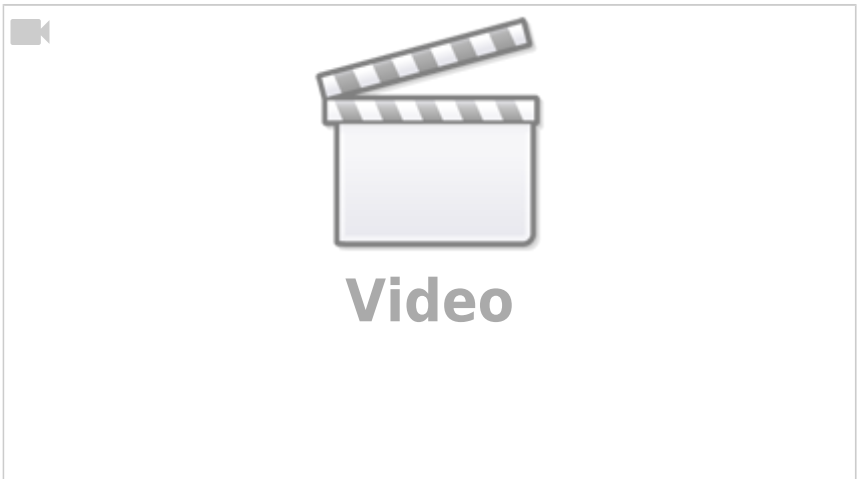
AC Sensorizer v0.4

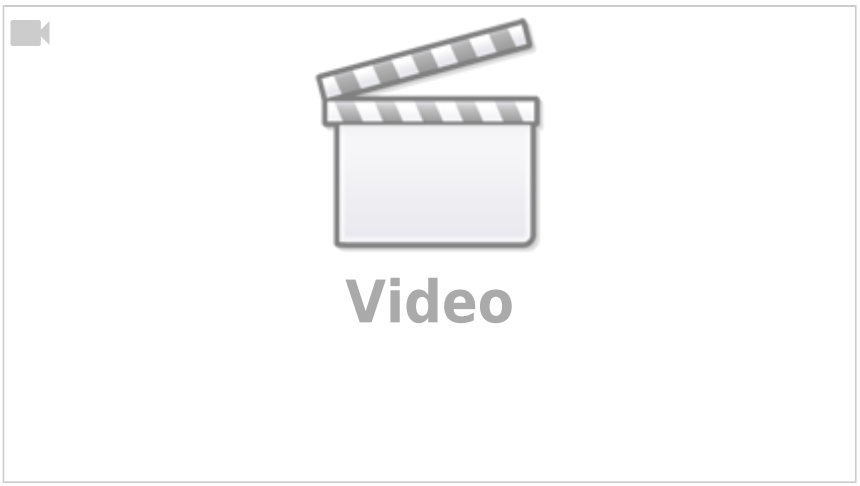
Description

AC Sensorizer sensorizes up to 8 sensors and interpolates its AIN-readings. The main target of this application are sensory devices delivering not exactly 0 - 5 V, like pressure-, distance-, resistor-based sensors or softPots.




These two videos show the ACSensorizer 0.2 which is using an outdated HUI, but nevertheless the concept of the Sensorizer is demonstrated quite well:





The ACSensorizer has been developed by Audiocommander (http://www.audiocommander.de)

Features

- supports up to 8 sensors
- enable/disable single AINs
- **assignable CH and Controller-Number** or **Note_On** generation (!)
- **harmonizer with 20 scales** (minor, major, blues, spanish...) ⇒ harmonizes generated or received (by MIDI!) note-signals
- **syncronizer**: master/slave mode (autodetect clock input switches to slave) and selectable BPM
- quantized events: 1/2/3/4/6/8/12/16/24/32/48, selectable per sensor
- **adjustable input range** by sense-min and sense-max (10bit values, ignore if not matched)
- **adjustable output range** with “scale from and scale to”
- sense-factor: used for signal interpolation... uses fast bitshifting or complex division depending on value
- AUTO-sense feature: **auto-calibration** of sensor, detect MIN/MAX and automatically adapts sense-factor!
- **invert** signal
- **pedal modes**:
  - filter ⇒ only forward if pedal down;
  - panic ⇒ send panic on release pedal;
  - combinations of all pedal mode options are possible
- **detect release**: send 0-value if signal drops below sense-min
- slowdown: slows down the signal and increases the gaps between generated values
- **bankstick** support: 1 connected bankstick provides 2 banks with 127 patches each (24LC256)
- midi configurable: full configuration possible with NRPN-messages
  - NRPN-MSB CC99 for sensorSelect / sysEx mode

    - NRPN-LSB CC98 for controlType
    - DataEntry MSB CC6 and LSB CC38 for controlValue
- **Mac OS X Onscreen Config Program** and MiniAudicle Setup Script examples included!
- LCD (2×16) with clearly structured menu for sensor-select, prg-select, sensor-config & -settings
- redesigned HUI Input to enable **better control with less hardware requirements**
- (optional) DOUT module supported (Sensors can be illuminated)
- ACSim Console Debugger: code integrated and ready to use configured for XCode
    - select “ACSim” as target and test the application via command-line
    - inspect variables with a (graphical) debugger (GDB support within XCode)
    - visit http://www.midibox.org → there's a tutorial how to use Code::Blocks

Required hardware

MBHP Modules:

- one MBHP_CORE module
- one MBHP_LCD module (2×16)
- one MBHP_DIN module for
    - 4 Encoders (no push-button functionality needed!)
    - 1 PEDAL button
    - 1 PANIC button
    - 1 STORE and 1 WRITE button
    - 1 pedal-input (jack at the backside)
- one MBHP_DOUT module for illuminated sensors (optional)

Sensors:

- up to 8 sensors connected to unmuxed AIN (J5 of MBHP_CORE).
- more informations on sensors can be found here: sensors

It is possible to use the sensorizer with only one Core Module. For these purposes a MAC OS X program is included to simulate encoders and buttons. You can easily test the application with one core module!

Application Software

- **http://www.audiocommander.de/downloads/midibox/ACSensorizer_046.zip**, 324 kB, released on 2007-11-10
- still BETA, but quite stable
- Please report bugs or errors here: ACSensorizer Forum Thread – *audiocommander*

Version History

- v0.1.0 2005-12: First testing versions, no code reused
- v0.1.1 2006-01: AIN-config, gate, expander, main functionalities
- v0.1.2 2006-01: Improved expander, inverter, smaller filesize
- v0.1.3 2006-04: Cleanup, code-splitting, rewrite (many fixes!)
- v0.1.4 2006-04: Improved inverter, expander, signal routing
- v0.1.5 2006-04: Added Bankstick Accessors (16byte / sensor)
- v0.1.6 2006-06: Rewrote Bankstick related functions, optimized vars
- v0.2.0 2006-07: Rewritten from scratch, optimized var-access & efficiency, added ENC and LCD menu (2×16/4×20 optimized) support (in main.c)
- v0.2.1 2006-08: Rewrote Bankstick Support (in main.c), 2×64 bytes per patch
- v0.2.2 2006-08: improved algorithms, added sensemode (efficient or exact), added pedalMode, releaseDetect config and PRG-CH, **initial release**
- v0.2.3 2006-09: minor bugfixing, removed MidiTrough and used MIOS_Merger, two example miniAudicle/Chuck NRPN scripts are now included
- v0.2.4 2006-09: fixed severe bank select bug (B,D,F,H,J,L were not accessible)
- v0.3.0 2006-09: rewritten main class, better HUI concept, re-organized Encoder Input, autoload patch #0 (in case of reset), added pedal to start/stop AutoSense Mode, corrected sensor-level-view for sensors 4..8
- v0.3.1 2006-10: added Clock-Sync support / Continue-Hack for m4, added clock-forwarding, even if mios_merger disabled
- v0.3.2 2006-11: fixed PRG-CH bug
- v0.4.0 2006-12: added harmonizer support, patches maintain full backward-compatibility to v0.2.1 versions
- v0.4.1 2006-12: added HUI Midi Remote Control (Simulate Encoder Movements)
- v0.4.2 2007-04: syncronizer support, unified ACMidiProtocol
- v0.4.3 2007-04: added bpm control (48..255 bpm), patches save harmonies & sync, fixed broken master/slave detection, CCs Sustain, Sustenuto & Soft Pedal (Damper) may also control the Pedal. Patch Names are now supported (7 chars max). Last active patch is stored in EEPROM and loaded on startup
- v0.4.4 2007-07: ENC_Speed optimized for Voti.nl encoders, autosense bugfix, Documentation cleanup & updates, **release**
- v0.4.5 2007-08: sync start signal now recognized (SLAVE & MASTER), continue is sent each bar (MASTER), start on patch load (MASTER), harmonizer now working correctly with base notes, **release**
- v0.4.6 2007-11: fixed MST/SLV autodetection bug, now behaves correctly; PANIC also sends STOP in MASTER mode (LOAD sends START); Global Channel now defaults to CH16, messages are sent/received on all channels except for PRG_CH (Global CH only) **release**
- v0.4.7 2007-11: Added DOUT support for external Sensors with LEDs; now recognizes QUANTIZE_SET as well (ACMidiProtocol), fixed QUANTIZE_BPM bug

Compiling Notes

The application can be recompiled with a variety of strictly separated #define- options. For example setting SENSORIZER_INTERFACE_HUI to 0 compiles the application without hardware input controls and therefore reduces the file- and application space. Compiling without HUI, BANKSTICK, NRPN-Config and LCD generates code with approx. 3 or 4 pages; compiling with all options will result in an application file of 19 pages.

HUI-Controllable Parameters

The Sensorizer provides:

- one 2×16 LCD
- four Encoders
- four Buttons

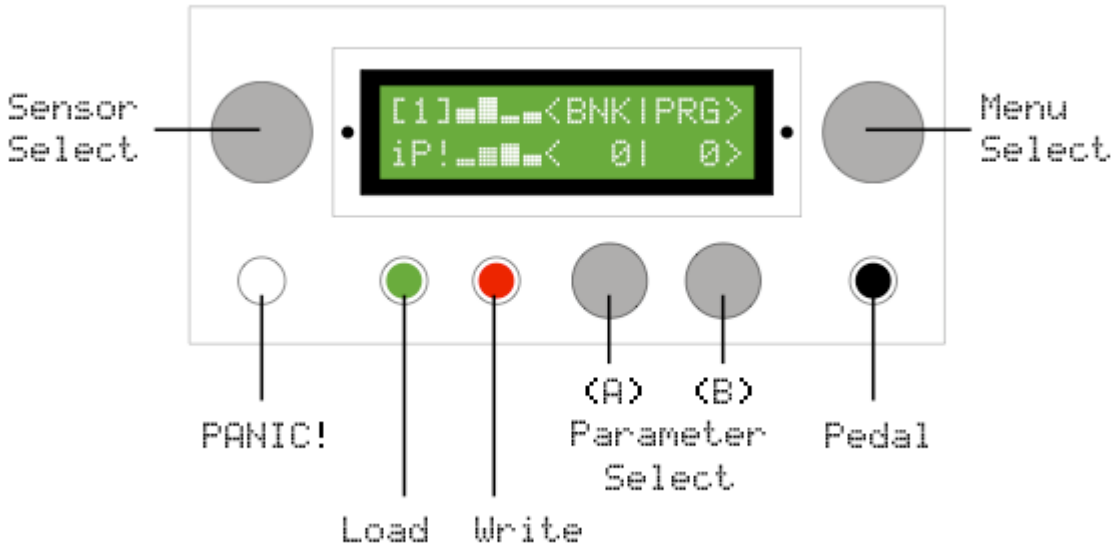
Front Side		
Top	Left Encoder	current sensor selector (1..8)
	Right Encoder	Menu Selection Wheel
Bottom	White Button	PANIC
	Green Button	LOAD PATCH
	Red Button	STORE PATCH
	Left Encoder	Value setter for selected menu item / parameter 1
	Right Encoder	Value setter for selected menu item / parameter 2
	Black Button	PEDAL (2nd pedal connector at the rear)

Back Side			
Left	8 6-pin Mini-DIN connectors	For up to 8 Sensors	Connector Type can be changed!
Middle	5-pin DIN connectors	Midi-In and Midi-Out	
Middle Center	6.5mm Jack	External Foot-Pedal	A pedal is highly recommended!
Right Top	Switch	ON/OFF Switch	
Right Bottom	DC Connector	+9V DC Power Supply	Connector Type can be changed!

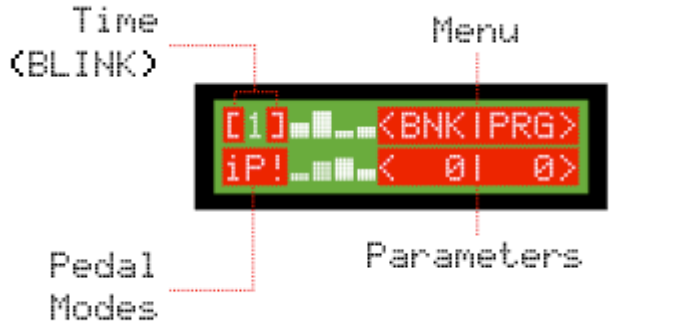
Manual: Interface

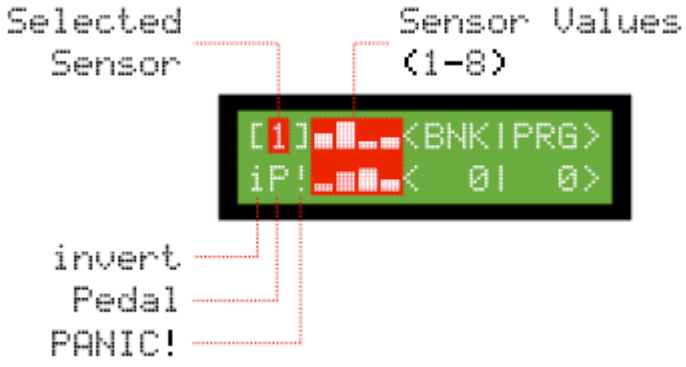
The Interface is clearly structured; the encoders control the values on the screen next to them. A

minimum set of additional buttons allow loading and saving of patches, sending PANIC! and an alternative pedal knob (it is recommended to add a second pedal on the backside. MIDI pedals (like Sustenuto or Pedal are of course also supported.

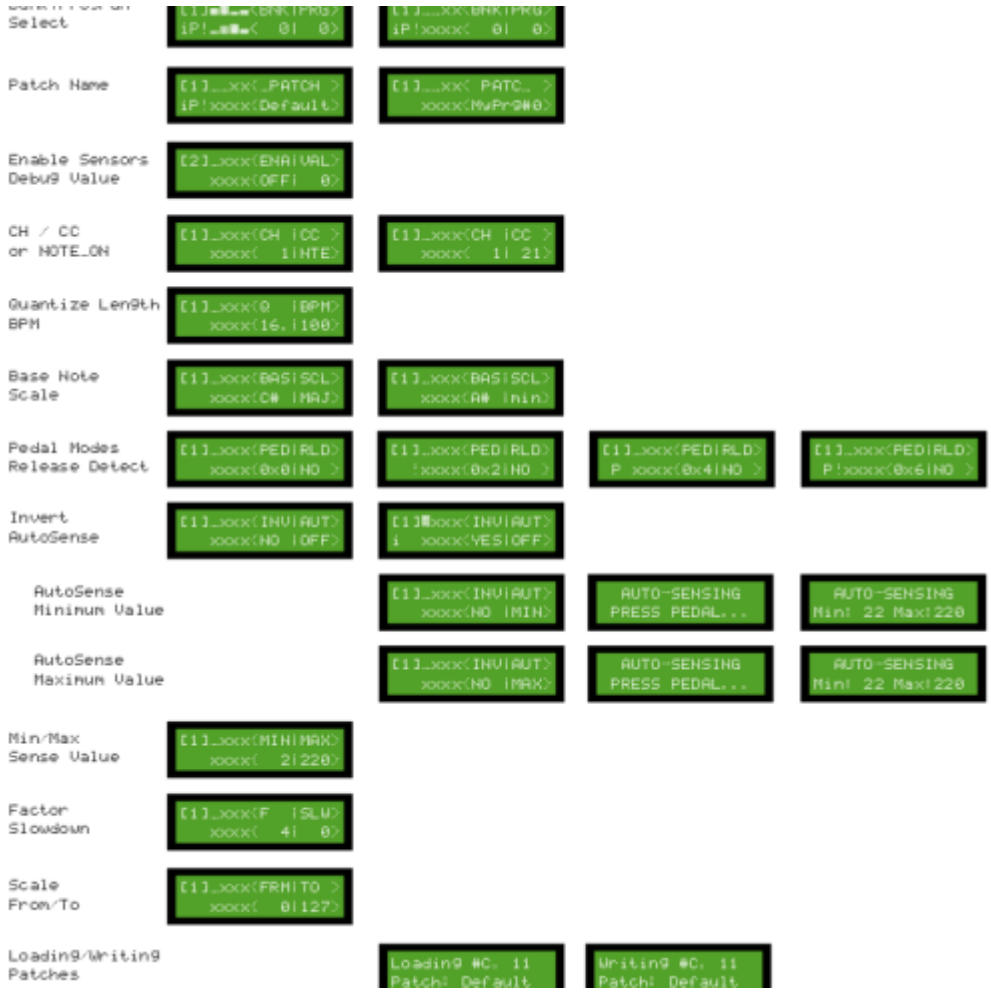


Manual: LCD-Menu





The following picture contains an overview of the onscreen LCD-menu structure. Click to view larger version:



MIDI Implementation Charts

See below which MIDI messages are recognized and sent by ACSensorizer:

Message Type	Received	Sent	Notes
NOTE ON	x	x	Harmonized
NOTE OFF	x	x	Harmonized
POLY AFTERTOUCH	-	-	
CC	x	x	See CC Message Table
PROGRAM CHANGE	G	G	Global Channel only
CHANNEL AFTERTOUCH	-	-	
PITCH WHEEL	-	-	

Table A: MIDI Messages Implementation Chart

CC	Name	Received	Sent	Notes
0-127		*see below*	x	
0	Bank Select	G	G	Global Channel only!
6	Data MSB	x	x	See NRPN Table D
38	Data LSB	x	x	See NRPN Table D
64	Pedal	x	x	Pedal
66	Sostenuto	x	x	Pedal
67	SoftPedal	x	x	Pedal
80	Harmony Base	x	x	Harmony (ACMidiProtocol)
81	Harmony Scale	x	x	0..20
82	Harmony Base Listen	x	x	<> 63
83	Harmony Scale Previous	x	x	> 63
84	Harmony Scale Next	x	x	> 63
85	Harmony Random	x	x	> 63
87	Quantize BPM	x	x	BPM = [0..127] + 60
98	NRPN LSB	x	x	See NRPN Table C
99	NRPN MSB	x	x	See NRPN Table C

Table B: Controller Change Implementation Chart

x YES
- NO
G Global Channel only

The channel numbers that are counted from 1 to 16 appear as 0 to 15 in code!

For more information on ACMidiProtocol supporting interchangeable notifications on BPM, Harmony and Scale changes, see ACMidiProtocol.h!

NRPN Controls

All Sensorizer parameters can be controlled and set by sending NRPN messages by MIDI:

1. Send NRPN MSB (Controller# 99) to select control type
2. Send NRPN LSB (Controller# 98) to set the control parameter
3. Send NRPN Data MSB (Controller# 6) and NRPN Data LSB (Controller# 38) to set the parameter value

NRPN MSB			
CC	Value	Control Type	Note
CC99, 0x63	0x00..0x07	Sensor 0..7	LBS 98, See Table B
CC99, 0x63	0x60	Sensor Wheel	LSB 98, 0..8
CC99, 0x63	0x61	Menu Wheel	LSB 98, 0..10
CC99, 0x63	0x62	Param Wheel A	LSB 98, 0..127
CC99, 0x63	0x63	Param Wheel B	LSB 98, 0..127

Table C: Control Types

NRPN LSB			**DATA ENTRY MSB/LSB**		
CC	**Value**	**Control Parameter**	**CC**	**Value**	**Description**
CC98, 0x62	0x00	enabled	CC38, 0x26	0/1	ON/OFF
CC98, 0x62	0x01	pedalMode	CC38, 0x26	0..7	FILTER/HOLD/PANIC/KOMBI
CC98, 0x62	0x02	autoSense	CC38, 0x26	0..2	AUTOSENSE_OFF/_MIN/_MAX
CC98, 0x62	0x03	invert	CC38, 0x26	0/1	0..127 or 127..0
CC98, 0x62	0x04	releaseDetect	CC38, 0x26	0/1	send 0 on release
CC98, 0x62	0x10	slowdown	CC38, 0x26	0..127	drop AIN notifications
CC98, 0x62	0x11	sense_min	CC38, 0x26 & CC6, 0x6	0..1023	drop below and set sense minimum
CC98, 0x62	0x12	sense_max	CC38, 0x26 & CC6, 0x6	0..1023	drop above and set sense maximum
CC98, 0x62	0x13	sense_factor	CC38, 0x26	0..64	f=(range/127)
CC98, 0x62	0x21	scale_from	CC38, 0x26	0..127	restrict and rescale output
CC98, 0x62	0x22	scale_to	CC38, 0x26	0..127	restrict and rescale output
CC98, 0x62	0x70	CH	CC38, 0x26	0..15	MIDI Channel of sensor
CC98, 0x62	0x71	CC	CC38, 0x26	0..127	MIDI Controller Change Number of sensor

Table D: Control Parameters

Examples:

Turning the Menu Wheel (virtually):

1. Send NRPN MSB (Controller# 99) with value 0x61 to select control type
2. Send NRPN LSB (Controller# 98) with value 0 to 10 to set the control parameter
3. No NRPN Data MSB (Controller# 6) and NRPN Data LSB (Controller# 38) required

Setting the CC to send for (already selected) sensor 1:

1. Send NRPN MSB (Controller# 99) with value 0x00 to select the setting for sensor 1 (or 0x01 for sensor 2)
2. Send NRPN LSB (Controller# 98) with value 0x71 to set the control parameter “CC” for the selected sensor

3. Send NRPN Data MSB (Controller# 6) with a value from 0 to 127 to set the CC Number. NRPN Data LSB (Controller# 38) is not required (only for values greater than 127)

BANKSTICK Patch Description

ACSensorizer supports writing and reading to 24LC256-type banksticks.
Each patch consists of 2 pages à 64 bytes ⇒ 128 bytes
2 banks with 128 patches each are available per 1 connected bankstick (24LC256)

Choose the appropriate bank by sending a Coarse-Adjust Bankselect (CC#0).
In HUI-Mode, switching a bank on the device also sends the current Bank/PRG.

Memory-map of one patch:

Data	**Size in Bytes = Sum**	**Page**	**Address**
Version	1 = 1	1 @ 0x00	0 @ 0x00
PatchName	8 = 9	1	1 @ 0x01
<reserved>	7 = 16	1	10 @ 0x0A
BPM	1 = 17	1	16 @ 0x10
<reserved>	5 = 22	1	17 @ 0x11
harmony_base	1 = 23	1	22 @ 0x16
harmony_scale	1 = 24	1	23 @ 0x17
sensor[8]	8 = 32	1	24 @ 0x18
CH[8]	8 = 40	1	32 @ 0x20
CC[8]	8 = 48	1	40 @ 0x28
sync_1[8]	8 = 56	1	48 @ 0x30
<reserved>	8 = 64	1	56 @ 0x38
slowdown[8]	8 = 8	2 @ 0x40	0 @ 0x00
sense_factor[8]	8 = 16	2	8
sens_min[8].MSB	8 = 24	2	16 @ 0x10
sens_min[8].LSB	8 = 32	2	24
sens_max[8].MSB	8 = 40	2	32 @ 0x20
sens_max[8].LSB	8 = 48	2	40
scale_from[8]	8 = 56	2	48 @ 0x30
scale_to[8]	8 = 64	2	56

Table E: Bankstick Patch Content

Patch addresses are: (patch * 0x80)
or PIC-optimized: (unsigned int)patch « 7

Example hex-output of patch#0 for Sensorizer > 0.4.0:

```
**MIOS_BANKSTICK_WritePage at 0x0
 0:     04 44 65 66 61 75 6c 74 00 ff 00 00 00 00 00 00  .Default........
16:     78 00 00 00 00 00 00 14 81 81 81 81 00 00 00 00  x...............
32:     00 00 00 00 00 00 00 00 14 15 16 17 18 19 1a 1b  ................
48:     08 08 08 08 08 08 08 08 00 00 00 00 00 00 00 00  ................
**MIOS_BANKSTICK_WritePage at 0x40
 0:     02 02 02 02 02 02 02 02 04 04 04 04 04 04 04 04  ................
16:     00 00 00 00 00 00 00 00 40 40 40 40 40 40 40 40  ........@@@@@@@@
32:     03 03 03 03 03 03 03 03 70 70 70 70 70 70 70 70  ........pppppppp
48:     00 00 00 00 00 00 00 00 7f 7f 7f 7f 7f 7f 7f 7f  ................
```

A reference to the last active patch (bank/prg) is stored in EEPROM to enable reloading on next startup. each time a patch is successfully loaded or stored the reference is automatically saved.

The available EEPROM adress range is from 0xF00000 to 0xF000FF (256 bytes):

EEPROM Address	Data	Size (bytes)
0x00 - 0x01	last bank	1 byte
0x01 - 0x02	last patch	1 byte
0x02 - 0xFF	<reserved>	254 bytes

Table F: EEPROM Content

Step-By-Step Building Instructions

1. MBHP Core

Follow the instructions at http://www.ucapps.de/mbhp_core.html. Don't forget to add MIDI-Cables and a 9V/800mA Power Supply!

2. MBHP LCD

Follow the instructions for a 2×16 LCD at http://www.ucapps.de/mbhp_lcd.html

3. MBHP DIN

Follow the instructions at http://www.ucapps.de/mbhp_din.html

4. MBHP DOUT

(optional) If you have lights on your Sensors, you can add a DOUT module:

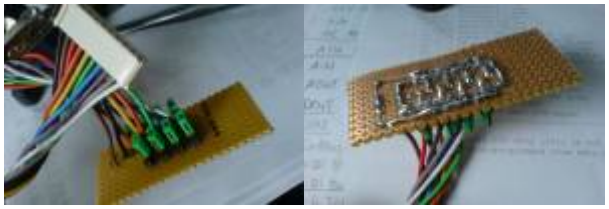
http://www.ucapps.de/mbhp_dout.html

5. MBHP Bankstick

Follow the instructions at http://www.ucapps.de/mbhp_bankstick.html. I'm using the Bankstick PCB supporting up to 8 Banksticks; maybe one Bankstick is sufficient for you (1 BS provides two banks with 127 patches each = 256 patches per Bankstick).

6. AIN “Breakout Board”

I use to solder extra 3-pin connectors on a seperate PCB. These pins allow quick grounding with a jumper or to switch the sensors easily to check for hardware errors. And it's a lot smarter to assemble the case without having to desolder all connections ;)



7. AIN Cables

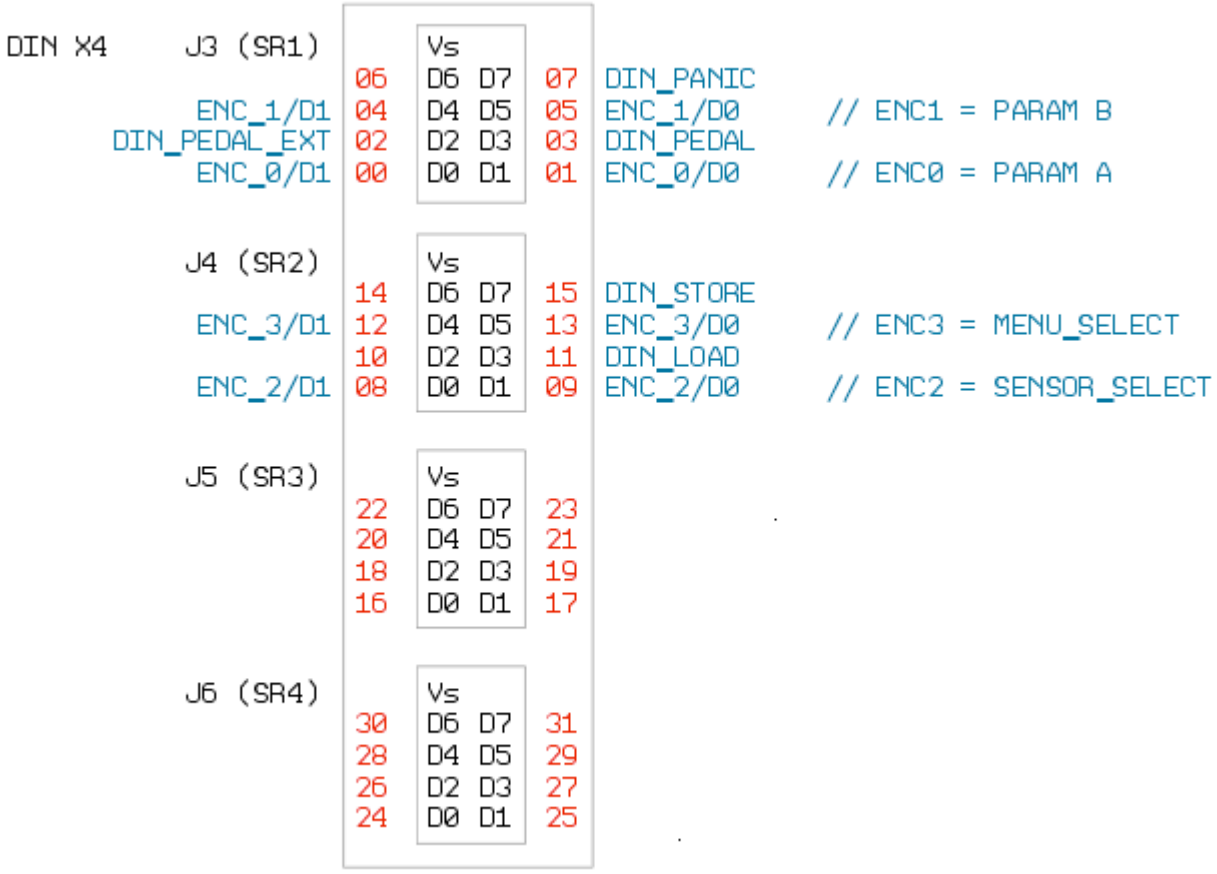
I'm using 6-pin Mini-DIN connectors. In theory, a three-pin connection would be sufficient, but with a 6-pin cable, I can use 2 pins for an external voltage supply or additional DIN/DOUT lines.

8. Encoders and Buttons

9. DIN Connections

Connect the Encoders and Buttons as shown on the following table. The DIN module has to be connected to J9 of core module (see din_module for connection diagram with SmashTV Core modules.

The following image is the upper view of a DIN-Board from Smash TV, check this PDF if you are using the "standard" design from ucapps (just note the name of the pins - D0,D1, D2, etc...):



10. DOUT Connection

(optional) Connect the Dout Pin #1 to a LED that sits in Sensor #1 (#2 to #2, #3 to #3 and so on...).

11. Upload MIOS

I'm running it with MIOS8 (PIC) 1.9e, but it should work with any newer 8-bit version. An update to the new app-structure is planned. See Downloads... and MIOS8 Upload for Newbies

12. Upload ACSensorizer

Upload “ACSensorizer.hex” /-OR-/ “ACSensorizer.syx” (depending on the method you are using... ⇒ see “Uploading an Application” at MIOS8 Upload for Newbies)

13. Sensor Calibration

- Connect your sensors
- Disable all sensors but the first one (Menu: ENA ⇒ OFF)

- “from” should be “0” and “to” should be “127”
- Try Autocalibration first:
  - Menu: AUT → MIN ⇒ Trigger the minimum value of the sensor, then press the pedal. Release the pedal once you have the right minimum value.
  - Menu: AUT → MAX ⇒ Trigger the maximum value of the sensor, then press the pedal. Release the pedal once you have the right maximum value.
  - Menu: AUT → OFF
- Repeat these steps for the remaining sensors.

- If the automatic calculations aren't satisfying, which may be the case if you're using sensors with a “jumpy” behavior like IR Distance sensors, you can set the sensing MIN/MAX values by hand. Do not mix up with the Scale from/to values these are just to interpolate the final signal:
  - Measure the electrical min/max values or take them from the datasheet (*Example: 0.2V min to 2.5V max*)
  - Calculate the 10bit minimum (Factor 1024 / 5V = 204.8) : *0.2Vmin * 204.8 = 40.96 ⇒ as 8bit number: 40.96 / 4 = 10.24 ⇒ Enter 15 as MIN.* Note that the value is just *shown* as 8bit value, internally it's a 10bit value. That's why you need 4 Encoder detends to go from 128 to 129...
  - Calculate the 10bit maximum (Factor 204.8) : *2.5Vmax * 204.8 = 512 ⇒ as 8bit number: 512 / 4 = 128 ⇒ Enter 128 as MAX*
  - Now set the sense-factor, Menu: F. The sensorized value gets divided by this factor to get the 7bit value. Normally this would be 8 (1024 / 127 = 8) ⇒ *in our example: 512 max (10bit) / 127 = 4 ⇒ Enter 4 as F*
  - Proceed with the remaining sensors and Save your patch.

Done!

This site is about to change while the Sensorizer is beeing developed further!

have fun! – *audiocommander*