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1 Disclaimer

dAISy Mini is a reliable, dual-channel AIS Receiver. However, under no circumstances should it be solely relied on for collision avoidance or navigation. It's the user's responsibility to use the product prudently. Neither Wegmatt LLC nor its dealers accept responsibility or liability to the product user or their estate for any accident, loss, injury, or damage whatsoever arising out of the use of this product.

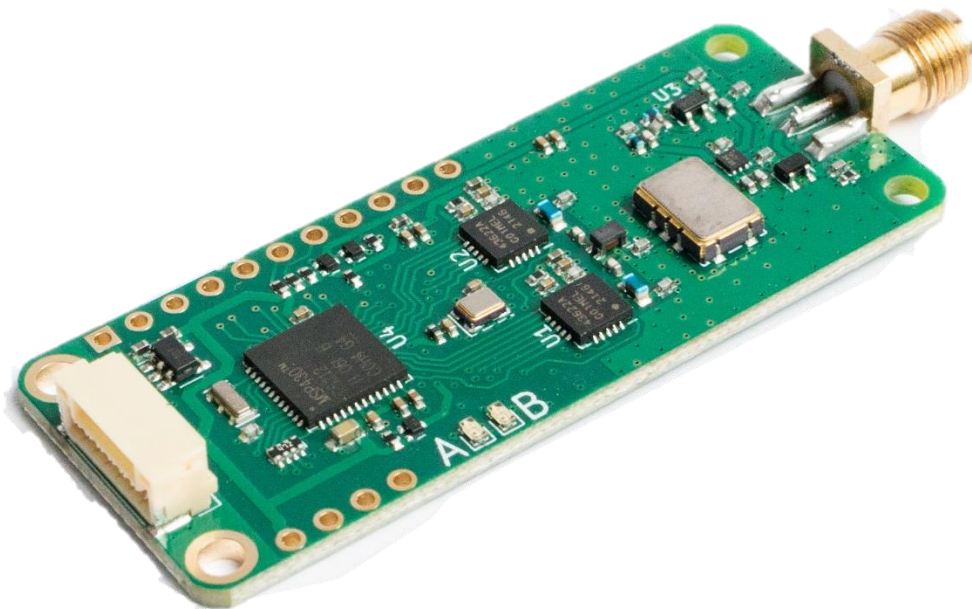
2 Introduction

The dAISy Mini is a dual-channel AIS receiver with integrated low-noise amplifier (LNA). Thanks to its small size and low power consumption the dAISy Mini is ideally suited for embedded applications.

AIS (automatic identification system) is an automatic tracking system for ships. Ships broadcast their position and other information over VHF¹. The dAISy Mini allows you to receive these transmissions, enabling real-time tracking of nearby vessels.

The dAISy Mini outputs the AIS data as a stream of ASCII messages, which are encoded in a marine standard format known as AIVDM sentences². This format is understood by applications and devices like chart plotters³, marine traffic aggregators⁴, and can be processed by many opensource libraries⁵.

The dAISy Mini is designed to be integrated with microcontrollers, single board computers and flight controllers.



¹ https://en.wikipedia.org/wiki/Automatic_identification_system

² <https://gpsd.gitlab.io/gpsd/AIVDM.html>

³ <https://opencpn.org>

⁴ <https://www.aishub.net>, <https://www.marinetraffic.com>, ...

⁵ <https://pypi.org/project/simpleais>, <https://pypi.org/project/libais>, <https://github.com/schwehr/libais>, ...

3 Pinout

All functions of the dAISy Mini are available on 0.1" headers. 5V power supply, serial 1, and optionally I2C are also available on the 6-pin JST-GH connector with the pinout compatible with the Pixhawk telemetry port.

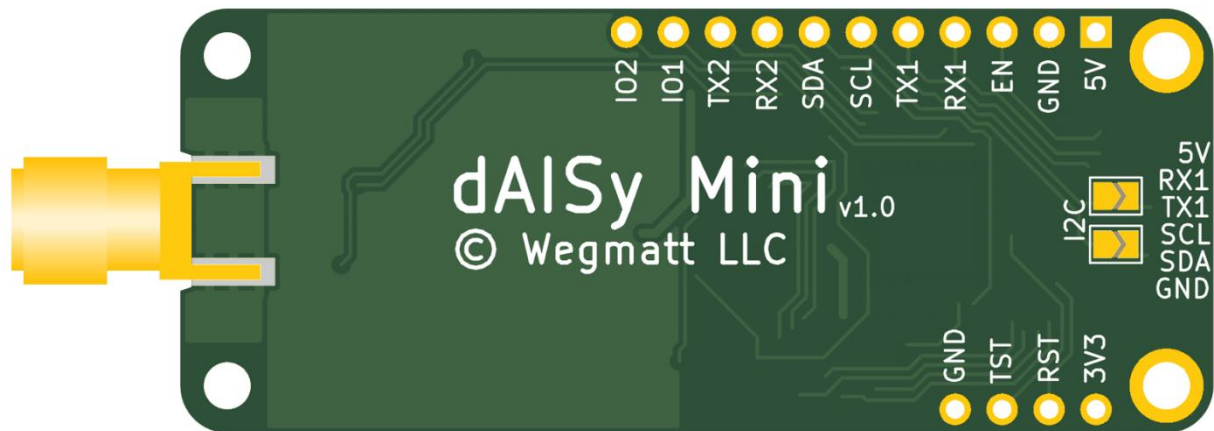


Figure 1: Bottom view of dAISy Mini

The table below lists all pins and their function. For a detailed description of a pin functionality see respective section in this chapter.

Important: All communication pins are 3.3 V only!

Pin	Function	JST pin	Notes
5V	5V power input	1	main power source for AIS receiver
GND	Ground	6	
EN	Enable input		power AIS receiver on or off, always on when not connected
RX1	Serial 1 RX input	2	always enabled, 38400 bps fixed
TX1	Serial 1 TX output	3	always enabled, 38400 bps fixed
RX2	Serial 2 RX input		configurable, disabled by default
TX2	Serial 2 TX output		configurable, enabled by default at 38400 bps
SCL	I2C clock	4 ⁶	configurable, enabled by default
SDA	I2C data	5 ⁶	configurable, enabled by default
IO1	GPIO 1		configurable I/O function, default off
IO2	GPIO 2		configurable I/O function, default off
3V3	3.3V power output		3.3V power rail of AIS receiver
RST	Reset		Used for factory programming
TST	Test		Used for factory programming

Table 1: dAISy Mini pinout

⁶ Close solder jumpers on the backside of the circuit board to make I2C available on the JST connector

3.1 Power

Power for the dAISy Mini is supplied through the 5V and GND pins.

Supported range for input voltage is 3.7V - 5.5V.

In regular operation the dAISy Mini draws 70 mA of current, equivalent to 350 mW of power. The built-in low-noise amplifier (LNA) can be disabled to reduce power consumption, with the trade-off of reduced AIS range.

The dAISy Mini can be put into low power sleep mode, which turns off AIS reception.

The dAISy Mini can be completely powered down by applying logic low (<0.2V) to the EN pin. The device is powered on when EN is high or not connected.

Mode	Current	Power (@5V)
LNA enabled (default)	70 mA	350 mW
LNA disabled	36 mA	180 mW
Sleep	0.4 mA	2 mW
EN low	< 0.01 mA	< 0.05 mW

Table 2: Power consumption

3.2 Serial 1

Serial 1 is the primary communication interface of the dAISy Mini. The pins are labelled RX1/TX1.

Serial 1 is always enabled and uses 3.3V UART signaling at a fixed speed of 38400 bits per second.

Baud rate	38400 fixed
Data bits	8
Parity	None
Stop bits	1
Flow control	None

Table 3: Serial 1 interface parameters

When in receive mode, the dAISy Mini will output AIS messages as NMEA AIVDM sentences⁷. Depending on the configuration, the output may include additional debug messages with information like signal strength or data errors.

Sending the ESC character (0x1B) on Serial 1 will bring up the configuration and debug menu.

⁷ <https://gpsd.gitlab.io/gpsd/AIVDM.html>

3.3 Serial 2

Serial 2 is a configurable UART interface. The pins are labelled RX2/TX2.

Serial 2 can be configured as NMEA output (default), NMEA input, or disabled. Speed is configurable to 4800, 9600 and 38400 bits per second.

Baud rate	4800, 9600, 38400
Data bits	8
Parity	None
Stop bits	1
Flow control	None

Table 4: Serial 2 interface parameters

When configured as NMEA output, Serial 2 will output NMEA AIS sentences.

When configured as NMEA input, all NMEA messages received on Serial 2 will be forwarded to Serial 1. One application for this mode is to add GPS data to the AIS data stream.

3.4 I2C

The I2C pins are labelled SDA and SCL. The I2C address is configurable, with a default value of 0x33.

The dAISy Mini includes 10K pull-up resistors on the SDA and SCL lines.

See chapter 4.1 for a detailed description of the I2C interface.

3.5 GPIO

IO1 and IO2 are configurable input/output pins. The pins are labelled IO1/IO2.

By default, no function is enabled, and the IO pins are disconnected.

See chapter 4.2 for a detailed description of the configurable GPIO functionality.

3.6 Antenna connector

The edge-mount antenna connector of the dAISy Mini is a female SMA connector with standard polarity.

The dAISy Mini is matched for an antenna with an impedance of 50 ohms, which is standard for marine VHF communication.

4 Interfaces

4.1 I2C

4.1.1 Read/Write Operation

The dAISy Mini supports the I2C protocol with 7-bit device address, followed by the R/W bit.

For a write operation, the first byte sent is the register address byte. The next byte sent is written to that address. The register address is automatically incremented after each byte sent, until the address reaches 0xff.

To read a register, first write the register address, then use the I2C read operation to access the register data. The register address is automatically incremented after each byte is read, until the address reaches 0xff.

4.1.2 Device Address

By default, the I2C device address of the dAISy Mini is 0x33.

The I2C address can be configured in the range from 0x30 to 0x3f.

4.1.3 Register Layout

Currently all registers are read-only. Writes to the registers will be ignored.

Address	7	6	5	4	3	2	1	0
0x00	Device type (12 for dAISy Mini)							
0x01	Firmware version major							
0x02	Firmware version minor							
..								
0xfd	Number of bytes available (high byte)							
0xfe	Number of bytes available (low byte)							
0xff	NMEA message stream							

Table 5: I2C register map

4.1.4 NMEA message stream

If I2C is enabled, AIS NMEA messages can also be read over I2C.

The currently available number of bytes in the message stream can be read at addresses 0xfd and 0xfe. The register at address 0xff allows the message stream to be read. If data is available, successive reads of register 0xff will return the waiting message data. If there's no data available, or if reading more bytes than available, the value 0xff will be returned.

When reading the NMEA message stream over I2C, it is recommended to use a polling interval of 100ms or shorter/faster. Longer/slower polling intervals may result in invalid or missed NMEA messages due to an overflow of the internal 512 bytes FIFO buffer.

4.2 GPIO

4.2.1 Overview

The functionality of pins IO1 and IO2 of the dAISy Mini is configurable.

The following functions are available:

Function	Electrical	Low	High
None (default)	Not connected		
Reset	Input, pull-down	Pulse high for > 100 ms to trigger reset	
Sleep	Input, pull-down	Receiver active	Sleep
LNA	Input, pull-down	LNA disabled	LNA enabled
AIS message	Output	Positive pulse when AIS msg received	
I2C data	Output	No I2C data	I2C data available

Table 6: GPIO pin functions

4.2.2 None

By default, IO pins are disabled. To minimize power consumption in sleep mode, it is recommended to either assign a function to all IO pins, or connect unused IO pins to GND.

4.2.3 Reset

With this function enabled, the selected IO pin is an input that can be used to reset the dAISy Mini.

In regular operation, the input is held low. A reset is triggered by setting the input high for longer than 100ms, and then setting the input low.

The startup time from reset to receiving AIS messages is 600 ms.

4.2.4 Sleep

With this function enabled, the selected IO pin is an input that controls the sleep mode of the dAISy Mini.

When the input is low, the AIS receiver is active.

When the input is high, the AIS receiver is stopped and enters the low power sleep mode.

In sleep mode, the power consumption is less than 0.35 mA. The wake-up time from exiting sleep mode to receiving AIS messages is approximately 50 ms.

4.2.5 LNA

With this function enabled, the selected IO pin is an input that controls the low-noise amplifier (LNA) of the dAISy Mini.

When the input is low, the LNA is turned off.

When the input is high, the LNE is turned on.

Switching the LNA off reduces power consumption by approximately 35 mA. The downside is a shorter range of the AIS receiver.

4.2.6 AIS message

With this function enabled, the selected IO pin will output a positive pulse when a valid AIS message is received. Typical applications include waking up another device when new AIS messages arrive, or driving an LED indicating when valid AIS messages are received.

The length of the pulse depends on the size of the AIS message and typically ranges from 400 to 1200 us. Minimum time between two pulses is 30 us.

The falling edge of the pulse happens after the AIS message data is stored in the output buffers of the serial and I2C interfaces.

For the serial interface, while the transmission of data may already start before the falling edge, the first byte of the AIS message won't be available from the master device's serial peripheral until the full byte is received.

For the I2C interface, the complete AIS message will be available in the I2C buffer at the time of the falling edge.

4.2.7 I2C data

With this function enabled, the selected IO pin will be high when data is available to be retrieved through the I2C interface. The IO pin will be low if no I2C data is available or if the I2C interface is disabled.

In case of an empty I2C output buffer, the rising edge of this signal occurs after a complete AIS message is stored in the buffer. The falling edge occurs after the last data byte is put onto the I2C bus, which may be before the last byte is available from the master device's I2C peripheral.

5 Using the dAISy Mini

Using the dAISy Mini is as simple as connecting it with an antenna and a PC and powering up your AIS capable application of choice. When powered on, the dAISy Mini automatically starts to listen for AIS transmissions.

5.1 Interpreting the status LEDs

The dAISy Mini has two two-color status LED, giving an indication about how it's doing. Each LED represents one of the two AIS channels.

Short GREEN flash every 5 seconds

The dAISy Mini is well and alive and in receive mode, listening for AIS messages.

While in receive mode, the mode dAISy starts in when powered up, it will very briefly blink green every 5 seconds to indicate that everything is ok.

Long GREEN flash

Yay! The dAISy Mini received a valid AIS packet.

For every packet received and passing all error checks, the LED will turn green for $\frac{1}{4}$ second. At the same time, the dAISy Mini will output the received message as NMEA AIVDM sentence on the serial port.

Long RED flash

The dAISy Mini received an invalid packet.

This means that the dAISy Mini received bits that looks like the start of an AIS package, but the data did not pass other sanity checks like checksum. It might be a ship just out of range, interference from another radio source, or just random noise.

Don't panic, you will see a lot of red even under optimal conditions.

RED turned on permanently

The dAISy Mini failed to initialize its hardware.

Remove power, plug it in again and see if this resolves the problem. If the condition persists, there is probably a hardware issue with your device. Please contact us.

Fast regular blinking RED

The dAISy Mini encountered an unexpected system error.

Remove power, plug it in again and see if this resolves the problem. If the condition persists, there is probably a hardware issue with your device. Please contact us.

No LED activity

The dAISy Mini may not receive power. Review all connections.

The LEDs are turned off while the dAISy Mini is in sleep mode. Ensure that the IO pin configured for sleep control is either driven low or not connected. Reconfigure the IO pins if sleep mode is not required.

The LEDs are also turned off while the dAISy Mini is in the configuration menu. Connect to dAISy with a serial terminal and press ESC. A message should tell you that it entered AIS receive mode and the green LED should start to blink every 5 seconds.

Another possibility is, that the dAISy Mini failed to boot or crashed. In this case, remove power. Plug it in again and see if this resolves the problem. If the condition persists, there might a hardware issue with your device. Please contact us.

5.2 Configuration and debug menu

The dAISy FeatherWing can be configured by connecting to Serial 1 with a serial terminal program like for example Putty.

Pressing ESC will bring up a menu with configuration and debug options:

```
dAISy v6.01 - dAISy Mini (5232/5222) (C)2014-2022 Adrian Studer
Radio 1: 161.975MHz AIS1          Radio 2: 162.025MHz AIS2          Format: A/B
Serial 2: 38400 8N1, NMEA out
LNA: on          IO1: off          IO2: off          Debug: off

Configure:
0-3   Set Serial 2 to 4800, 9600 or 38400 baud (1-3) or disable port (0)
S     Toggle function of Serial 2 as NMEA output or NMEA input
C     Configure AIS channels
G     Configure GPIO pins
L     Toggle low noise amplifier on/off
#     Save current settings

Debug:
D     Toggle debug messages on/off
N     Read current RSSI (indication for noise)
V     Show statistics for valid messages received
T     Output NMEA test messages
B     Launch bootloader to update firmware

ESC   Return to AIS receive mode

> █
```

Figure 2: Configuration and debug menu

The configuration options are:

0-3: Control the speed of the Serial 2 interface. Pressing 1 enables the serial port with a speed of 4800 baud, 2 is for 9600 baud, and 3 is for 38400 baud. Pressing 0 turns Serial 2 off.

S: Select the function of the Serial 2 interface. There are two modes:

1. **NMEA output:** Output AIS messages as NMEA AIVDM sentences.

2. **NMEA input:** Act as an input for NMEA sentences, for example from a GPS module. All NMEA sentences received through Serial 2 will be forwarded to Serial 1.

C: Configure the radios of the dAISy Mini to listen to specific AIS channels. The dAISy Mini has two radios, which by default are configured to listen on channel A at 161.975 MHz and channel B at 162.025 MHz respectively. The dAISy Mini also support the less common “Long range AIS” channels at 156.775 and 156.825 MHz.

G: Configure the function of the two I/O pins. See chapter 4.2 GPIO for more details.

L: Enable or disable the on-board low-noise amplifier (LNA).

#: Save current settings (serial, AIS channel, GPIO, LNA and debug) as power-on defaults. This is particularly useful when you want to persist the settings for the auxiliary serial output.

ESC: Resume receiving AIS messages.

Debug options are:

D: Toggles debug messages. When enabled and in AIS receive mode, signal strength and other information about valid and invalid AIS packets will be displayed. It is normal to receive a lot of broken packages as there always will be radio noise and ships just out of range. With some experience, you can use the debug messages to analyze and improve reception issues.

N: Keep pressed to get an idea of the current noise level. -120 to -100 dBm is normal. dAISy will only be able to receive valid packets roughly 15 dBm above that level, consistent reception 25+ dBm above noise.

V: If valid packages were received, this gives a summary of the signal strength at which AIS messages arrived (min, max, average).

T: Enter test mode. In this mode, dAISy outputs a test message every 5 seconds. You can enter your own message or have it output a preprogrammed AIS message. This mode is useful when you want to test dAISy but do not have AIS reception at your current location. You can exit test mode by pressing **ESC** or power-cycling dAISy.

B: Enter boot loader mode for firmware updates. dAISy exits this mode through power-cycling, after a 20 second timeout without further activity, or after completing firmware upgrade.

6 Tips for good AIS reception

Due to their low-cost architecture, dAISy AIS receivers are not as sensitive as some higher priced receivers. The dAISy Mini has an integrated low-noise amplifier (LNA) to improve range. In addition, the following basic measures can be taken to improve performance.

6.1 Antenna

If everything else is optimal, almost any antenna tuned to the VHF band will do. I used a simple wire cut to length for my first prototypes. However, a good antenna will greatly improve results.

AIS messages are broadcast on two channels around 162 MHz, which is in the maritime VHF band. This means that any antenna sold as “*marine VHF antenna*” will be a good start.

The short VHF “rubber duck” antennas are cheap and will work at short distance. If you check whether 162 MHz is inside the supported frequency range, you can even ignore the “marine” and save a few bucks. However, the more broadband the antenna, the worse the reception quality.

A step up are VHF whip antennas. These are steel rods about 90 centimeters (3ft) long. While bulky, these don’t cost much more than the “rubber duck” but provide superior range. Personally, I use the TRAM 1600-HC which cost around US \$40.

The AIS antenna should be separated as far as possible from the voice VHF antenna to avoid unnecessary interference. The best separation is achieved by vertically separating the antennas or at least mounting them on opposite sides of a vessel.

To avoid damaging dAISy Mini with strong transmissions by other devices, the antenna should be mounted at least 3 meters away from, or at least out of the transmitting beam, of high-power transmitters such as radars or other VHF antenna installations.

IMPORTANT: Do NOT directly connect the dAISy Mini to the same antenna as your VHF radio. This will damage the AIS receiver! To share an existing antenna with a VHF radio, use an ACTIVE splitter. Active splitters protect the AIS receiver by automatically disconnecting it when the VHF radio is transmitting. Several customers reported good results with the inexpensive Glomex RA201 VHF/AIS/Radio Splitter.

6.2 Location, location, location

Good AIS reception requires line of sight.

A few buildings and trees between you and your targets aren’t ideal, but you will still be able to catch a few messages. Hills and mountains however are almost certain showstoppers. A clear view of the water and your targets is ideal.

In my experience the most important factor is the height of the antenna above sea-level (or lake-, river-, wherever-level the ships are). Sitting at the beach or on the deck of a boat will work. Mounting the antenna on the mast of your boat or standing on the observation deck of a cruise ship is better. A hill overlooking the harbor is great. Climbing that 2000m mountain that towers over the coast is AIS heaven.

In a nutshell: The farther you can see, the better.

6.3 Radio frequency noise

The main weakness of the dAISy Mini, and probably most low-cost and SDR-based AIS receivers, is susceptibility to out-of-band RF noise. The effect of noise is reduced range, and fewer successfully received packets. Unfortunately, there's not much we can do except finding a spot that's less impacted by noise. Outdoors is better than indoors (computers, power-supplies, wireless networks, LED lights ...). Countryside is better than down-town (taxi radios).

The dAISy Mini has an integrated bandpass filter to reduce the impact of radio frequency noise outside the marine VHF band frequency.

7 Troubleshooting

Problem	Solution
No activity of the status LEDs	Verify that the dAISy Mini is properly connected.
Device in reception mode, but not valid AIS messages received (no ¼ second green flashes)	Verify the antenna connection and location. Good AIS reception requires line-of-sight, verify your setup from a location that is certain to have traffic, for example near a harbor.
Device indicates valid AIS messages (¼ second green flashes), but no messages received on the serial port.	Verify that the serial pins are connected, and with the correct RX/TX polarity. Verify the serial configuration of your software.
Software receives positions, but fewer than expected and/or with worse range than expected.	Verify the antenna connection and location. Good AIS reception requires line-of-sight. Move the antenna away from sources of electrical noise.
After some time, the dAISy Mini indicates a device error (fast blinking red LED)	Power cycle the Mini to resolve the issue. If this is a regular occurrence, contact us.

Table 7: Troubleshooting tips

If a problem persists don't hesitate to contact us.

8 Specifications

Power	
Input voltage	3.7 V - 5.5 V, 5 V recommended
Input current with LNA enabled (default)	70 mA
Input current with LNA disabled	36 mA
Input current in sleep mode	0.4 mA
Input current with EN low	< 0.01 mA
Radio	
Independent receivers	2
Frequency bands	161.975 MHz, 162.025 MHz, 156.775 MHz, 156.825 MHz
AIS channels	2, freely configurable
Sensitivity with LNA enabled (default)	-113 dBm @ 20% PER
Sensitivity with LNA disabled	-103 dBm @ 20% PER
Bandpass filter	SAW 156.3 - 162.025 MHz pass band
RF connector	SMA
Input impedance	50Ω
Data I/O	
AIS message encoding	NMEA 0183 (AIVDM)
Supported AIS message types	1-27
Serial speed Serial 1	38400 Baud fixed
Serial speed Serial 2	4800, 9600, 38400 Baud configurable
Serial protocol	8 data bits, no parity, 1 stop bit (8N1)
Serial mode Serial 1	NMEA out fixed
Serial mode Serial 2	NMEA out, NMEA in configurable
I/O voltage	3.3 V
Data connector	JST-GH 6-pin
Dimensions	
Circuit board without SMA connector	55.9 mm x 22.9 mm (2.2" x 0.9")
Circuit board with SMA connector	65.4 mm x 22.9 mm (2.6" x 0.9")
Circuit board mounting holes	4x Size: 2.54mm (0.1") Distance: 50.8 mm x 17.78 mm (2.0" x 0.7")
Weight	
Circuit board with SMA connector	7 g (0.25 oz)

9 Source code and schematics

Currently the dAISy Mini is only partially open source.

The core of the dAISy Mini, how the Silicon Labs Si4362 radio IC is programmed to receive AIS, is available on Github. While that project does not include all the functionality of the dAISy Mini as sold, we do backport any bug fixes that are relevant to the task of receiving AIS.

<https://github.com/astuder/dAISy>

There is also a long thread on 43oh that documents the journey of dAISy from its humble beginnings.

<https://forum.43oh.com/topic/4833-potm-daisy-a-simple-ais-receiver/>

If you want to experiment with the real code, brick your device with custom firmware or even build your own dAISy from scratch, contact us. Tinkerers welcome!

10 Contact

The best way to reach us is by email: daisy@wegmatt.com

Please don't hesitate to contact us if you need support. We also love to hear about your projects and are happy to share your related blog posts, videos, and pictures on our social media.

You can also reach us on [GitHub](#), and [Twitter](#).

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