ECE448 Spring 2025

Lesson 33

AIS



Nominal Schedule

Lesson	Topics	Notes
22	RF Reverse Engineering	**Final Project Proposal due**
23	RF Reverse Engineering	
24	RF Reverse Engineering	
25	Flex day	**RF RE Project Due**
26	ADS-B	
27	Project Work Day	**Background Research due**
28	ADS-B	
29	ADS-B	
30	AIS	
31	AIS	**Design Description due**
32	WBFM Radio	**ADS-B/AIS Project**
33	HD Radio	
34	HD Radio	
35	Project Work Day	**Prototype Description due**
36	QAM	
37	QAM /OFDM	
38	QAM /OFDM	
39	Project Day	
40	Final Project Presentations	**Final Project due**

Lesson 33 Learning Objectives

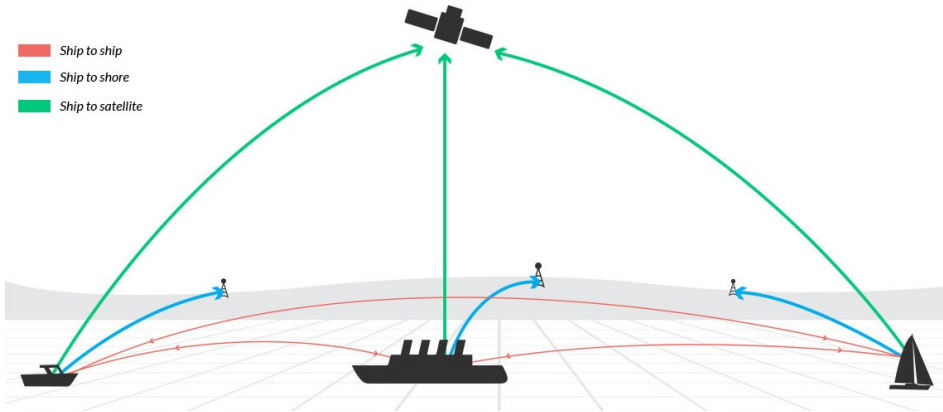
1.1 Articulate the purpose and implementation of the Automated Identification System (AIS)

1.2 Understand the encoding and modulation schemes of AIS

1.3 Use existing tools to receive and decode AIS messages

Automatic Information System (AIS)

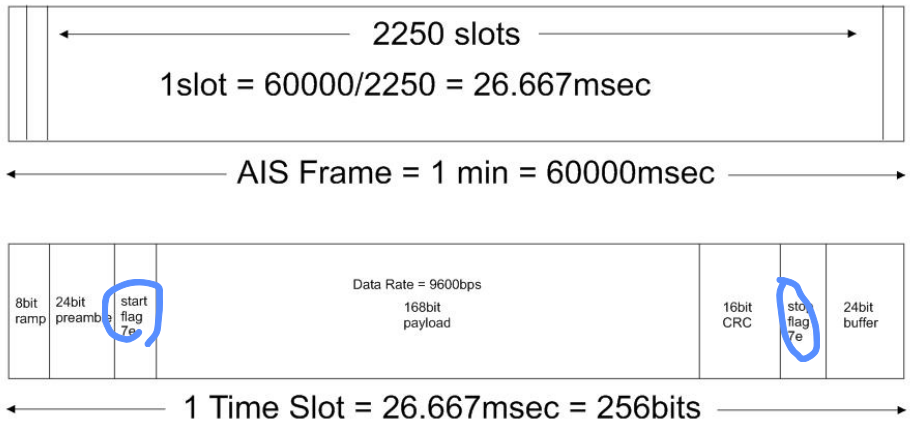
- Allows ships to automatically identify themselves
- Broadcasts various classes of messages on VHF (161.975MHz & 162.025MHz)
- Self Organizing Time Division Multiple Access (SOTDMA)
  - Each slot is 26.66 ms
  - Two channels, 2250 slots per frame, 1 frame per minute
  - 9600 baud
- Non-Return to Zero Inverted (NRZI) encoding, GMSK Modulation



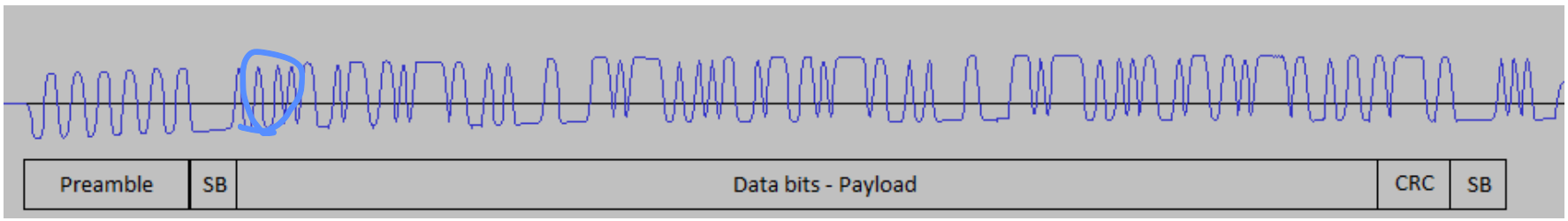
Source: https://shipping.nato.int/nsc/operations/news/2021/ais-automatic-identification-system-overview

AIS Message Structure

- 8-bit ramp up
- 24-bit preamble (`01010...`)
- 8-bit start flag (`0x7e`)
- 168-bit payload
- 16-bit CRC



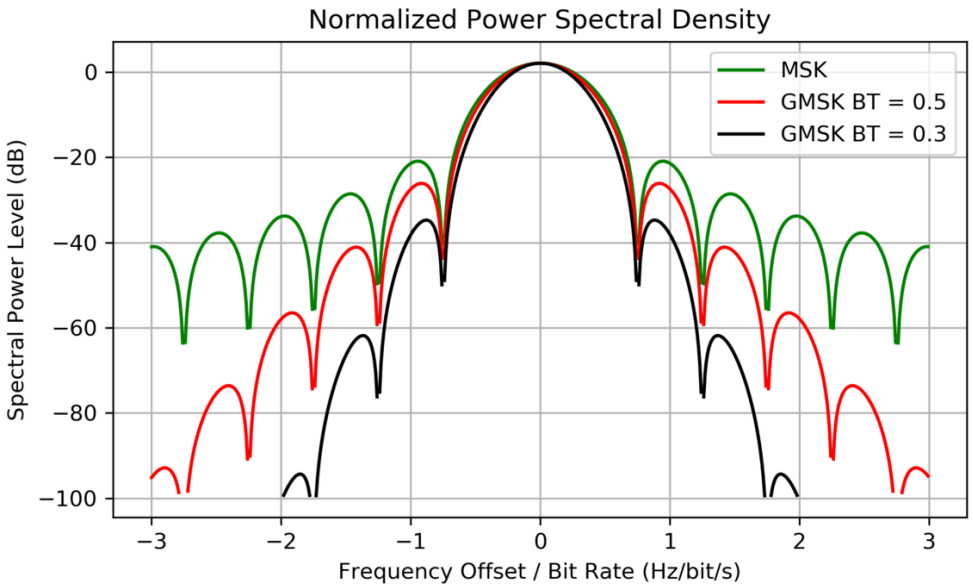
Source: https://jeremyclark.ca/wp/nav/ais-modulator-scicos-simulation/

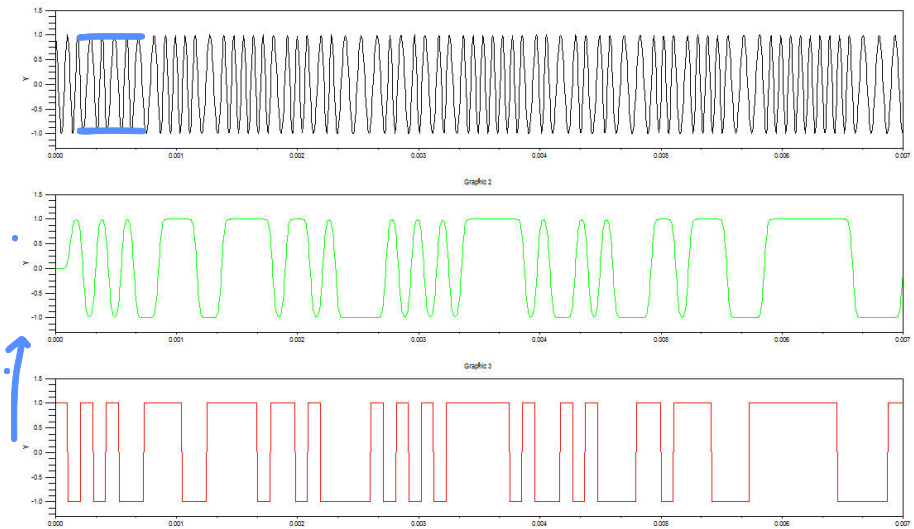


Source: https://en.wikipedia.org/wiki/Automatic_identification_system

GMSK Modulation

- Gaussian Minimum Shift Keying (GMSK)
- Type of FSK
- Reduces power in harmonics
- Constant envelope





Example Data

NMEA 0183 governs format, data sent as printable ASCII:

```
!AIVDM,1,1,,A,14eG;o@034o8sd<L9i:a;WF>062D,0*7D
```

`!AIVDM`	NMEA message type, other NMEA device messages are restricted
`1`	Number of sentences (some messages need more than one, maximum generally is 9)
`1`	Sentence number (1 unless it is a multi-sentence message)
	Blank is the sequential message ID (for multi-sentence messages)
`A`	AIS channel (A or B), for dual channel transponders it must match the channel used
`14eG;...`	Encoded AIS data, using AIS-ASCII6
`0*`	End of data, number of unused bits at end of encoded data (0-5)
`7D`	NMEA checksum (NMEA 0183 Standard CRC16)

Example Data: AIS Payload

The data payload is:

```
!AIVDM,1,1,,A,14eG;o@034o8sd<L9i:a;WF>062D,0*7D
```

Which needs to be interpreted as 6-bit ASCII and then parsed bitwise according to its message type.

Field	Bits
Message ID	6
Repeat Indicator	2
MMSI User ID	30
⋮	⋮

Tools

- gr-ais
- gr-satellites
- SDR Angel
- SCEPTRE

CRC

- Cyclic Redundancy Check
- CRC16 = 16 bits
- Checksum for data
- Easily generated using CRC library in Python
- Can be used for error correction

```
from crc import Calculator, Crc8
data = bytes((0, 1, 2, 3, 4, 5))
calculator = Calculator(Crc8.CCITT)
checksum = calculator.checksum(data) #expected = 0xBC
print(f"CRC8-CCITT checksum: {checksum:02x}")

# Verify checksum
is_valid = calculator.verify(data, checksum)
print(f"Is checksum valid: {is_valid}")
```

Activities

- Generate NMEA sentence using pyais
- Check out the Sigmf file from the Noir CTF challenge – use whatever tool you like
- Parse payload data
- Try to send AIS data to someone
  - Could use AIVDM generator, NRZI encode, GMSK mod
  - Could also use AIS Simulator
  - Another approach?