Black Cat Absolute ACARS
Version 1.1.0b1 – 9 October 2024

Program information and download:

https://blackcatsystems.com/software/black_cat_absolute_acars_decoder_sdr_iq_file_decoding.html

NOTE: Suggestions / new feature requests are welcome. Bug reports are also welcome, please include step by step instructions for reproducing them.

Most traditional ACARS decoding programs only decode audio from one frequency at a time, some can handle a few frequencies. This means you're missing out and not receiving ACARS messages on the frequencies you're not monitoring.

And even with decoders that can handle multiple audio sources, you need to set up receivers in your SDR software for each frequency (up to whatever limit it has) along with multiple virtual audio cables to pass audio from the SDR software to the ACARS decoding program. What a mess.

This program does away with those limitations. It directly demodulates and decodes ACARS transmissions from SDR I/Q recording files, covering several MHz of bandwidth. It monitors the directory your SDR program saves I/Q files in, detects when a new file has been created, waits for that file to be finished written to, then opens it, decodes on all the selected ACARS frequencies, and then deletes the file, so your hard drive doesn't fill up. As new I/Q files are written every minute or two, there's minimal delay in seeing the ACARS messages.

SDR I/Q recording files to analyze. Presently the following formats are supported:

- Elad
- Gqrx
- KiwiSDR
- Perseus
- RFSpace (Spectravue and SdrDx)
- SDR Radio -WARNING – THIS FILE FORMAT CHANGES OFTEN, MAY NOT WORK
- SDR# / Baseband Recorder
- SDR++
- Studio 1
- SDRuno (Studio1, format 2)

Please note: SDR I/Q recording file formats are not well documented. I've done my best to figure out the formats, but it involves a lot of guesswork. There's a good chance of some edge cases that cause problems. Or SDR app authors that routinely change the format, breaking things. I won't name any names ☺ If some files don't appear to work, contact me, and maybe we can figure things out. Likewise, if there's a format not presently supported, I can look into adding it. I'll need sample files of course, and ideally some scraps of information from the program author as to the format.

IMPORTANT: PLEASE DO NOT CHANGE I/Q RECORDING FILENAMES! The filename format is one of the characteristics this program uses to distinguish between formats (which SDR program wrote the file). If you change the filename, the file will likely be misidentified and not properly processed.

You can even run this decoding program on a second computer, and access files on the computer with the SDR software creating writing the I/Q files over your local network.

In addition to displaying decoded messages, both on a per channel basis as well as all frequencies combined into one display, messages can be

written to text logging files, either with a manually selected filename, or into rolling timestamped files.

Messages are also sorted by message type, aircraft tail number, flight number, and frequency. Display/logging of messages of specified types can also be disabled, reducing the amount of "clutter" of unwanted messages.

The Open Sky Network database file can also be used with this program, to display information about aircraft along with their messages.

Currently within the USA, VHF ACARS transmissions are found in the 128.975 – 131.850 MHz frequency range. Centering your SDR at approximately 130.4 MHz with at least a 3 MHz effective bandwidth (which usually means about a 4 MHz sample rate) will cover this entire range, allowing you to decode every ACARS channel at the same time.

Basic Setup / Quick Start:

Open the Setup window, and change the number of decoders to at least as many ACARS frequencies as you wish to monitor. Close the Setup window, quit the program, and restart it, so this change takes effect.

Go back into Setup, set the **File watch delay** to 4 seconds, and make sure the **Bandwidth** setting is blank (or set to the appropriate value if you decide to change it). Check the **Delete I/Q file after processing** checkbox. Also check the **Suppress Parity Errors** checkbox. Leave the other settings at their default values for now.

Set up this program so it is monitoring your SDR program's I/Q recording file directory (where it writes recording files). Do this by selecting **Set Directory To Monitor For New I/Q Files** from the **File** menu. Then select **Monitor I/Q File Directory** also from the **File** menu.

Next you need to set the frequency for each decoder tab. You can do this manually, or you can use **Set Frequencies** from the Edit menu to bulk set many or all of the frequencies. Currently you need 18 decoders to decode every possible ACARS channel in the USA.

Set up your SDR software so that it covers your frequency range of interest. Since this program decodes from the I/Q recording file, it does not matter what demodulation mode you set the program for, or other related settings.

Set up your SDR software to record I/Q files. You want to make sure the software is writing a series of I/Q files, not one giant file, as files cannot be decoded until they are written to and closed. Many SDR programs allow you to specify a maximum I/Q file length, select this so that a new file is created every minute or two. Often a file length of around 2 GB is ideal, but you can experiment to see what works best for you. Make sure you are recording I/Q files, not audio files.

Once all this has been done and your SDR software is running and writing I/Q files, the status display at the bottom of the main window in this program indicating that it is verifying a new file is finished, followed by the filename. If not, double check that files are actually being written by your SDR software, and this program is looking for them in the correct directory.

Once a file has been finished being written to by the SDR program and closed by it, this program will start reading/processing the file, the status display at the bottom of the main window will show how many seconds of the file have been processed so far, and decodes should start appearing.

If you're not getting any decodes, it's likely that one or more small errors could have been made in setting up either this or your SDR program. I'd suggest going back and double/triple checking everything.

It's important to remember that decoding many channels can be processor intensive. You need to use a reasonably fast computer. Processing time is a factor of how many ACARS channels are being decoded, as well as the characteristics of the I/Q file itself. The higher the bandwidth (faster sampling rate) the more CPU resources are needed to demodulate/decode it. So only set the sampling rate as fast as needed to cover all the channels of interest. Also, a 24 or even 32 bit I/Q file is larger than a 16 bit, and will take longer to process, with little or no improvement in decoding results.

A tour of the Menu Bar:

File Menu:

Open I/Q File – Manually add one or more I/Q files to the processing queue.

Abort Processing – Stop processing the current file as well as any in the processing queue.

Set Directory To Monitor For New I/Q Files – Specify which directory will be monitored, looking for new I/Q files.

Monitor I/Q File Directory – Start monitoring the directory selected above. When a new I/Q recording file has been written and closed by the SDR program, it will be added to the processing queue.

Show I/Q Files Awaiting Processing – Opens a window displaying a list of I/Q files in the processing queue.

Start Logging – Start logging decodes to a text file. You'll be prompted to specify which file to write to, if this file does not exist it will be created. If it does exist, decodes will be appended to it.

Start Rolling Log – Similar to the above, but logs will be written to a directory specified in the program Settings. You can specify what duration, in hours, each file will cover. New files will be automatically created as need, each file's name is a timestamp of the date and hour of creation.

Stop Logging – Stop logging decodes to the text file.

Frequency List Window – Opens a window which shows how many messages have been received on each frequency. You can double click on an entry to open another window showing all the messages on that frequency.

Planes List Window - shows messages sorted by the plane tail number. You can double click on an entry to open another window showing all the messages from that plane.

Flights List Window - shows messages sorted by the flight number. You can double click on an entry to open another window showing all the messages from that flight.

Messages List Window - shows messages sorted by the message type. You can double click on an entry to open another window showing all the messages of that type.

Messages Per Minute Window – shows the number of messages sorted by the frequency.

Aircraft Models Window – shows which aircraft models have sent messages, if you've downloaded and installed the aircraft database file (elsewhere later in this documentation). You can double click on an

entry to open another window showing the tail numbers of planes of that model. And double click on an entry there to see the messages.

Frequencies In Passband Window – Lets you determine which ACARS frequencies are contained within the passband of an I/Q file, given the center frequency and sample rate.

Kiosk Window – Lets you use the full screen to display received messages. After selecting this from the menu, hit the ESC key to enter full screen mode, and ESC again to exit. Note that only messages received after opening the full screen window will be displayed, previously received messages will not be displayed.

Exit – Quit the program.

Edit Menu:

Settings – Opens the Settings window. See further down this documentation for a description of the various program settings.

Enter Registration Code – Enter your registration / license code after purchasing your copy of the program.

About Black Cat Absolute ACARS – Displays the program version number.

Download aircraft.csv – Attempts to download and install the aircraft.csv aircraft database file. See elsewhere in this documentation for details about this file.

Copy Decode Text – Copy text from the currently selected decoder to the clipboard.

Clear Decode Text – Clears text from the currently selected decoder.

Clear All Decode Text – Clears text from all decoders.

Clear All Summaries – Clears all of the summaries (frequencies, flights, planes, message types)

Sort Decoder Tab Frequencies – Sorts all of the decoder tabs by frequency.

Clear Decoder Tab Frequencies – Clears the frequencies in all decoder tabs.

Set Frequencies – Opens another window which allows you to set the decoder tab frequencies from a list of known ACARS frequencies.

Set Text Color – Lets you set the color of the text in all program windows.

Set Background Color – Lets you set the background color in all program windows.

Set Selection Color – Lets you set the text selection color.
Set Text Font – Lets you set the text font.

Set Text Size – Lets you set the text size.

Auto Scroll Messages Window – When checked/selected, the program will automatically scroll to the end of text in windows. You may want to disable this temporarily when scrolling back to look at older messages.

Update Messages Window – When checked/selected, the program will automatically add new messages to windows. You may want to disable this temporarily when scrolling back to look at older messages.

Set Highlight Color – Lets you set the text color that will be used when a message contains a word from the list of highlighting words.

Highlighting Words – Lets you set the list of highlighting words. These are words that, when present in a message, will cause that message to be displayed in a different color, so they are more obvious. Optionally, a system alert/beep sound will be generated. It can also be used to prevent the display of messages that contain certain words, or characteristics, such as run on text, via a scoring system. This can be helpful if you want to prevent the display of automated messages that contain engineering data, etc.

The three checkboxes at the top allow you to select whether messages should be highlighted, if the score of a message is displayed (for scoring tuning purposes), and whether an alert sound should be displayed for highlighted messages.

In the new window that appears, right click in the list area to add a word. Also add a score to the right of the word, this score can be a negative number. Right click on an existing entry to be given the option to remove it from the list.

For a message to be highlighted (and optionally generate an alert sound) the score of the message must be at least equal to the Min(imum) Highlight Score. Typically, this will be a positive number.

If the score of a message is less than the Hide Below value, it will not be displayed, nor written to a log file. Typically, the Hide Below threshold will be a negative number.

There are two additional scores generated for a message:

The first is if the ratio of numbers to letters in the message is larger than some specified ratio (positive always a decimal number), along with the score to add if that is the case, typically a negative number. Messages

with engineering data tend to have a lot of number vs letters, and this can be used to reject them.

The second is the length of the longest word, along with it's (usually negative) score. Engineering data messages tend to have a very long string of characters without a space.

It will take some experimentation to generate your list of words and related scores. To aid in this process, you can check the Show Score checkbox. Each message will be prepended with three numbers between braces, such as:

{-27 80 1.462 }

These numbers are:
The computed message score (-27 in this case)
The maximum word length (80)
The Number to Letter ratio (1.462)

While testing, you can set the Hide Below value to a large negative number, such as -999, so that messages will never be hidden, so you can see their score and adjust your settings until you're happy with the generated scores. Then set it to a suitable threshold to block messages you do not wish to see.

Next Tab – Advances to the next decoder tab.

Previous Tab – Skips back to the previous decoder tab

Frequencies Menu – Lets you set the frequency of the currently selected decoder tab from an entry in this list.

Decoder Tabs:

For each decoder, you set the frequency in MHz, with a value like this: 129.125

The number of good and bad messages is displayed, along with the percentage of good. A bad message is one that failed the checksum or another message integrity test. If you have not checked Suppress Parity Errors in the Settings, then messages will not be marked as bad.

The Reset button will clear the good/bad count for a decoder. Clicking on Reset on the Combined tab will clear the count for all decoders.

The Combined tab shows messages for all decoders.

The Debug tab is for displaying some program diagnostic messages, which as which I/Q files have been processed, and how long the processing took.

At the bottom of the main window are some status displays:

The first displays the status of monitoring the I/Q file directory. When this is active, one of the the following three pieces of information will be displayed:

Checking for new files in…
Verifying new file is finished
Found new file…

When a file is being decoded, the processing status is displayed, as the number of seconds that have been processed so far / the duration of the file in seconds.

The number of active decoders is displayed, a decoder is considered active if the frequency is within the I/Q file passband.

If a logging file is open, the name of the file will be displayed, along with the number of messages written, and the size of the file.

Settings Window:

Number of decoders – The maximum number of decoders (frequencies) that can be decoder. After changing this, you will need to restart the program for the change to take effect.

Data feed delay – The program attempts to use all CPU cores and available processing power. Making this value larger than zero will increase the program's idle time, giving extra time to other applications as well as possibly reducing the heat/stress on your system. Generally you will want values starting at several hundred milliseconds. Experimentation will be required to find the optimal value for your setup/

File watch delay – How long the program waits after it thinks the SDR program is done writing the I/Q file, before processing begins. Make non zero to avoid false starts when the SDR program has not yet closed the file.

Delete I/Q file after processing – When processing is done, the file will be deleted. Generally, you want to turn this on when monitoring the I/Q file directory and automatically processing files, so your hard drive does not fill up.

UTC Offset – Most SDR programs set the starting time for I/Q recording files using UTC. If yours does not, this can be used to adjust the reported time, in hours, positive or negative.

Bandwidth – If left blank, the bandwidth in the header of the I/Q file will be used. Some I/Q file formats do not indicate the bandwidth, in

such cases 80% of the sample rate is used. If this assumption is wrong, you can enter a number between 1-100 into this field to be used.

I/Q file data offset – Usually left at zero. If your I/Q files are non standard, you may need to set this value to align the I and Q data. Generally, don't make this non-zero unless you know what you are doing, or decoding problems may occur.

Suppress parity errors – When checked, the message checksum and other data will be used to determine if the message was received correctly. If not checked, any message that is received will be displayed – often with garbled text.

Monitor directory on launch – Automatically enable monitoring the I/Q file directory at launch, so you don't need to manually.

Set Rolling Logs Directory button – Specifies where rolling logs are written.

Roll log every N hours – Specifies how often a new rolling log file is created.

Start rolling on launch – Automatically enable writing rolling logs at launch, so you don't need to manually.

Open Application Data Directory button – Opens the directory where the aircraft.csv file should be placed in Explorer (Windows) or Finder (macOS).

Demodulation parameters:

The following are demodulation parameters, which can be changed by the user. In general, the default values, listed with each parameter, should be used:

AGC – Enable AGC. Defaults to on.
Hang – Enables AGC Hang. Defaults to off.
Slope – AGC slope in dB. Defaults to 8 dB.
Threshold – AGC threshold in dB. Defaults to -160 dB.
Decay – AGC decay in milliseconds. Defaults to 100 milliseconds.
Gain – Manual gain, if AGC disabled. Defaults to 10 dB.
IF Width – IF/Audio bandwidth, in Hz. Defaults to 3000 Hz.

Blocking display of certain messages / Message Types:

There is a tremendous amount of "clutter" in ACARS traffic, due to all the automated messages. This program offers two strategies to reduce this:

First, the highlighting text option (described earlier) also allows messages that score below a specified value to not be displayed.

Second, display can be blocked by message type. In the Messages List window, right click on a line for a type of message. Select Ignore this message type to stop display of these messages. You can always right click on an entry again to resume display of those messages. Ignored message types are saved for the next time the program is run.

Aircraft Database:

This program can use the Open Sky Network database file to display information about many commercial aircraft.

You can download this file from:
https://opensky-network.org/datasets/metadata/

As of now the direct URL for the file is:
https://opensky-network.org/datasets/metadata/aircraftDatabase.csv

A ZIP archive version is currently available here:
https://opensky-network.org/datasets/metadata/aircraftDatabase.zip

Make sure the file is named aircraftDatabase.csv

There are three possible locations where you can place the file on your computer, so Black Cat ACARS can find it:

1. In the BlackCatSystems directory in the Application Data directory for your user account. For Windows, this is usually:
\Users\UserName\AppData\Roaming\BlackCatSystems

For macOS, this is usually:
/Users/UserName/Library/Application Support/BlackCatSystems

You can easily navigate to this directory on your computer by opening the Settings/Preferences window, and then click on the Open Application Data Directory button. Note that this directory will not exist until you have run this program at least once.

2. In the Documents directory for your user account. If running macOS, make sure your privacy settings for this program allow it to access your Documents directory.

3. In the same directory as this program itself. If running macOS, note that due to Gatekeeper Translocation, you may have to move it out of your Downloads directory first.

When the database is correctly loaded at program startup, a message will be displayed in the first decoder tab, showing how many aircraft were loaded. Usually this number is about half a million, so it will take the programs a few seconds at launch to read and process this much data.

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