the software will perform a check for all available MACIE cards and responsive ASICs. In the log window, a report will be given with respect to which MACIE cards and which ASICs are responding, and are therefore configured properly for operation. Please note that ASICs will only be recognized if they are powered-up and properly configured (e.g. by means of a master config file on the first tab).

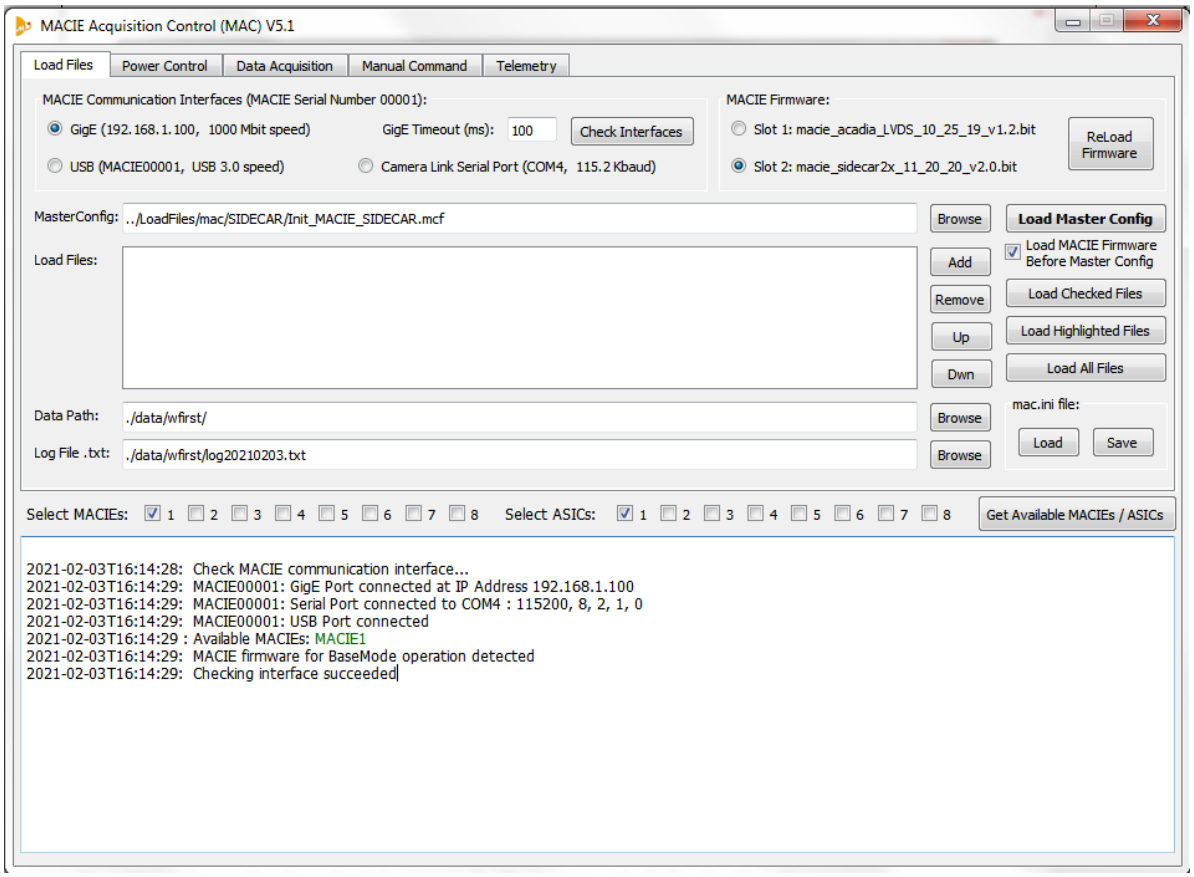
Power Down ASICs: turn off the SIDECAR and SCA power in a controlled and safe way. It is recommended to execute this function before turning the 5V power supply off.

7.2 MAC

The MAC software is a generic application for all MACIE controlled systems. It is capable of operating SIDECAR ASIC, ACADIA ASIC, and other connected systems. By loading the load files, the MAC interprets each command in the load file and sends the command to MACIE card or SIDECAR / ACADIA properly.

7.2.1 Load Files

If the MAC starts properly, the GUI will look like the following picture:



If an error occurs that indicates some libraries are missing, please follow the on-screen instructions to install any missing software packages or updates. In the case of QT libraries loading errors under Linux, please see the Software Installation section above to resolve any library path issues. If an xcb related plugin loading error occurs, please make sure the symbolic link for the shared library libQt5XcbQpa.so.5.10.1 is created.

Once the software has launched, it automatically executes the following functions:

- Searching for all the connected MACIE cards and reporting the connection status. If a MACIE card is found, the corresponding interface radio button will be activated. The MACIE card serial number,

FPGA firmware version, GigE and USB data transfer speed will also be reported on the GUI. If an error message appears that indicates a GigE / USB / Serial Port interface problem, please use the MACIE Configuration Tool software to verify the interface connection.

- Reading the mac.ini file and populating the load files and other parameters on the GUI, including:
    - Master configuration file (for example: Init_MACIE_SIDECAR.mcf)
    - Load files
    - Image Data Saving Path (for example: ./data)

  If the load files don't appear on the GUI, it is likely that the mac.ini file was not found by the software. In this case, the mac.ini file can be copied from the delivery package, or the load files can be selected using the Browse buttons on the GUI.

- Loading the MACIE FPGA firmware from the selected slot (slot 1 vs. slot2)

The major functions of the first tab are as follows:

Check Interfaces: Refresh interface status, in case there has been a change to the GigE, USB, or Camera Link interface.

Reload MACIE Firmware. Reload the selected FPGA firmware from Slot 1 vs. Slot 2 for MACIE card operation

Load Master Config: Download the configuration file which is listed in the master config field (file name.mcf). Several examples of configuration files are provided in the "\Load Files\mac\" in the software installation folder. New and modified files can be easily created by the user. Since the configuration files listed in the .mcf iles can reference other files, and can be used to perform a complete configuration of MACIE and connected ASICs. The sample file referenced in the image above configures MACIE1 and ASIC1.

To modify files in the mac.ini file, use either an absolute file format or a relative file format. When using a relative path, add prefix "./" if the modified file is in a sub-directory of "Bin", otherwise add "../". For example, modifying the .mcd file in the C:\Markury Scientific\MACIE V4.0\Bin\mac.ini:

- Absolute path:
  ASIC_MCD= C:\Markury Scientific\MACIE V4.0\LoadFiles\mac\SIDECAR\HxRG_main.mcd
- Relative path:
  ASIC_MCD=../LoadFiles/msac/HxRG_Main.mcd ("LoadFiles" is outside of "Bin")
  Or:
  ASIC_MCD=./LoadFiles/msac/HxRG_Main.mcd ("LoadFiles" is inside of "Bin")

Reload Files: The load file list can be used to load the file types .glf (global load files), .mcd (SIDECAR machine code files), and .ald (ACADIA load file) The buttons of Load Checked Files, Load Highlighted Files and Load All Files can be used to load the selections of the file list. The buttons of Add, Remove, Up and Down can used to add new load files to the list, remove existing files from list and adjust the order in the file list. The ASIC and MACIE Selection check boxes below determine the destination of the Load Files (Master Config files where the destination is controlled by certain keywords in the file itself).

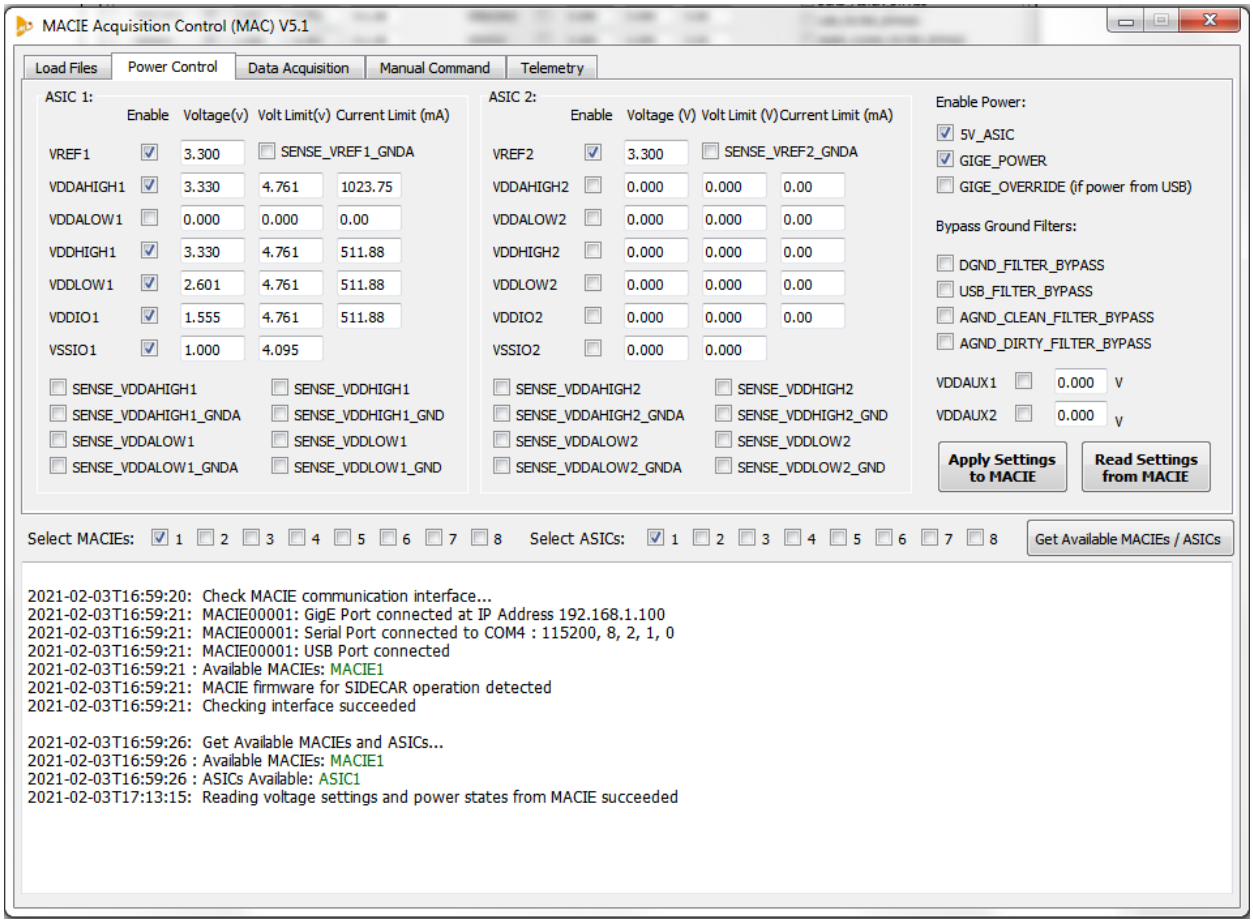
Section 7.3 below describes the syntax of the load files in more detail.

Get Available MACIEs / ASICs: This function is available in all the window tabs. It perform a check for all available MACIE cards and ASIC cards. In the log window, a report will be given with respect to which

MACIE cards and which ASICs are responding, and are therefore configured properly for operation. Please note that ASICs will only be recognized if they are powered-up and properly configured (e.g. by means of a master config file on the first tab).

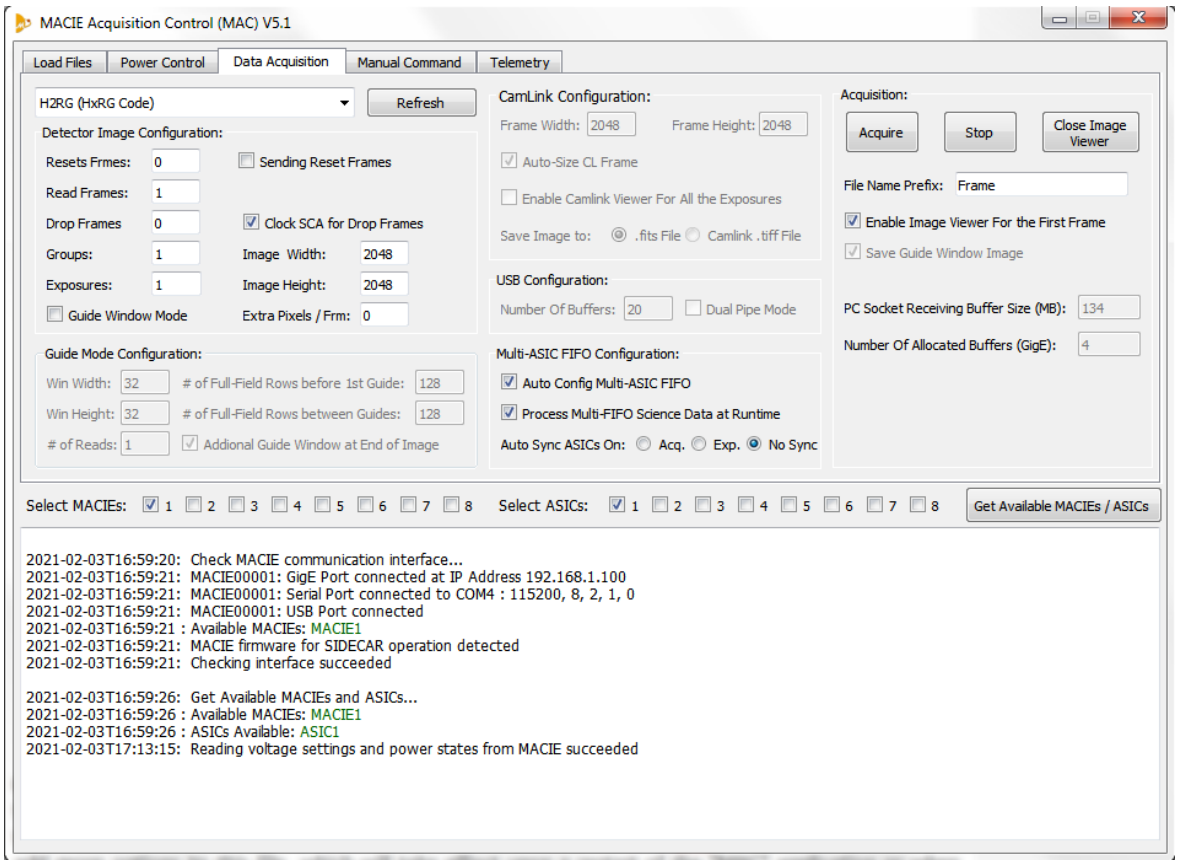
In the early versions of the software which only support single MACIE and ASIC application, this function only reports at most one MACIE and one ASIC. Starting with v5.1, the software will check and report all the available MACIE cards and ASIC cards (note: requires Multi-MACIE Dual-ASIC firmware)

7.2.2 Power Control



Here, the power to the ASICs can be enabled and configured. If a master config file has already been loaded on the first tab, there is usually not much to do on this tab. It might be helpful to press the "Read SettingsFrom MACIE" button, though, to read back what the power configuration is (based on what has been loaded). If the power is not set via a master config file, it can be set manually on this tab. The “Enable” column enables ASIC power supplies. The left half shows the individual ASIC supplies, and the corresponding current limits and voltage limits. All power supplies are fully programmable.

7.2.3 Data Acquisition



Configuration Select: The pull-down menu in the upper left corner provides several options with respect to the specific ASIC and detector configuration. The options in the pull-down menu are populated based on the contents of the "Config_Acquire.ini" file located under the "load files\mac\" folder. The user is free to add more options to this file, which will take effect upon a restart of the "MAC" application or when pushing the Refresh button. The options to be defined in the config file include the addresses for number of reset frames, number or read frames, number of groups, number of drop frames, trigger register, frame size, timeout, and a few configuration bits. That way, a different assembly code or detector type can be accommodated within the application.

In v5.1, two extra MACIE test patterns are added to the configuration list. The first one is Test Pattern Multi-MACIE 2xASIC (2048 x 2048) which provides the option to read test patterns from a maximum of 4 MACIEs with a maximum of 2 FIFOs on each MACIE (corresponding to the 2 ASICs per MACIE). The checkboxes ASIC 1 and 2 correspond to the two FIFOs on the MACIE1; the checkbox ASIC 3 and 4 corresponds to the two FIFOs on the MACIE2, and so on.

The second one is the Test Pattern Multi-MACIE 1xASIC (2048 x 2048) which provides the option to read test patterns from a maximum of 8 MACIEs with 1 FIFO (=ASIC) on each MACIE. The checkbox ASIC 1 corresponds to FIFO1 on MACIE1; checkbox ASIC 2 corresponds to FIFO1 on MACIE2, and so on.

Both test patterns will work with single MACIE and single ASIC operation, as long as only the MACIE 1 and ASIC 1 checkboxes are set (and "Auto-Config Multi-ASIC FIFO" is disabled).

Detector Image Configuration: The parameters on the left control the configuration of the acquisition ramp. They control the number of reset frames, read, frames, groups, and drop frames (as long as the utilized assembly code supports these parameters). There is also an Exposure count option that specifies how many times the same ramp/exposure is to be executed. Additional checkboxes specify whether the reset frames should be read out, and whether the detector is to be clocked during drop frames. If the assembly code offers additional configuration options (e.g. type of reset, number of outputs, enhanced vs. normal clocking, etc.), they can be configured by means of the manual register writes on the Manual Commanding tab prior to starting the acquisition.

Frame Size: Before acquiring a new set of science data, it needs to be ensured that the correct frame size is configured. Based on the configuration selection in the pull-down menu, the detector frame size will be pre-filled with the corresponding values. The user can manually alter the values as long as it matches the expected frame size (for example to operate window mode). The CameraLink frame size is automatically computed based on the number of ASICs and the detector frame size. If more or less overhead is desired, the value can be manually overridden If the "auto-size CL frame" check box is checked, the CameraLink frame size will be automatically determined based on the number of selected ASICs and ACE cards on the right side of this dialog window.

CameraLink Config: This section will active only if the CameraLink interface is selected for data acquisition. If the "auto-size CL frame" check box is checked, the CameraLink frame size will be automatically determined based on the number of selected ASICs and ACE cards on the right side of this dialog window.

USB Buffer Config: This section will be active only if the USB interface is selected for data acquisition. The number of buffers indicates how many frames the USB driver software can hold in its memory. The dual pipe mode will enable the software to configure dual USB pipes to allow reading of configuration (register) data and image data in parallel. This is typically not needed for the MAC software since the manual register read function is disabled during science acquisition (so no parallel access is possible). However, the feature may still be useful for debugging purposes.

USB Dual Pipe mode: If selecting this option, the software will set up a separate USB pipe for receiving science data when operating the Acquire function below. In dual pipe mode, the software will be able to read MACIE/ASIC registers and science data simultaneously. In single pipe mode (Dual Pipe mode option is not selected), the software cannot read any MACIE/ASIC registers while science data is being transferred, since they share one USB pipe.

Multi-ASIC FIFO Configuration: If selecting the option of Auto Config Multi-ASIC FIFO, the MAC softare will enable MACIE mult--FIFO mode when the Acquire button is pressed to capture images , so that the MACIE will rotate reading FIFOs on different ASICs and MACIEs. In a Multi-MACIE or Multi-ASIC application, this option should be selected. If it is not selected, the corresponding manual configuration by writing MACIE registers will take effect.

If selecting the option of Process Multi-FIFO Science Data at Runtime, the software will write the individual ASIC images into separate fits files. Otherwise, the images from all ASICs are combined into a single fits file.

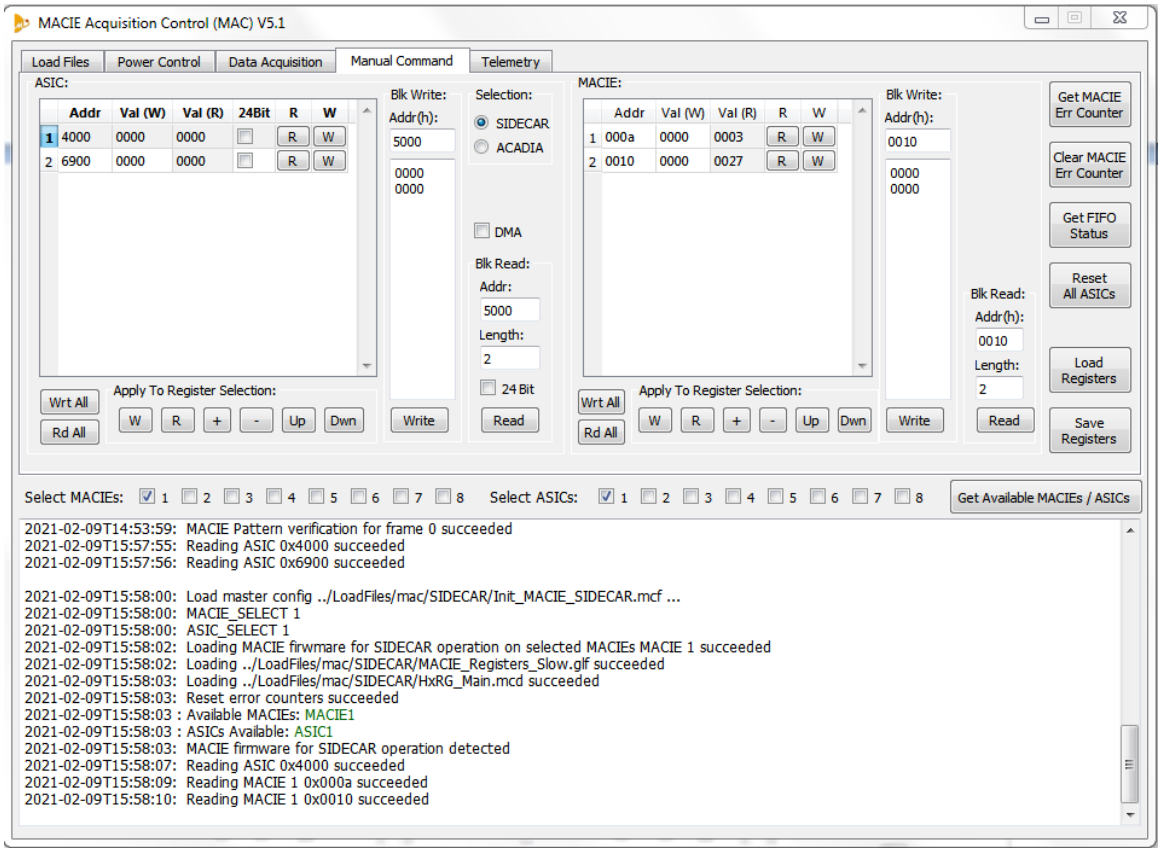
In addition, the software also provides Multi-ASIC synchronization capability. By providing a sync file in the config_acquire.ini file and selecting Auto Sync ASIC on Acquire vs. Exposure, the software will load the sync file at the beginning of an acquisition. The option "Sync On Acq" will load the sync file once when starting the acquisition. The option "Sync On Exp" will load the sync file before triggering each ramp. The option "No Sync" will not load the sync file at all.

Acquire: When pressing the ***Acquire*** button, the configuration in the ASICs is updated according to the specified values, and a new exposure is triggered by means of the trigger command that has been specified in the Config_Acquire.ini file for the given mode. The application will now wait to receive the expected amount of science data through the selected interface. If the requested data is not received in time, a timeout will occur, and an error message will appear.

Science Data Storage: Whenever science data is received, it gets stored in the folder specified in the mac.ini file. If USB or GigE interfaces is selected, the science data is saved as .fits file. If CameraLink interface is selected, the science data is saved as .tiff file by the CameraLink Driver software. Since the CameraLink interface is typically used for fast mode operation, saving .tiff file directly by the CameraLink Driver software makes the CPU time more efficient during the data transfer.

7.2.4 Manual Command

In addition to the Load File functions in the first tab, the MAC software also provides the manual command functions to read and write the use defined registers for the MACIE and ASIC configuraitons.



Manual Config .ini files: Two configuration files can be found in the load file folders (manual_regConfig_acadia.ini and manual_regConfig_sidecar.ini). Depending on the definition in the mac.ini file and which MACIE firmware (slot 1 vs. slot 2) is loaded when the software is started, one of these two manual configuration files is selected and loaded to the Manual command tab. Modifying the manual

configuration file will allow the software to load different registers and options for ASIC and MACIE configuration.

Single Register Read/Write: On this tab, a single register read and write can be performed by using the R and W buttons inside the tables. A sequence of selected register read and write can be performed by using the R and W buttons below the tables. Reading and writing all the registers listed in the table can be performed by using the Rd All and Wrt All buttons. By entering the desired destination address and pressing the R button, the software will read the corresponding register and display the result in the Val (R) field. Furthermore, by entering a value into the Val (W) field and pressing the W button, corresponding register is being written. Since the MAICE card, and the ASICs all have their independent 16-bit register space, the hardware destination has to be specified in addition to the register address. This is accomplished by using the "Destination" radio buttons and check boxes in the right half of the window. Here, either the MAICE card or ASIC can be selected. In addition, if the ASIC option is selected, the ASIC controls options of 24 bit register read/write and DMA/mSPI_Reg (DMA is for SIDECAR, mSPI_Reg is for ACADIA) can also be selected at the same time.

Block Read/Write: Besides single register read/write operations, a block write or block read operation can be performed. To write a block of data to the MACIE, enter the address in the edit field under "Block Write", and then enter the list of desired data words to be written in the table below. To write the block, press the "Write Block" button. Reading a block is accomplished by entering the address in the edit field on the lower left, then specifying the length of the block (edit field marked as "Length", and the pressing the "Read Block" button.

ASIC Selection: Although the ASIC is automatically selected as SIDECAR or ACADIA when the software is started, the selection can still be changed using the radio buttons. If the ASIC selection is changed, the ASIC controls options of 24 bit, DMA, mSPI_Reg, Addr Auto Increment will be enabled correspondingly.

Get Available MACIEs/ASICs: A very useful function available on this dialog tab is the "Check ASICs" button. When pressed, this button will perform a check for all available MACIE cards and responsive ASICs. In the log window, a report will be give with respect to which MACIE cards and which ASICs are responding, and are therefore configured properly for operation. Please note that ASICs will only be recognized if they are powered-up and properly configured (e.g. by means of a master config file on the first tab).

Get MACIE Error Counters: Read MACIE error counter registers

Clear MACIE Error Counters: MACIE has a number of error counter registers for storing the communication errors count, (for example the red blinking LEDs (ASIC status) on the MACIE card indicates the communication errors). Pressing the button, the software will clear all the error counter registers, the LED which is blinking in red will turn to green and stop blinking.

Get FIFO Status: Read MACIE registers for FIFO counters

Reset ASICs: Lastly, this window also provides the means to reset and ASICs (either all or individually). This is a helpful function to bring the system back from an unknown or unexpected state.

Load Registers and Save Registers: Load register settings from different manual register files and save the GUI settings to the current loaded manual configuration file

7.2.5 Telemetry

Voltage/Current Measurements: The functions on this tab are mostly self-explanatory. It allows the user to measure the various voltages and currents that are provided to the SIDECAR ASIC. A complete set of measurements can be requested (press button in lower right corner), which will trigger the measurement of all voltages and currents for the selected ASIC.

The results are reported in the edit fields as well as in the log window.

7.2.6 Syntax for Config_Acquire.ini

The Config_Acquire.ini file is parsed by the MAC application upon launch, and whenever the refresh button is pushed on the Data Acquisition tab. It defines the various science data configuration options of image capture that are available to the MAC, and can be modified by the user as needed. The following is a list of all the keywords that are understood by the parser. If a keyword is not used for a given configuration, a default value will be assigned as stated in the description.

NAME	Text string that is displayed in the MAC application selection list. Needs to be placed at the beginning of each configuration section of the Config_Acquire.ini file.
XSIZE	width of the image to be captured (default: 2048)
YSIZE	height of the image to be captured (default: 2048)
RESET	16-bit ASIC hex address that will be used for programming the number of requested reset frames (default: 0x0000, i.e. disabled)
READ	16-bit ASIC hex address that will be used for programming the number of requested read frames (default: 0x0000, i.e. disabled)
GROUP	16-bit ASIC hex address that will be used for programming the number of requested acquisition groups in the ramp (default: 0x0000, i.e. disabled)
DROP	16-bit ASIC hex address that will be used for programming the number of requested drop frames (default: 0x0000, i.e. disabled)
DROP2	16-bit ASIC hex address that will be used for programming the number of requested drop2 frames, meaning depends on application (default: 0x0000, i.e. disabled)
DROPWAIT	read time per drop frame in milliseconds, used to calculate timeout (default: 1500)
SENDRST	16-bit ASIC hex address of register that controls whether reset frames should be sent out or not by the ASIC. Requires second parameter (separated by space) to state which bit in the given register controls the "send reset frame" function (default: 0x0000 0, i.e. disabled)
CLKDRP	16-bit ASIC hex address of register that controls whether the detector should be clocked or not while in drop frames. Requires second parameter (separated by space)

	to state which bit in the given register controls the "clock drop frames" function (default: 0x0000 0, i.e. disabled)
TRGDEST	Determines whether to send the acquisition start trigger to a MACIE or and ASIC register. Allowed values are the strings MACIE and ASIC (default: ASIC)
TRGADDR	16-bit hex address of register that needs to be written to trigger the acquisition (default: 0x0000, i.e. disabled)
TRGVAL	hex value that needs to be written to the TRGADDR register to trigger the acquisition (default: 0x0001)
STOPVAL	hex value that needs to be written to the TRGADDR register to stop the acquisition before it is completed, i.e. abort (default: 0xffffff, i.e. disabled)
TRGDEFVAL	hex value that will be written to the TRGADDR register before the TRGVAL is written (at the start of an acquisition) to reset the trigger register in case it was still active from before (default: 0xffffff, i.e. disabled)
PRETRIGADDR	16-bit hex address of register that needs to be written to before a new acquisition can be triggered, e.g. to trigger any potential exposure configuration (default: 0x0000, i.e. disabled)
PRETRGVAL	hex value that needs to be written to the PRETRIGADDR register before a new acquisition can be triggered (default: 0x0000)
PRETRGWAIT	wait time in milliseconds after the PRETRGVAL has been written to the PRETRIGADDR before the actual acquisition trigger takes place (write to TRGADDR) (default: 1000)
TIMEOUT	read time per read/reset frame in milliseconds, used to calculate timeout (default: 1500)
CLWIDTH	width of Camera Link frame (default: 2048)
CLHEIGHT	height of Camera Link frame (default: 2048)
DATAFORMAT	unsigned integer (0-3) that indicates the science data format (default: 0): 0 = 16-bit words 1 = 24-bit words (e.g. 2*12bit) 2 = 32-bit words 3 = 32 bit words (2 * 12 bit aligned on word boundary)
RESETPOLARITY	determines whether the reset control line has active-low (0) or active-high polarity, in order for the reset button to work properly (default: 0)
CAMLINKOVERHEAD	extra pixels per row to be used in the Camera Link frame, only applied when the auto-mode for the Camera Link frame size is checked in the Data Acquisition tab of the GUI (default: 0)

EXTRAPIXELS	extra pixels per frame that exceed the amount calculated by the XSIZE * YSIZE plus potential guide windows (if enabled). These pixels are assumed to be at the very end of the frame, and will not be included in the saved fits file. (default: 0)
SORTMODE	configures pixel sorting per row to restore correct pixel order of detector. Valid options are 0 (no sorting), 1 (normal sorting, i.e. all output scan in the same direction), and 2 (alternative sorting, i.e. even outputs scan in opposite direction of odd outputs), (default: 0)
SORTCHANS	number of output channels per detector. This parameter is used to determine the sorting algorithm described under SORTMODE (default: 32)
SCIHEADERS	number of additional pixels per row (like science header words) that need to be ignored when applying the sorting algorithm described under SORTMODE (default: 0)
GUIDEMODEEN	enable (1) or disable (0) the guide mode handling in the GUI (default: 0)
GUIDEXSIZE	width of the guide windows (default: 16)
GUIDEYSIZE	height of the guide windows (default: 16**)**
GUIDESTARTROW	number of full field rows before first guide window (default: 256)
GUIDENROWS	number of full field rows between guide window reads (default: 256)
GUIDENREADS	number of guide window read or reset frames per guide window section (default: 1)
GUIDEEND	if set (1), guide windows are expected at the end of the full field. If not set (0), no guide windows are expected at the end of the frame (default: 0)
TESTPATTERN	MACIE test pattern options, decides what test pattern to run if the TRGDEST parameter is set to MACIE: OFF - no test pattern configuration. This can be used when requiring triggering ASIC acquisitions through a MACIE register write. PORT_FIFO (default) - Generate and capture USB/GigE/CamLink test pattern ASIC_FIFO_2X - Generate and capture Main FIFO test pattern (2 ASICs per MACIE) ASIC_FIFO_1X - Generate and capture Main FIFO test pattern (1 ASIC per MACIE)

7.3 Load Files

The software package also provides a list of load files for the general operation. These load files are defined in a custom text format which can be easily modified by the user as needed. The following syntax and keywords can be used to determine the behavior of the files:

7.3.1 .mcf file: Master Configuration File:

MACIE_Select n [n n n n n n n]	determines which MACIE cards are to be addressed during register writes, where n specifies the specific MACIE ID number. n can be any value 1, 2, ... 8. Examples: MACIE_Select 1 MACIE_Select 2 4 5
ASIC_Select n [n n n n n n n]	determines which ASICs are to be addressed during register writes, where n specifies the specific ASIC ID number. n can be any value 1, 2, ... 8. Examples: ASIC_Select 1 ASIC_Select 1 2 7 8
LOAD Filename	specifies a file to be loaded. Filename includes the path, which can be relative or absolute, and the file name itself. Load files can be of the following types: .glf (global load file): contains register configurations for MACIE and ASIC .mcd (machine code): contains SIDECAR ASIC configuration/assembly code .ald (ACADIA load file): contains ACADIA ASIC config/sequencer code
WAIT n	inserts a wait time of n milliseconds before continuing with the next line
#	comment

7.3.2 .glf file: Global Load File, .mcd file: Machine Code, .ald file: ACADIA Load File

ADDR VALUE	4 digit hex address, followed by 4 or 6 digit hex value. Specifies a write to the given address, using the provided value. Examples: 1234 5555 65e4 a4bc 8040 123456 # address is above 7000 for SIDECAR, i.e. 24-bit
MACIE_MODE	switches the destination to MACIE, i.e. all subsequent register writes go to the MACIE FPGA.

	Note: all files default to ASIC_MODE if no destination is specified. This means that .mcd and .ald files do not need a destination since they always have to go to the ASIC. For a .glf file, it is usually best to include the destination in the file to avoid confusion.
ASIC_MODE [DMA/MSPI_REG]	switches the destination to ASIC, i.e. all subsequent register writes go to the ASIC. An optional keyword can be appended to configure the DMA bit (SIDECAR ASIC) or the mSPI write destination (ACADIA ASIC): DMA: if present, it configures the SIDECAR register writes to use the DMA bit option (i.e. interface takes priority of micro-controller when accessing memory resources). If not present, DMA bit will not be used. This applies to all subsequent write actions until a new ASIC_MODE keyword is detected. By default, the DMA option is configured to not set the DMA bit. MSPI_REG: if present, all subsequent ACADIA mSPI write actions will go to the special mSPI register address space rather than the generic ACADIA address space. If not present, the generic ACADIA address space will be used. By default, the MSPI_REG option is not set.
blockstart, address nnnn, length n, blockend	defines a consecutive section of memory or register space that will be written. Inside the block, only the values are listed. Each block requires 3 keywords at the beginning (blockstart, address, length) and one keyword at the end (blockend). The address is a 4 digit hex number, the length is a decimal number not to exceed 512 for the SIDECAR, and 510 for the ACADIA ASIC Example: blockstart address 4444 length 3 5555 abcd dead blockend
WAIT n	inserts a wait time of n milliseconds before continuing with the next line
#	comment

7.4 Multi-MACE and Multi-ASIC Operation

Starting with MACIE software v5.1, Multi-MACIE and Multi-ASIC applications through USB or GigE interface are supported (requires specialized MACIE firmware, please contact Markury Scientific to obtain further information).

Please note that the Camera Link interface is currently not supported for Multi-MACIE and Multi-ASIC application.

7.4.1 Functions Supported:

In v.5.1, the MAC software and MACIE library have been upgraded to support Multi-MACIE and Multi-ASIC applications. Please note that the MSAC GUI still only supports single MACIE and ASIC applications.

Check Interfaces: If the MAC software detects multiple MACIE cards that are each connected to the PC through their own USB, GigE, or CameraLink interface, a dialog window will pop up with a list of all detected MACIEs and their communication interfaces. The user is prompted to select one of the MACIEs for operation (MAC only supports one interface at a time, multi-MACIE support in the MAC is only provided through stacking of MACIE cards, and communicating through a single PC interface). After the dialog window is closed, the main window GUI will be updated with the selected MACIE card and its communication interface. In the MACIE library, this function will output a list of MACIEs for the user to select a one (or multiple) for operation.

Get Available MACIEs: Reports the current master MACIE (the card connected to the PC), and all slave MACIEs which are connected to the master MACIE through the MACIE-to-MACIE board connector (i.e. stacked on top of the master MACIE). The maximum number of MACIEs is 8.

Get Available ASICs: Reports all the connected ASIC cards. The maximum number of ASICs supported for operation is 8, and each MACIE has a maximum number of 2 ASICs connected. If operating 2 ASICs per MACIE, the maximum number of MACIEs supported is 4. If operating 1 ASIC per MACIE, the maximum number of MACIEs supported is 8.

Image Ramp Acquisition: Perform multi-MACIE / multi-ASIC image acquisition through USB or GigE interface. By selecting the Auto Config Multi-ASIC FIFO and corresponding ASICs (checkboxes) on the MAC GUI, the software will read science data from multiple FIFOs after the Acquire button is pressed. Based on whether the option of "Process Multi-FIFO science data at Runtime" is selected or not, the software will:

if "Process Multi-FIFO data" checked: save the science data into individual fits files (one file per ASIC), or

if "Process Multi-FIFO data" not checked: save the science data to a combined fits file with the image dimension being width x n by image height (n = number of ASICs).

MACIE Test Pattern: Two new pre-configured test patterns have been provided, in support of Multi-MACIE and Multi-ASIC operation. Please see the description in Section 7.2.3 under "Configuration Select" for further details.

7.5 MACIE Configuration Tool

MACIE Configuration Tool is a windows-based GUI application for upgrading the MACIE FPGA firmware. It requires the following packages to be pre-installed on the windows:

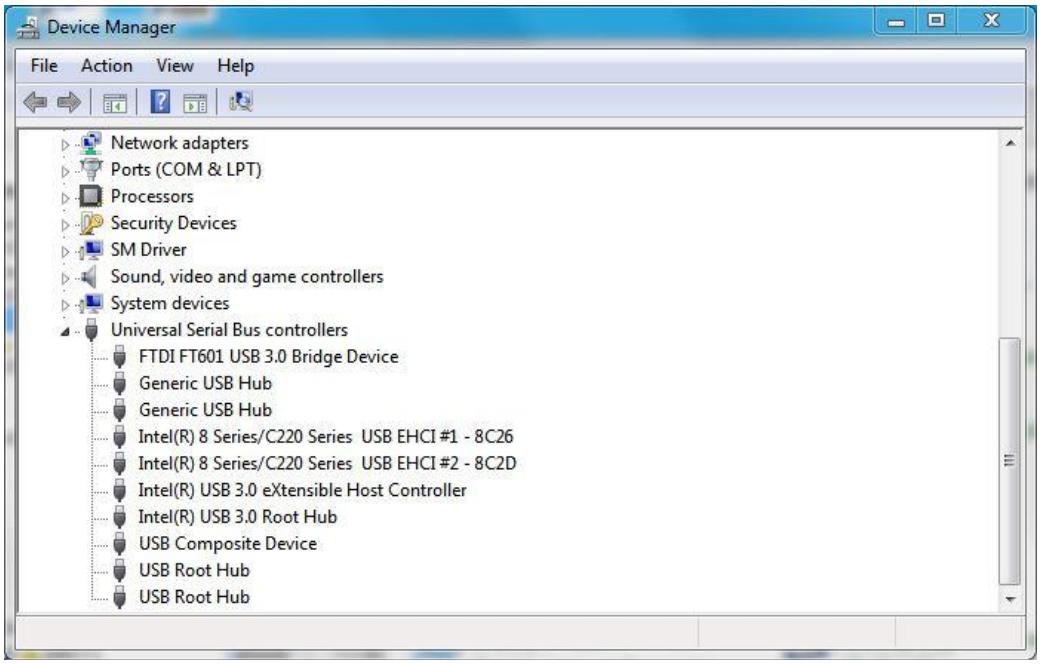
- .NET 4.0 or later
- Visual C++ 2010 Redistributable, 32-bit

8 Communication Interface Troubleshooting

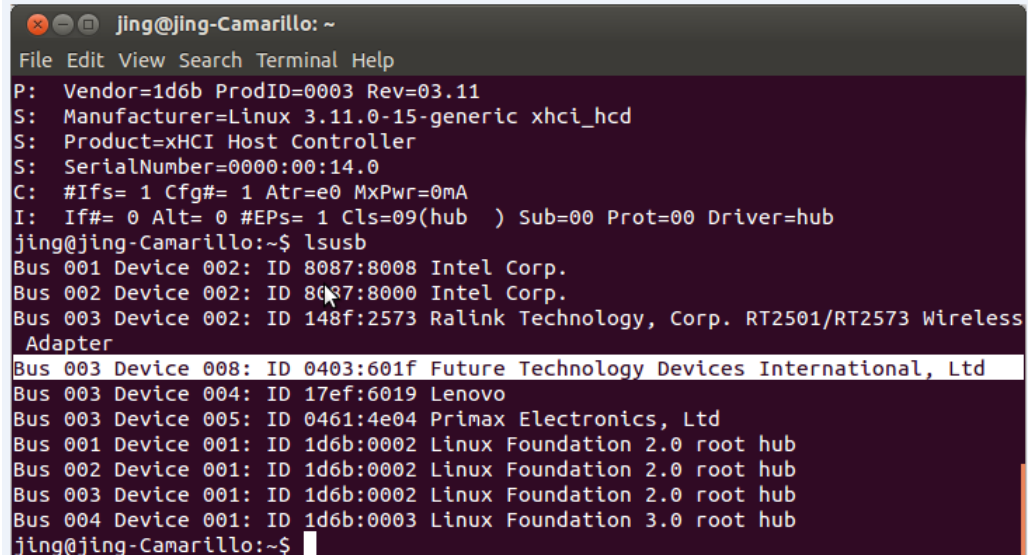
If any of the connected communication interfaces is not detected by the software GUI, the following troubleshooting steps can be taken:

8.1 USB Interface Troubleshooting:

On Windows: Go to Windows -> Front Panel -> System -> Device Manager, and check if the MACIE card is listed under the USB ports. It is listed as FDTI FT601 USB 3.0 Bridge Device.

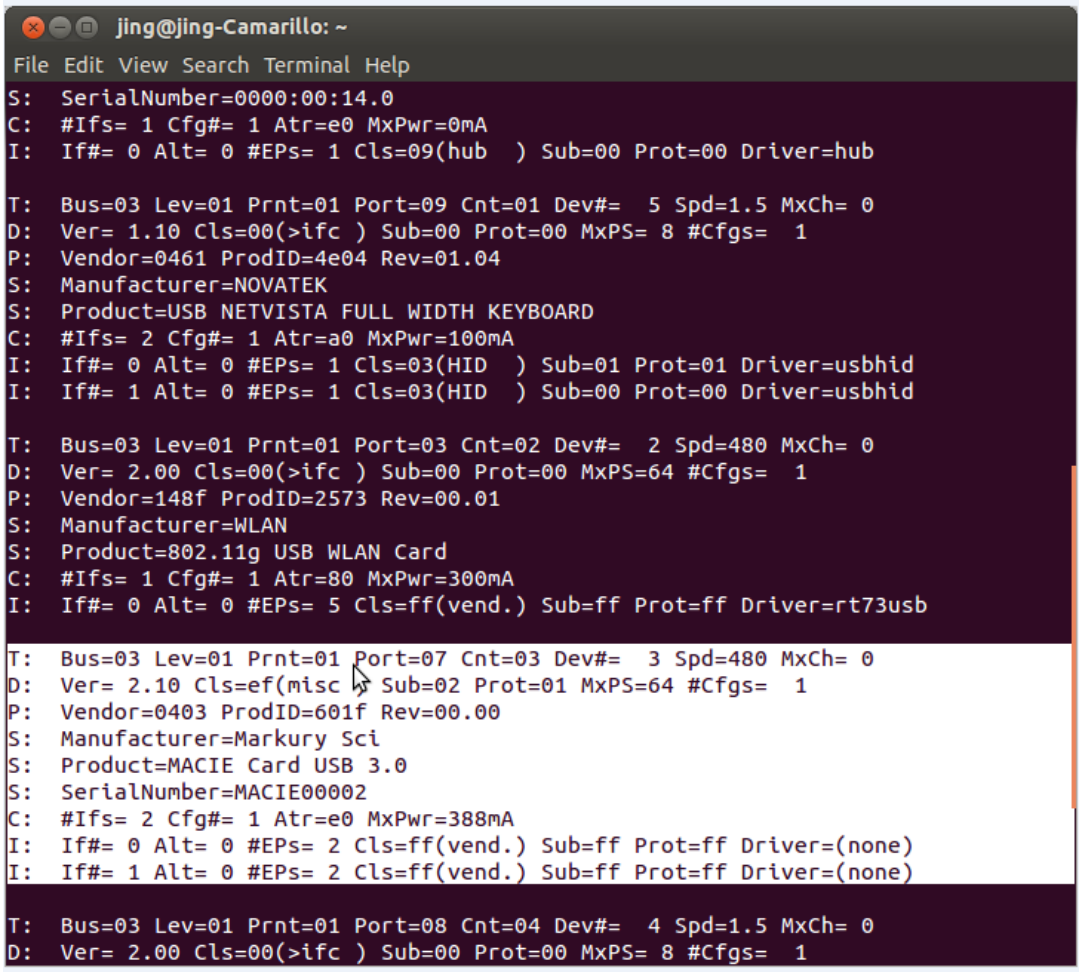


On Linux: Type “lsusb” command in terminal:



Terminal commands (“lsusb –v”, “lsusb-t”) may also be helpful.

Type **“usb-devices”** in terminal:



8.2 Disable USB Auto-Suspend Mode - Linux

After the communication interfaces are detected successfully, the corresponding LEDs on the MACIE card will turn to green. If the LED for the USB communication interface turns to red after 1-2 seconds, it is likely the USB driver is in auto-suspend mode. It is optional to disable the auto-suspend mode by the following command to avoid the LED turning from green to red

On Linux:

- Open file /etc/default/tlp
- Add line USB_BLACKLIST="0403:601f" to USB section
- Disconnect/reconnect USB device, possibly reboot Linux machine (may not be necessary)