Embeddable Digital Video Recorders
4000 Series

Models 4011, 4012, 4013
Hardware Manual

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SENSORAY | embedded electronics

Designed and manufactured in the U.S.A

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Introduction

Sensoray's 4000 series of compact digital video recorders (DVR) are designed for embedded OEM applications. The family currently includes models 4011, 4012 and 4013. All of those record audio and video (A/V) to USB storage media and can capture JPEG images on-the-fly without interrupting recording. The units output live video, recorded A/V or JPEG snapshots to an external composite 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.

The DVRs encode standard NTSC/PAL composite video using efficient H.264 compression. Audio is digitized and compressed using AAC encoding. The compressed A/V streams are multiplexed and recorded as MP4 files on a user-supplied USB storage device, with file names automatically generated by the real-time clock. Videos and snapshots are saved to the DCIM directory on the storage device(s). Bit rates can be tailored to match application requirements and storage capacity.

Models 4012 and 4013 include two incremental encoder interfaces, which allow position information to be captured in real time and overlaid directly onto the video. The DVR provides power to the encoders, 5 or 12V, selectable with a switch (model 4013) or a jumper (model 4012). Each encoder's power line is protected by a 0.2A resettable fuse.

Various text overlays can be applied to appear in the recorded video and preview.

An external USB storage device is required for DVR operation. If desired, a second USB storage device may also be connected and the DVR will simultaneously record to both devices. A common application for this is recording to a removable device while creating an archival copy on a non-removable device. USB connectors are located on both sides of the board to facilitate connection to both removable and embedded storage devices.

The DVR user interface supports a user-supplied keypad working in conjunction with the board's flexible on-screen menu system. Each keypad connector pin can be routed directly to any keypad switch and configured to match the control scheme of your custom keypad. If preferred, a standard keyboard can be plugged into any USB port and used to control the DVR.

All members of the 4000 series use the same firmware. Some features are available on particular models only. Connector pinouts are listed for each model in respective chapters below. Differences between the models are summarized in Table 1.

Table 1. Summary of differences between the members of 4000 series.

Features	4011	4012	4013
External USB ports	vertical	vertical	right-angle
Incremental encoder interfaces	0	2	2
Built-in microphone	yes	yes	no
Line audio input	no	optional	yes
RS-232 (Note 1)	optional	yes	yes

Note 1: Firmware implementation of RS-232 communications requires knowledge of application specific protocols and is provided on a custom basis. Please contact Sensoray if this feature is required.

Connectors

USB Connectors

There is a total of three USB 2.0 connectors on all models: two on the top side and a single connector on the bottom side. All connectors are functionally interchangeable. The only difference is that a storage device plugged into the connector on the top side is considered “external”, on the bottom side – “internal”.

Model 4011

Power

J11, Molex 0705530002.
Mating part: Molex 0050579403, crimping contacts Molex 0016020102.

Pin	Signal
1	+ 12V
2	n/c
3	ground

Video

In (J10), out (J2), Molex 0705530001.
Mating part: Molex 0050579402, crimping contacts Molex 0016020102.

Pin	Signal
1	video in/out
2	ground

Audio out

J13, Molex 0705530003.
Mating part: Molex 0050579404, crimping contacts Molex 0016020102.

Pin	Signal
1	left channel
2	ground
3	ground
4	right channel

Keypad

J4, Molex 90500-4007, 7 pin.
Accepts a ZIF-style flex tail, 0.1" pitch.

Recommended mapping for keypad pins and functions:

Pin	Function	Signal
1	Record/Pause	DIO33V0
2	Stop/Back	DIO33V1
3	Snapshot	DIO33V2
4	Down	DIO33V3
5	Menu/OK	DIO33V4
6	Common (ground)	
7	Up	DIO33V6

Keypad functions could be remapped, as discussed in Customizations chapter, using signal names from the table above.

Each key is expected to be a normally open tactile switch to a common line. No external debouncing is required.

RS-232

Optional, J7, Molex 53047-0310.
Mating part: Molex 0510210300, crimping contacts 0500588000.

Pin	Signal
1	TX
2	RX
3	ground

Model 4012

Power

J11, Molex 0705530001. Mating part: Molex 0050579402.

Pin	Signal
1	ground
2	+12 V DC

Video

In (J10), out (J2)
Molex 0705530002. Mating part: Molex 0050579403.

Pin	Signal
1	video
2	ground
3	not connected

Audio out

J13, Molex 0705530003. Mating part: Molex 0050579404.

Pin	Signal
1	left
2	ground
3	ground
4	right

Keypad

J1/J4, Standard part: Amphenol/FCI 76382-407LF, 7 pin.
Options:
76382-408LF – 8 pin;
76382-409LF – 9 pin;
76382-410LF – 10 pin.

Mating connectors: Amphenol/FCI 65801-007LF, 65801-008LF, 65801-009LF, 65801-010LF.

Standard pinout:

Pin	Function	Signal
1	Record/Pause	DIO33V0
2	Stop/Back	DIO33V1
3	Snapshot	DIO33V2
4	Down	DIO33V3
5	Menu/OK	DIO33V4
6	common (ground)	
7	Up	DIO33V6

Keypad functions could be remapped, as discussed in Customizations chapter, using signal names from the table above.

Each key is expected to be a normally open tactile switch to a common line. No external debouncing is required.

Incremental encoders

JP1, JP2, Molex 0532610671. Mating part: Molex 0510210600.

Pin	Signal
1	Power. Selected with JP3 (+5V or +12V). Protected with a 0.2A resettable fuse
2	A+
3	A-
4	B+
5	B-
6	Ground

Note: If using single ended encoder signals, leave the negative line (A-, B-) unconnected.

RS-232

J18, Molex 0705530002. Mating part: 0050579403.
Optional, J7, Molex 53047-0310. Mating part: Molex 0510210300, crimping contacts 0500588000.

Pin	Signal
1	TX
2	RX
3	ground

Model 4013

Video

J2, Samtec IPL1-106-02-L-SH-K.
Mating part: Samtec IPD1-06-S-K, crimp terminals CC79L-2630-01-L.

Pin	Signal
1	n/c
2	ground
3	video in
4	n/c
5	ground
6	video out

Power

J11, Samtec IPL1-102-02-L-SH-K.
Mating part: Samtec IPD-02-S-K, crimp terminals CC79L-2630-01-L.

Pin	Signal
1	ground
2	+12 V DC

Incremental encoders

JP1, JP2, Samtec T1M-06-GF-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

Note: If using single ended encoder signals, leave the negative line (A-, B-) unconnected.

Keypad

J1, Samtec IPL1-110-02-L-SH-K.
Mating part: Samtec IPD1-10-S-K, crimp terminals CC79L-2630-01-L.

Recommended mapping for keypad pins and functions:

Pin	Function	Signal
1	unused	
2	Encoder #2 reset	DIO33V8
3	Encoder #1 reset	DIO33V7
4	Up	DIO33V6
5	Common (ground)	
6	Menu/OK	DIO33V4
7	Down	DIO33V3
8	Snapshot	DIO33V2
9	Stop/Back	DIO33V1
10	Record/Pause	DIO33V0

Keypad functions could be remapped, as discussed in Customizations chapter, using signal names from the table above.

Each key is expected to be a normally open tactile switch to a common line. No external debouncing is required.

Audio in

J17, Samtec T1M-03-F-SV-L-P.
Mating part: Samtec ISS1-03-L, crimp terminals CC09M-01-GF.

Pin	Signal
1	ground
2	Right
3	Left

Audio out

J13, Samtec IPL1-104-02-L-SH-K.
Mating part: Samtec IPD1-04-S-K, crimp terminals CC79L-2630-01-L.

Pin	Signal
1	Right
2	ground
3	ground
4	Left

RS-232

J18, Samtec IPL1-103-02-L-SH-K.
Mating part: Samtec IPD1-03-S-K, crimp terminals CC79L-2630-01-L.

Pin	Signal
1	TX
2	RX
3	ground

Overlays

DVRs support a wide choice of text overlay information displayed on the preview, recorded video, and screen shots. Overlay's position on the screen, font size and background transparency can be adjusted.

The overlays are divided into primary and secondary overlay groups. One selection from each group can be displayed on the screen at any time. Overlay transparency and screen position can be set separately for each group.

Primary overlay

Primary overlay allows display of one selection of the following data:

1. Date/time
2. Encoder reading
3. Arbitrary text

Date and time display supports various formats. Encoder readings are converted into length units (feet or meters). Up to five arbitrary text messages (up to 40 characters long) can be stored and later selected for display, one at a time.

Secondary overlay

Secondary overlay allows display of one selection of the following data:

1. Title overlay
2. Coded overlay
3. Extra overlay

Title overlay is an arbitrary text (32x14 characters) that could be entered and saved to/loaded from a file on the internal or external storage device (`parameters.txt`).

Coded overlay allows assigning a 2-letter code to text messages and retrieving those for display by typing in the code (a USB keyboard is required). Coded overlays are stored in a file on the internal or external storage device (`codes.txt`). Codes and corresponding messages could be entered using a standard USB keyboard connected to the unit, or `codes.txt` file could be created on a computer and transferred to the USB storage device. Codes are separated from messages with one or more spaces.

Extra overlay is similar to Title overlay. It is an arbitrary text (32x14 characters) that could be entered and saved to/loaded from a file on the internal or external storage device (`extra.txt`).

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	
M	Mute toggle	
F	Fast forward (by an increment)	
D	Rewind (by an increment)	
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
File management
Setup
Help with Keys

Play video
Plays video (.mp4) 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) recordings stored on the media. Behavior is similar to "Play video".

File management
Selecting "File management" brings up the following selections:

Copy video from internal
Copy video from external
Copy snapshots from internal
Copy snapshots from external
Delete files from internal
Delete files from external

Some of the choices may not be present depending on the number of storage devices connected.

Setup

Selecting "Setup" brings up the next menu level:

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 Standard

Allows selecting between NTSC and PAL.

Interpolate

Turning interpolation ON gets rid of motion artifacts at an expense of some vertical resolution loss.

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.

Playback Seek

Adjusts the amount 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.

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

Audio
Brings up Audio setup menu:

==Setup Audio==

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

Mute Recording at Start
Selecting "On" disables audio recording each time recoding is started. Audio recording can be enabled and disabled while recording is in progress by pressing "M" key on the keyboard, or a corresponding 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.

Overlays
Brings up Overlay menu:

==Overlays==

Text Display
Turns the overlay text on or off. Allows selecting one of 2 font sizes.

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;
^e – encoder #1 data;
^f – encoder #2 data.
Currently selected length unit (m or ft) is displayed for each encoder. Units are selected in **Rotary Encoders** menu (see below).

Custom text
Allows entry of up to 5 custom strings for an overlay. Only one of five is displayed at any given time.

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.

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.

Rotary Encoders (4012, 4013 only)
Brings up Select Encoder menu.

==Select Encoder==
Encoder 1
Encoder 2
Allows selecting 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 firmware version, detected storage devices with free space available. Allows saving system parameters to the flash drive, restoring those from the flash drives, or resetting to default values. Parameters are saved to config.txt file to the root directory on the external flash drive. Loading parameters from file allows fast cloning of system settings.

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 `s4011.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. Selecting it installs a 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.`

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.

Firmware updates

Except for a few special cases updating the firmware is a straightforward procedure. First, the firmware file is copied to the root directory of a storage device, the storage device is then connected to the 4011. After that "Update firmware" selection appears in the Setup menu. Selecting this option starts the process which takes about 30 seconds. After that the unit automatically reboots.

The process maybe a bit more complicated when updating from a relatively old firmware version to the new, WiFi-enabled firmware. Adding WiFi support to the Sensoray's family of DVRs resulted in a significantly different layout of the firmware. Therefore the process of firmware update may be different when updating from an older version without WiFi support to the version with WiFi support.

Update procedure:

1. Find out the current version of the firmware installed on your unit by going to Set-up/System Information in the Menu.
2. Obtain the WiFi-enabled firmware file from Sensoray (s4011.fw, approximately 11 MB in size). Please contact support at `support@sensoray.com`.
3. If the version of the firmware installed on your unit is 1660 or newer (version number is greater or equal), skip to step 6.
4. Obtain a non-WiFi firmware file version 1660 or newer from Sensoray (s4011.fw, approximately 6.5 MB in size) .
5. Copy non-WiFi firmware v.1660 or newer to the root directory of a USB drive, plug it into your unit, and perform the firmware update procedure (Setup/Update firmware). If the unit does not reboot for longer than 1 minute, cycle the power. If the pass-through video is black, reset system parameters (Setup/System Information/Reset System Parameters). Make sure the firmware version now matches that of the firmware obtained from Sensoray.
6. Copy WiFi-enabled firmware to the root directory of a USB drive replacing the previous file, plug it into your unit, and perform the firmware update procedure (Setup/Update firmware). If the unit does not reboot for longer than 1 minute, cycle the power. If the pass-through video is black, reset system parameters (Setup/System Information/Reset

System Parameters). Make sure the firmware version now matches that of the firmware obtained from Sensoray.

7. The option "Turn WiFi on" should be now available in Setup menu section (if the WiFi adapter is present).

Customizations

Keypad functions

The 4000 series DVRs allow creating custom keypad functions and layout. The process is simple and takes 2 steps: assigning custom keypad functions and saving the custom layout to the flash drive. After that the units are customized by loading the custom mapping file. Once loaded the file does not have to be present on the flash drive.

Assigning custom keypad functions requires a USB keyboard to be connected to the DVR. Press "K" key to start the process. For each pin of the keypad connector select the corresponding signal name (DIO33V0, etc.), press Enter, and pick a desired function or combination of functions from the list. Once the process is complete, save the custom configuration to the file by going to Menu/Setup/System information/Save system parameters. The configuration is save to `custom.txt` file in the root directory of the flash drive. Note that all other settings are saved as well.

To load custom settings on another system connect the flash drive with `custom.txt` file present on it, and select Menu/Setup/System information/Load system parameters. Once the parameters are loaded the system no longer needs `custom.txt` file to be present on the flash drive.

Splash screen

A custom splash screen can be created as described in "Update custom.zip" section of "Menu system" chapter.

Wireless

All members of the 4000 DVR series support streaming video over the wireless network. This feature requires special WiFi enabled firmware to be programmed. Please refer to "Firmware updates" chapter for the details.

To implement a network, plug in an approved USB WiFi adapter into one of the USB ports and power up the unit. Once the DVR boots a WiFi network named “s4011” becomes available. Please note that the WiFi adapter has to be already plugged in when the unit is powered up.

As with any wireless network, connection is handled by the operating system of the connecting device. The “s4011” network is unsecured. Any device can connect to it without a password and can connect either to the video stream directly, via RTSP, or access the browser based interface.

WiFi adapters

Only devices based on the Realtek RTL8192CU chipset and qualified by Sensoray will work.

Currently Sensoray recommends 2 products:

1. The Edimax EW-7811Un adapter, one of the smallest. Available from https://www.amazon.com/Edimax-EW-7811Un-150Mbps-Raspberry-Supports/dp/B003MTTJOY.
2. The Lib-Link adapter with a large antenna for extended range up to 100 feet. Available from https://www.adafruit.com/product/1030.

Please note that availability information may change.

Streaming video from a DVR

By using an RTSP client like VLC or RTSP Player a video stream can be viewed on a mobile device or a computer. Type the URL rtsp://192.168.0.100:554/0 into the location field of the RTSP viewing application.

There are various free programs available from Google Play or iTunes to directly view RTSP streams. Sensoray tested two of those: VLC (http://www.videolan.org/vlc/index.html) and RTSP Player (http://rtsp-player.soft112.com).

Specifications

Input video	Composite, NTSC or PAL, 75 Ohm
Output video	Composite, NTSC or PAL, 75 Ohm
Video compression	H.264, High Profile at Level 3
Snapshots compression	JPEG
Recorded file format	MP4
Audio	Built-in microphone (4011, 4012 - option) Line input (4012 – option, 4013)
USB ports	3, USB 2.0, high speed
Incremental encoder channels	2, quadrature (4012, 4013)
Incremental encoder power	5 or 12 V (selectable), 0.1A max per channel. Each channel protected by a 0.2A resettable fuse.
Incremental encoder input signal range	Differential RS-422 / single-ended TTL
Power	12 V DC (± 4 V), 2.5 W (encoder power not included)
Mechanical	3.3 x 2.5 inch; height varies between models (0.8 to 1.2 inch). Please contact Sensoray for drawings and STEP models.
Operational temperature	0 to +50 °C

Revision history

Version	Notes
2.0.0, March 2017	Initial release of combined 4011, 4012, 4013 manual.