WEGMATT LLC   dAISy FeatherWing AIS Receiver

Contents

1 Disclaimer

dAISy FeatherWing 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 FeatherWing is a dual-channel AIS receiver with integrated low-noise amplifier (LNA). Thanks to its small size and low power consumption the dAISy FeatherWing 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 VHF[1]. The dAISy FeatherWing allows you to receive these transmissions, enabling real-time tracking of nearby vessels.

The dAISy FeatherWing outputs the AIS data as a stream of ASCII messages, which are encoded in a marine standard format known as AIVDM sentences[2]. This format is understood by applications and devices like chart plotters[3], marine traffic aggregators[4], and can be processed by many opensource libraries[5].

While the dAISy FeatherWing is designed to be mounted directly on top of any Adafruit Feather development board, it can also be used with other microcontrollers and single board computers.

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[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

The pinout of the dAISy FeatherWing is compatible with the Adafruit Feather Specification[6].
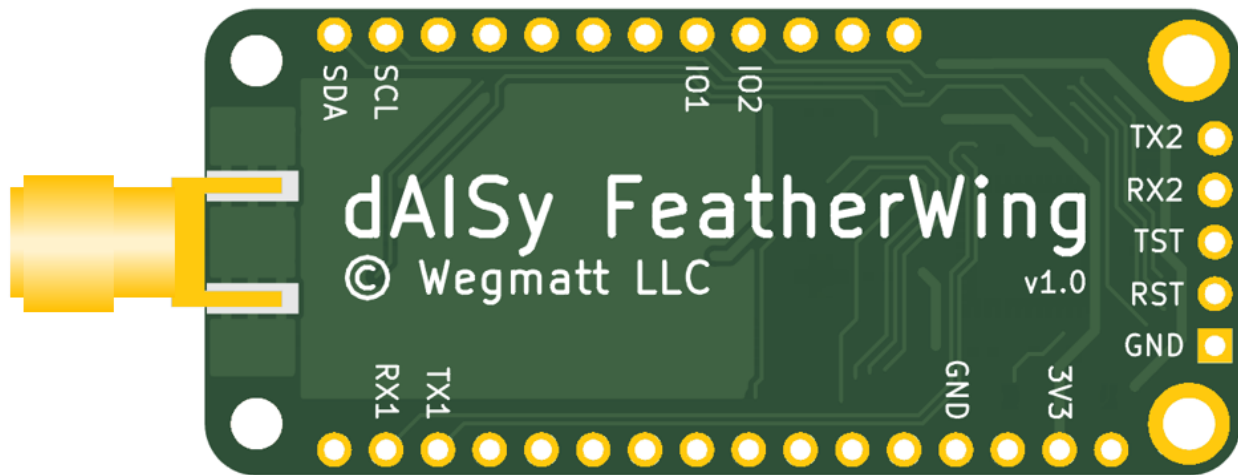

Figure 1: Bottom view of dAISy FeatherWing

The table below lists all pins and their function. All other pins are not connected to any part of the circuit. For a detailed description of a pin functionality see respective section in this chapter.

Note that all communication pins are 3.3 V only!

Pin	Function	Feather	Notes
3V3	3.3V power input	3.3V	
GND	Ground	GND	
RX1	Serial 1 RX input	TX	always enabled, 38400 bps fixed
TX1	Serial 1 TX output	RX	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	SCL	configurable, enabled by default
SDA	I2C data	SDA	configurable, enabled by default
IO1	GPIO 1	D12	configurable I/O function, default off
IO2	GPIO 2	D13	configurable I/O function, default off
RST	Reset	-	Used for factory programming
TST	Test	-	Used for factory programming

Table 1: dAISy FeatherWing pinout

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[6] https://learn.adafruit.com/adafruit-feather/feather-specification

3.1 Power

Power for the dAISy FeatherWing is supplied through the 3V3 and GND pins. The pins align with 3.3V and GND pins of the Adafruit Feather.

dAISy	Feather
3V3	3.3V
GND	GND

Table 2: Power pinout

The dAISy FeatherWing is a 3.3V device. Applying a voltage higher than 3.3V will damage the dAISy FeatherWing!

In regular operation the dAISy FeatherWing draws 70 mA of current, equivalent to 230 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 FeatherWing can also be put into a low power sleep mode, which turns off AIS reception.

Mode	Current	Power
LNA enabled (default)	70 mA	230 mW
LNA disabled	35 mA	115 mW
Sleep	0.35 mA	1.15 mW

Table 3: Power consumption

3.2 Serial 1

Serial 1 is the primary communication interface of the dAISy FeatherWing. The pins are labelled RX1/TX1 and align with the TX/RX pins of the Adafruit Feather (Serial1 in Arduino).

dAISy	Feather
RX1	TX
TX1	RX

Table 4: Serial 1 pinout

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 5: Serial 1 interface parameters

When in receive mode, the dAISy FeatherWing will output AIS messages as NMEA AIVDM sentences[7]. Depending on the configuration, the output may include additional debug messages with information like signal strength or data errors.

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[7] https://gpsd.gitlab.io/gpsd/AIVDM.html

Sending the ESC character (0x1B) on Serial 1 will bring up the configuration and debug menu See chapter 5.2 for more information about the configuration and debug menu.

3.3   Serial 2

Serial 2 is a configurable UART interface. The pins are labelled RX2/TX2 and are not aligned with the standard pinout of Adafruit Feathers.

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 6: 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/SCL and align with SDA/SCL pins on the Adafruit Feather (Wire in Arduino). The I2C address is configurable, with a default value of 0x33.

dAISy	Feather
SDA	SDA
SCL	SCL

Table 7: I2C pinout

The dAISy FeatherWing 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 and align with D12/D13 pins on the Adafruit Feather (digital pins 12 and 13 in Arduino).

dAISy	Feather
IO1	D12
IO2	D13

Table 8: GPIO pinout

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 FeatherWing is a female SMA connector with standard polarity.

The dAISy FeatherWing 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 FeatherWing 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 FeatherWing 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 (11 for dAISy FeatherWing)							
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 9: 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 FeatherWing 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 10: GPIO pin functions

See chapter 5.2 for information about configuring the dAISy FeatherWing.

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 FeatherWing.

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 FeatherWing.

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 FeatherWing.

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 the Feather 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 Feather'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 Feather's I2C peripheral.

5 Using the dAISy FeatherWing

Using the dAISy FeatherWing 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 FeatherWing automatically starts to listen for AIS transmissions.

5.1 Interpreting the status LEDs

The dAISy FeatherWing 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 FeatherWing 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 FeatherWing received a valid AIS packet.

For every packet received and passing all error checks, the LED will turn green for ¼ second. At the same time, the dAISy FeatherWing will output the received message as NMEA AIVDM sentence on the serial port.

Long RED flash

The dAISy FeatherWing received an invalid packet.

This means that the dAISy FeatherWing 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 continously

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

The LEDs are turned off while the dAISy FeatherWing 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 FeatherWing 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 FeatherWing 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 v6.02 - dAISy FeatherWing (5232/5222) (C)2014-2023 Adrian Studer

Radio 1: 161.975MHz AIS1      Radio 2: 162.025MHz AIS2       Format: A/B
Serial 2: 38400 8N1, NMEA out   I2C: 0x33
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
I       Configure I2C interface
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

5.2.1   Configuration options
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 FeatherWing to listen to specific AIS channels. The dAISy FeatherWing 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 FeatherWing also support the less common "Long range AIS" channels at 156.775 and 156.825 MHz.

I: Configure I2C interface. Enable or disabled I2C and set the I2C device address.

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.

ESC: Resume receiving AIS messages.

5.2.2   Debug options

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 FeatherWing 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 FeatherWing 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 FeatherWing 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 FeatherWing, 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 FeatherWing has an integrated bandpass filter to reduce the impact of radio frequency noise outside the marine VHF band frequency.

7 Troubleshooting

7.1 Known issues

7.1.1 ESP32-based Feather boards

Issue: The dAISy FeatherWing does not start when mounted on a ESP32-based Feather, like for example Adafruit Huzzah ESP32 or SparkFun ESP32 Thing Plus. The issue is due to an incompatibility between ESP32 pin IO13 and dAISy FeatherWing IO2.

Solution 1: Configure a GPIO function for dAISy FeatherWing IO2, like for example Sleep, and store that setting as power-on default. See chapters 4.2 GPIO and 5.2 Configuration and debug menu for information about GPIO functions and how to configure them.

Solution 2: Connect dAISy FeatherWing IO2 to a different I/O pin on the ESP32 Feather.

7.2 General troubleshooting tips

Problem	Solution
No activity of the status LEDs	Verify that the dAISy FeatherWing 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 FeatherWing indicates a device error (fast blinking red LED)	Power cycle the FeatherWing to resolve the issue. If this is a regular occurrence, contact us.

Table 11: Troubleshooting tips

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

8 Specifications

Power	
Input voltage	3.3 V
Input current with LNA enabled (default)	70 mA
Input current with LNA disabled	35 mA
Input current in sleep mode	0.35 mA
Radio	
Independent receivers	2
Frequency bands	161.975MHz, 162.025MHz, 156.775MHz, 156.825MHz
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 - 162.025MHz pass band
RF connector	SMA female
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	3.3V
Dimensions	
Circuit board without SMA connector	50.8 mm x 22.86 mm (2.0" x 0.9")
Circuit board with SMA connector	60.7 mm x 22.86 mm (2.4" x 0.9")
Circuit board mounting holes	4x Size: 2.54mm (1.0") Distance: 45.72 mm x 17.78 mm (1.8" x 0.7")
See also: https://learn.adafruit.com/adafruit-feather/feather-specification	
Weight	
Circuit board with SMA connector	6 g (0.21 oz)

9   Source code and schematics

Currently the dAISy FeatherWing is only partially open source.

The core of the dAISy FeatherWing, 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 FeatherWing 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.

Wegmatt LLC
6356 138th Ave NE #212
Redmond, WA
United States of America
https://wegmatt.com

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