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# Embeddable Analog HD DVR

Model 4023

Hardware Manual  
Ver. 1.2.0 | December 2019

SENSORAY | embedded electronics



Designed and manufactured in the U.S.A

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## Limited warranty

Sensoray Company, Incorporated (Sensoray) warrants the hardware to be free from defects in material and workmanship and perform to applicable published Sensoray specifications for two years from the date of shipment to purchaser. Sensoray will, at its option, repair or replace equipment that proves to be defective during the warranty period. This warranty includes parts and labor.

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A Return Material Authorization (RMA) number must be obtained from the factory and clearly marked on the outside of the package before any equipment will be accepted for warranty work. Sensoray will pay the shipping costs of returning to the owner parts that are covered by warranty. A restocking charge of 25% of the product purchase price will be charged for returning a product to stock.

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# Introduction

Model 4023 is a compact digital video recorder, designed for embedded OEM applications. It captures video from analog HD (TVI, CVI, AHD) sources in resolutions up to 1080p30, or analog SD (composite) source, and records to a USB media. Snapshots (in JPEG format) can be captured on-the fly without interrupting the recording. Analog audio can be captured from a microphone or a line source. Model 4023 outputs live or recorded video, or JPEG snapshots to an external DVI monitor. Date and time are maintained by a real-time clock with battery backup. Implementing a complete DVR requires connecting power, a custom keypad or a keyboard, and a USB storage device(s).

The video processor implements H.264 or MJPEG video compression, producing output data formatted as MPEG transport stream (MPEG-TS) or MP4 file formats. Audio compression is performed using AAC-LC. The stream multiplexer employs high precision hardware timestamps to ensure perfect audio-video sync during playback.

Model 4023 provides a set of general purpose I/O lines that could be used to control DVR's functions. It can also be configured to automatically start recording on power up. The delay between applying the power and start of recording doesn't exceed 20 seconds. With MPEG-TS recording format the recording is preserved after power is turned off without issuing a Stop record command.

Three host USB ports are provided for connecting storage, a keyboard, or a WiFi adapter. Simultaneous recording to 2 storage devices is supported.

# Connectors

All mating connectors use crimping contacts Molex 0500798100 for 26-28 AWG wire. Contacts labeled "reserved" should be left unconnected.

## ***J4 (video input 2), J5 (video input 1)***

BNC female connectors.

## ***J3, composite video output***

Molex 5023520410. Mating part: Molex 5023510400.

Pin	Signal
1	reserved
2	composite out <sup>1)</sup>
3	ground
4	reserved

Notes.

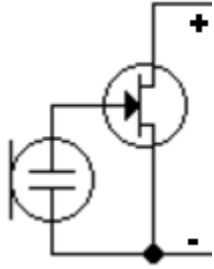
1. Operational with a composite input source only.

## ***J6, audio inputs***

Molex 5023520610. Mating part: Molex 5023510600.

Pin	Signal
1	microphone in +
2	microphone in -
3	ground
4	line input right
5	ground
6	line input left

Note: microphone input expects an electret condenser microphone:



### ***J7, audio output***

Molex 5023520410. Mating part: Molex 5023510400.

Pin	Signal
1	line audio out, left
2	ground
3	ground
4	line audio out, right

### ***J10, power***

Molex 5023520210. Mating part: Molex 5023510200.

Pin	Signal
1	ground
2	+ 12V DC

### ***J9, RS-232***

Molex 5023520310. Mating part: Molex 5023510300.

Pin	Signal
1	RS-232 TX <sup>1)</sup>
2	RS-232 RX <sup>1)</sup>
3	ground

Notes:

1. Functionality not implemented in standard firmware.
2. TX and RX are 4023's transmit and receive lines, respectively.

## **J2, keypad GPIOs**

Amphenol/FCI SFW15R-2STE1LF. Mates with an FPC cable, for example, Wurth 686615152001.

Pin	Signal
1	DIO33V8
2	DIO33V7
3	DIO33V6
4	DIO33V5
5	DIO33V4
6	DIO33V3
7	DIO33V2
8	DIO33V1
9	DIO33V0
10	ground
11	SCL
12	SDA
13	+3.3V
14	ground
15	+5V

Notes:

1. Please refer to "Keypad functions customization" chapter for the details on using the GPIO signals.
2. SCL, SDA are I2C bus signals. The 4023 is the I2C bus master. Use of the I2C bus requires firmware customization. Please contact Sensoray if that is required.

## **JP1, JP2, incremental encoders connectors**

Samtec T1M-06-F-SH-L-K. Mating part: Samtec ISS1-06-L, crimp terminals CC09M-01-GF.

Pin	Signal
1	Encoder power (+)
2	A+
3	A-
4	B+

5	B-
6	ground

Notes:

1. If using single ended encoder signals, leave the negative line (A-, B-) unconnected.
2. Encoder power is selectable between 12V and 5V with a switch SW1. Each encoder port is protected with a 0.2A resettable fuse.



# DVI video output

Model 4023 outputs pass-through HD video on the DVI output. DVI cables of different lengths are available from various sources. Also available are DVI-to-HDMI adapters and cables, which may be required in case the monitor has an HDMI input. DVI and HDMI interfaces use identical video signaling, so adapters and cables are passive and inexpensive.

Most DVI (HDMI) monitors support multiple resolutions and frame rates, and automatically adjust to the input signal. However not all monitors support all resolutions and frame rates. Please read the following section carefully to understand the limitations that may arise in some camera/monitor combinations.

Model 4023 supports camera resolutions up to 1080p30. That means that in practice there are 3 possible input signal resolution/frame rate combinations:

- 720p30(25);
- 720p60(50);
- 1080p30(25).

Out of those three the most popular mode supported by the DVI monitors is 720p60(50). It will work with the majority of monitors. If the input video is 720p30(25), the 4023 doubles the frame rate on the output port to make it compatible with 720p60(50) monitors. However, frame rate doubling cannot be performed with 1080p30(25) input due to hardware limitations. On the other hand, some displays only support 1080p60(50), but not 1080p30(25). To deal with such situation, the 4023 provides 2 options that could be selected from the Setup/Video/Display output submenu.

## **Option 1. Scaling display output, recording in original resolution.**

Selecting "Auto" from the Setup/Video/Display output submenu results in the 4023 setting the DVI output to the resolution supported by the monitor, closest to the input resolution. The video will be recorded at camera's resolution, up to 1080p30(25), but will be scaled up or down for display. One limitation of this mode is that the text overlays will not be displayed continuously on the monitor once the overlay configuration is complete. The overlays will be present on the recording. If one or more overlays are enabled, a corresponding message will appear on the screen, but the overlays will not be displayed on the monitor.

The other limitation is that videos and snapshots recorded at resolution that is not supported by the monitor, will not play back on the 4023.

## **Option 2. Scaling down input video, recording in reduced resolution.**

Selecting a specific resolution from the Setup/Video/Display output submenu could serve two purposes. First, it allows forcing a specific resolution in case the 4023 cannot get correct information from the monitor. Second, it will force the input video to be scaled down to the resolution supported by the display. The benefits of such an approach are that the text overlays will be present both on the display and the recording, and recorded videos could be played back directly on the system. However, this approach may result in loss of resolution on the recording.

# Menu system

The DVRs are controlled using a keypad or a standard keyboard and the on-screen menu system.

Context-dependent keyboard functions mapping:

Key	Functions	
	Outside of the menu	Inside the menu
Enter, Space	Menu	OK
F2	Menu	
Up arrow	Rewind by set amount	Move up
Down arrow	Fast forward by set amount	Move down
Escape	Stop	Back
R	Record/Pause	
S	Snapshot (screen shot)	
P	Pause toggle during recording or playback; Play video otherwise	
M	Mute toggle	
F	Fast forward by set amount	
D	Rewind by set amount	
K	Keypad mapping menu	
O	Overlays menu	
T	Title overlay toggle	
C	Coded overlay toggle	
E	Extra overlay toggle	
F4	Toggles the mode that allows adjusting the current secondary overlay position with arrow keys	

Context-dependent keyboard functions mapping (continued):

Key	Functions	
	Outside of the menu	Inside the menu
F6	Resets the first incremental encoder footage to 0 without affecting the calibration factor	
F10	Enters the free text mode. Escape exits the free text mode	

### Top menu

**Play video**  
**View snapshots**  
**Overlays**  
**File management**  
**Setup**  
**Help with Keys**

### Play video

Plays video recordings stored on the media. Selecting “Play video” brings the next menu level:

```
===Play video source===  
Internal  
External
```

Selections are displayed if both internal and external storage devices are present. If only one is present, the files list is displayed. File selection is made using arrow keys. Pressing OK/Enter starts playback. Escape or Stop terminates the playback.

### View snapshots

Displays snapshots (.jpg) stored on the media. Behavior is similar to “Play video”.

### Overlays

Brings up Overlay menu:

```
==Overlays==
```

**Primary Overlay:**

Toggles the overlay text on or off. Allows selecting one of 3 font sizes.

**Setup Primary Overlay**

Primary overlay setup. The available options are:

**Text**

Brings up Select Overlay Text menu.

**== Select Overlay Text==**

This menu allows selection of text to be displayed on top of live and recorded video.

The following conventions are used:

^d - current date;

^t - current time;

Products with incremental encoder additionally allow display of encoder data:

^e - encoder #1 data;

^f - encoder #2 data.

Selected length unit (m or ft) is displayed for each encoder. Units are selected in **Incremental Encoders** menu (see below).

Custom text strings set up in **Custom Text** menu (see below) are also listed.

^n - new line character.

**Custom text**

Allows entry of up to 5 custom strings for an overlay. Only one of five is displayed at any given time. Entry of each string is terminated by pressing Enter key.

**Date Format**

Allows selection of various date formats for date overlay.

**Time Format**

Allows selection of various time formats for time overlay.

**Background**

Selects background transparency for overlays.

**Move . . .**

Moves the overlay box across the screen in selected direction.

**Reposition top left**

Moves the overlay text to the top left corner of the screen.

**Secondary overlay**

Allows selecting a secondary overlay which is displayed concurrently with primary from the following options:

**Off**

Turns secondary overlay off

**Title**

Selects Title overlay as secondary

**Coded**

Selects Coded overlay as secondary

**Extra**

Selects Extra overlay as secondary

**Addtl**

Selects Additional overlay as secondary

**Setup Title (Coded, Extra, Addtl) Overlay (T, C, E, A)**

== Title Overlay ==

**Edit Text**

Allows manual text entry

**Load**

Loads from parameters.txt

**Save**

Saves parameters.txt

**Text size**

Selects text size

**Background**

Selects background transparency

**Move...**

Selects overlay's position on the screen

**File management**

Selecting "File management" brings up the following selections (selections depend on the presence of internal and/or external drives):

**Copy video from internal**

**Copy video from external**

**Copy snapshots from internal**

**Copy snapshots from external**

**Delete files from internal**

**Delete files from external**

**Rename files on internal**

**Rename files on external**

**Toggle copy or move**

**Select files:**

The last item allows switching between individual and group files selection. The latter allows selecting files for a group operation (copy or delete).

## **Setup**

Selecting "Setup" brings up the next menu level:

**== Setup ==**

**Set Date/Time**

Allows setting the battery backed-up real-time clock. The real-time clock is used to automatically generate file names for saved video files and snapshots. There is also an option of having the date/time text overlay present in recorded video and snapshots.

**Video**

Brings up Video setup menu:

**==Setup Video==**

**Video Input**

Allows selecting one of the two available video inputs.

**Interpolate**

Turning interpolation ON gets rid of motion artifacts at an expense of some vertical resolution loss for interlaced sources. Has no effect on progressive scan sources.

**Video Bit Rate**

Determines the compression level of recorded video. The higher the bit rate, the higher is the quality, the more space is required on the storage device. Bitrate value can be used to calculate approximate storage requirements. For instance, with default bitrate of 5 Mbits per second, a 64 GB flash drive can hold  $64,000 \text{ Mbyte} * 8 \text{ bits/byte} \div 5 \text{ Mbits/sec} = 102,400 \text{ sec} = 28.4 \text{ hours}$  of recording. This number is approximate, it also does not take audio into account, which may reduce it by approximately 10%.

**Playback Seek**

Adjusts the amount (in seconds) of time skipped when using Rewind and Fast Forward functions.

**Snapshot quality**

Adjusts the compression level of JPEG snapshots. The higher the setting, the higher the quality and the larger the file size.

**Snapshot overlay**

Determines whether the overlay is present on snapshots.

**Recording at power-on**

When set to ON recording starts automatically once the board is powered on with approximately 20-30 second boot delay.

**Recording format**

Presents a choice of MP4 or TS (transport stream). Default is MP4 (for compatibility reasons). TS format, which is now supported by most hardware and software players, may be preferable because of better robustness in case of an accidental recording interruption, for example, due to a power loss.

**Recording limit**

Due to 4GB file size limitation of FAT32 file system, long recordings may be split into multiple files. The maximum size of the recorded file (4GB by default) can be adjusted using this menu selection. Zero size means maximum allowed by the file system, which for FAT32 is the same as 4GB.

**Display output**

Selects the resolution and frame rate of the DVI output. Please refer to the "DVI Video Output" section for the details.

**Audio**

Brings up Audio setup menu:

**==Setup Audio==**

**Audio Volume**

Adjusts input volume. The higher the value the louder recorded audio is.

**Audio AGC**

Turns audio automatic gain control on or off.

**Mute Recording at Start**

Selecting "Mute" disables audio recording each time recording is started. Selecting "Unmute" enables audio recording each time recording is started. Selecting "Disabled" keeps the current setting at the start of the recording (set previously with a keyboard or a keypad). Audio recording can be enabled



and disabled while recording is in progress by pressing "M" key on the keyboard, or a corresponding (Mute/Unmute) key on the keypad.

**Audio Input**

Selects between microphone and line. Note that available type of input depends on the model and assembly option of the board.

**Playback Volume**

Adjusts audio playback volume.

**Audio passthru**

Enables or disable audio pass-through.

**Record Storage Device**

Allows selecting device(s) that video and snapshots are recorded to: internal, external or both. If "Prompt" option is selected the user is prompted each time a recording is started.

**Incremental Encoders**

Brings up Select Encoder menu.

**==Select Encoder==**

**Encoder 1**

**Encoder 2**

Selects one of the two available encoder interfaces. Selecting one of those brings up Setup Encoder 1(2) menu:

**==Setup Encoder 1(2)==**

**Units**

Selects length units: meters or feet.

**Set Zero Point**

Sets zero length point.

**Set calibration point**

In order to calibrate encoder readings in length units the known length of cable needs to be dispensed (after zero has been set). Select one of suggested calibration points (after having dispensed the corresponding length).

### **Set offset**

Allows manually adjusting the offset point after the calibration.

### **System Information**

Displays various system information, including the unit's serial number, firmware version, detected storage devices with free space available. Additionally allows managing system parameters.

#### **Reset system parameters**

Resets system parameters to default values. The defaults can be either factory, or custom. Please see "Maintaining custom settings" section for the details.

#### **Save system parameters**

Saves current system parameters to `config.txt` file.

#### **Load system parameters**

Loads system parameters from `config.txt` file.

### **Update firmware**

This selection is available only if a firmware file is detected in the root directory of one of the connected storage devices. Please obtain the firmware file `s4023.fw` from Sensoray and copy it to a root directory of a USB drive. Update process usually takes about 30 s, after which the board restarts. Please refer to "Firmware updates" chapter for the details.

### **Update custom.zip**

This selection is available if `custom.zip` file is detected in the root directory on one of the connected storage devices. This file contains custom settings, such as a splash screen and default system parameters.

#### Custom splash screen

The splash screen has to be created as a JPEG file with the name `splash.jpg` with one of the following resolutions: 720x480 for NTSC systems, or 720x576 for PAL systems. This file has to be placed into the directory called `images`, and zipped to `custom.zip`. To remove a custom splash screen place a zero byte `custom.zip` file into the root directory of a storage device and then select "Update custom.zip". To create a zero length file in Windows open a command prompt window and type `copy NUL /b custom.zip`.

#### Custom default parameters

Custom default parameters (activated by selecting "Reset system parameters" from "System information" menu) must be first saved to `config.txt` (using "Save system parameters" from "System information" menu). The resulting `config.txt` must be zipped into the root directory of `custom.zip`, and loaded using "Update custom.zip" from "Setup" menu.

#### **Turn WiFi On/Off**

This selection is available only if the unit is programmed with WiFi-enabled firmware and a WiFi adapter is detected in one of the USB ports. Please note that in order to be detected by the DVR a WiFi adapter needs to be present at the power up.

#### **Turn WiFi ping on (available only when WiFi is turned on)**

Enabling WiFi pings may help with some wireless clients (receiving devices) that keep dropping the connection. Should be turned off normally.

#### **Serial setup**

Sets up serial communication port.

##### **==Serial Setup==**

##### **Baudrate**

Selects the baud rate of the serial port.

##### **Protocol**

Selects communications protocol.

# Keypad functions customization

Model 4023 provides a set of GPIO signals for DVR control. Those could be connected to an external microcontroller, or a keypad. All GPIO lines are pulled up to +3.3V and activated by briefly connecting to ground. The selected function is activated on a disconnect from the ground. No hardware debouncing is required.

The default functions assigned to GPIO lines are listed below:

Signal	DVR function
DIO33V0	Record/Pause (recording or playback)
DIO33V1	Stop (recording or playback)/Back (while in menu)
DIO33V2	Snapshot
DIO33V3	Down (menu navigation)
DIO33V4	Menu/OK
DIO33V5	not assigned
DIO33V6	Up (menu navigation)

The functions could be reassigned using the following procedure. A USB keyboard needs to be connected to the 4023.

1. Press "K" on the keyboard. The 4023 will enter the Keypad Configuration screen.
2. Select the signal that needs to have a different function assigned to (DIO33Vx) using arrow keys, and press Enter.
3. Select a required function from the list.
4. Repeat the procedure for all required signals.
5. Exit the Keypad Configuration screen by pressing Esc key. Enter the system Menu by pressing Enter key. From the menu select Setup/System Information/Save system parameters. The file containing customized assignments (`config.txt`) is saved to the root of the external flash drive.
6. On all units that require customization load `config.txt` by going to the menu and selecting Setup/System Information/Load system parameters. Once it's done, the `config.txt` is no longer required to be present on the flash drive. Alternatively, it could be arranged that your customized `config.txt` is loaded at the factory. Please contact Sensoray's technical support to set it up ([support@sensoray.com](mailto:support@sensoray.com)).

GPIO lines not covered by the default functions assignment (DIO33V7, DIO33V8) can be used for custom functions. Implementation of those requires firmware modifications.

Please contact Sensoray to discuss available options.

# Specifications

Video Input/Output	
Input video formats	HD-TVI, HD-CVI, AHD, composite (NTSC/PAL)
Maximum input resolution/frame rate	1920x1080p30
Video output	DVI
Recorded video streams	
H.264	High Profile @ Level 3 (MP4, AVI, transport stream)
JPEG	Single snapshots, AVI
Storage media	USB drives <sup>1)</sup>
Electrical, mechanical and environmental	
Dimensions	3.25 x 2.375 x 0.875 inches
Operating temperature	0° to 70° C.
Power	12 V DC, not to exceed 3.0 W <sup>2)</sup>

## Notes:

1. Only FAT32 file system is supported on storage media. If reformatting is required, the following utility could be used:  
[www.verbatim.com/includes/binary\\_details.php3?show=1&id=840](http://www.verbatim.com/includes/binary_details.php3?show=1&id=840)
2. Power consumption without any storage media, other USB devices and incremental encoders plugged in.

# Firmware updates

Model 4023 features flash memory that contains the firmware used to operate the hardware on the device. This firmware can be updated in the field to fix problems or add new features. Please follow the procedures below.

1. Obtain the latest firmware file, `s4023_fw`, from Sensoray, and copy it to the root directory of a USB drive.
2. Plug the USB drive into one of the ports, and follow the update procedure (Setup/Update firmware). Please note that "Update firmware" option appears in the Menu only if a valid firmware file is detected on the USB drive.
3. The unit should reboot automatically after the update is complete. If it does not reboot within 1 minute, please cycle the power.
4. If the pass-through video is black (menu still visible), reset the system parameters (Setup/System Information/Reset system parameters).

## Revision history

Version	Notes
1.2.0, December 2019	Detailed menu description added.
1.1.2, December 2019	Clarifications of DVI output and recording options.
1.1.1, July 2019	Clarifications of DVI output options.
1.1.0, May 2019	DVI output section added.
1.0.1, March 2019	Incremental encoders connector information added.
1.0.0, March 2019	Initial release.