Goin’ Digital

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v2

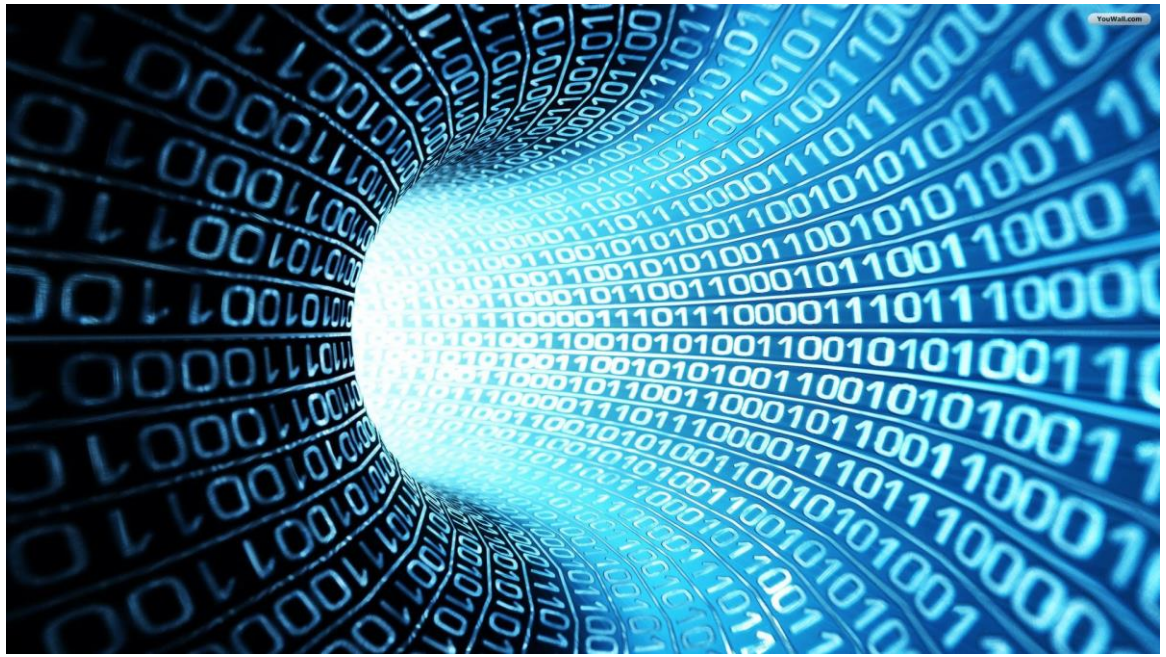
Want to get into digital modes?

The “world” has gone digital, but you are unsure what that means?

Want to get into digital modes and find it a mystery?

Maybe you understand a lot about Ham Radio and not about digital modes?

Why digital? What was wrong with analog?



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Basics

"Digital" is really just a representation of information in the form of numbers

The "numbers" can be used to represent information

- Pure data , ie numbers themselves
- Audio (think of a CD and streaming audio)
- Pictures (your digital camera)
- Video (MPEG4 video, etc)
- Voice (VoIP, Cell phones, DMR, Fusion, D-Star)
- Messaging (text converted to numbers)
- There is much more… and it all rides on the Internet these days
- Digital Ham Radio leverages some of these technologies

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Simplest Digital System is Binary

Binary means **two** states. We typically refer to them as ‘0’ and ‘1’, called bits

The bits are arranged as a **byte** or 8 bits

Larger arrangements described in a variety of way such as a ‘word’ or ‘double-byte’. The size of a ‘word’ is usually a function of the system it is referencing to.

Example: A word for 16 bit microprocessor is 16 bits, but could be 32 bits for a 32 bit microprocessor.

In binary it is using base 2 arithmetic.

The decimal numbers 2 = 01, 5 = 101, and 8 = 1000

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Encoding data

To be stored or sent, data must be encoded into Binary form.

Most common used is ASCII

American **S**tandard **C**ode for **I**nformation **I**nterchange

Example:

A = 41 and 0100 0001

The number 1 is 0011 0000 (31 decimal)

ASCII Code: Character to Binary

0	0011 0000	O	0100 1111	m	0110 1101
1	0011 0001	P	0101 0000	n	0110 1110
2	0011 0010	Q	0101 0001	o	0110 1111
3	0011 0011	R	0101 0010	p	0111 0000
4	0011 0100	S	0101 0011	q	0111 0001
5	0011 0101	T	0101 0100	r	0111 0010
6	0011 0110	U	0101 0101	s	0111 0011
7	0011 0111	V	0101 0110	t	0111 0100
8	0011 1000	W	0101 0111	u	0111 0101
9	0011 1001	X	0101 1000	v	0111 0110
A	0100 0001	Y	0101 1001	w	0111 0111
B	0100 0010	Z	0101 1010	x	0111 1000
C	0100 0011	a	0110 0001	y	0111 1001
D	0100 0100	b	0110 0010	z	0111 1010
E	0100 0101	c	0110 0011	.	0010 1110
F	0100 0110	d	0110 0100	,	0010 0111
G	0100 0111	e	0110 0101	:	0011 1010
H	0100 1000	f	0110 0110	;	0011 1011
I	0100 1001	g	0110 0111	?	0011 1111
J	0100 1010	h	0110 1000	!	0010 0001
K	0100 1011	I	0110 1001	'	0010 1100
L	0100 1100	j	0110 1010	"	0010 0010
M	0100 1101	k	0110 1011	(	0010 1000
N	0100 1110	l	0110 1100	)	0010 1001
				space	0010 0000

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Representations

Binary numbers get long really quick and are hard to read by people.

01100100101001001011101010111100

To make things more readable we represent them as **hexadecimal** numbers, which is **base 16**. Grouping in 4 bits.

It has 0-9 and A-F as its digits.

Example:

FC01 = 1111 1100 0000 0001

This is 64513 in decimal

0000	0	1000	8
0001	1	1001	9
0010	2	1010	A
0011	3	1011	B
0100	4	1100	C
0101	5	1101	D
0110	6	1110	E
0111	7	1111	F

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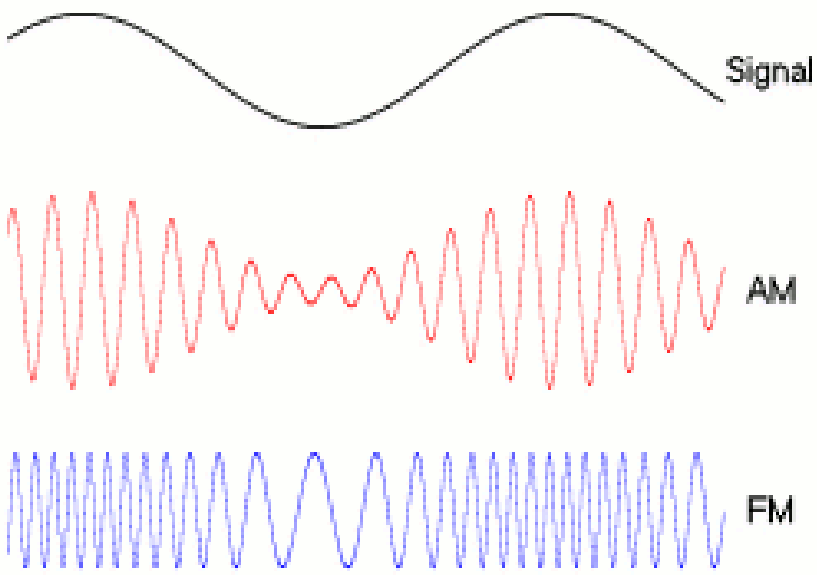
Sending Digital Data

Over most mediums other than just short wires, the digital data is used to modulate a signal. This could be RF or even light.

Modulation is “impressing” the data on a signal, for Hams this is a radio wave.

A ***mode*** is the method of communicating using modulation as a scheme.

Demodulation is the reverse process and would result in a digital stream.



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Basic Modulation schemes for Digital

Binary must be used to drive a MODEM to send data over analog channels.

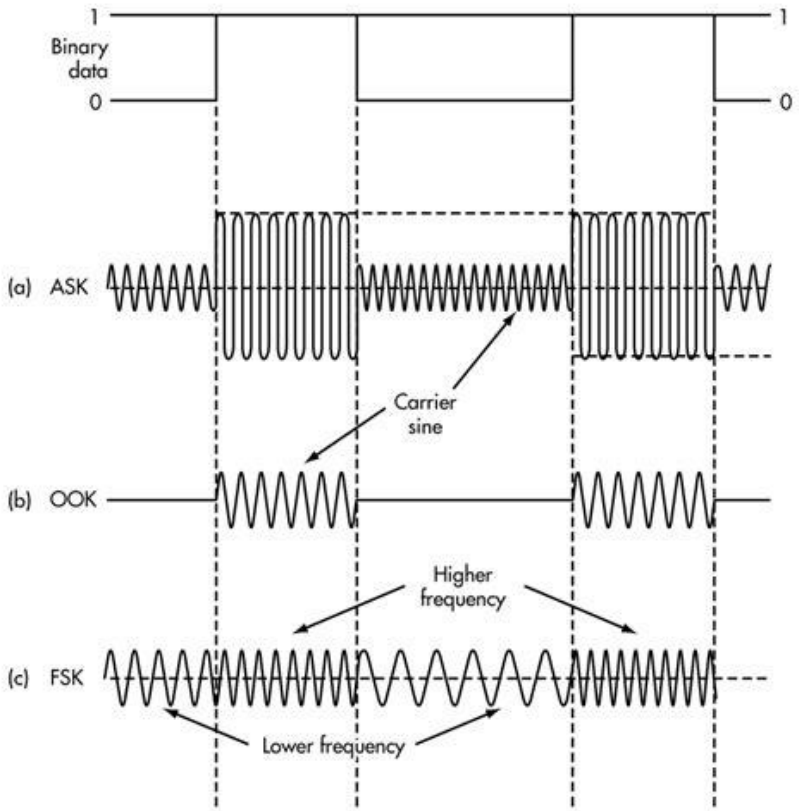
Different schemes can be used to do this, as shown here.

ASK = amplitude shift keying

OOK = On Off Keying (CW)

FSK = Frequency Shift Keying

PSK = Phase Shift Keying (not shown)



What do they sound like?

PSK31

JT-65

Packet Radio

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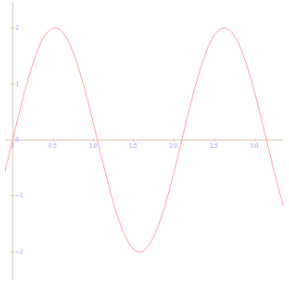
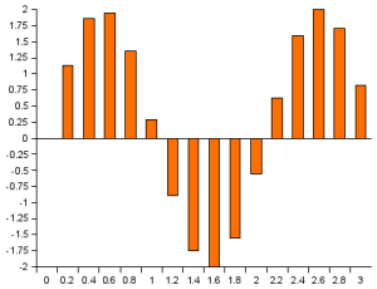
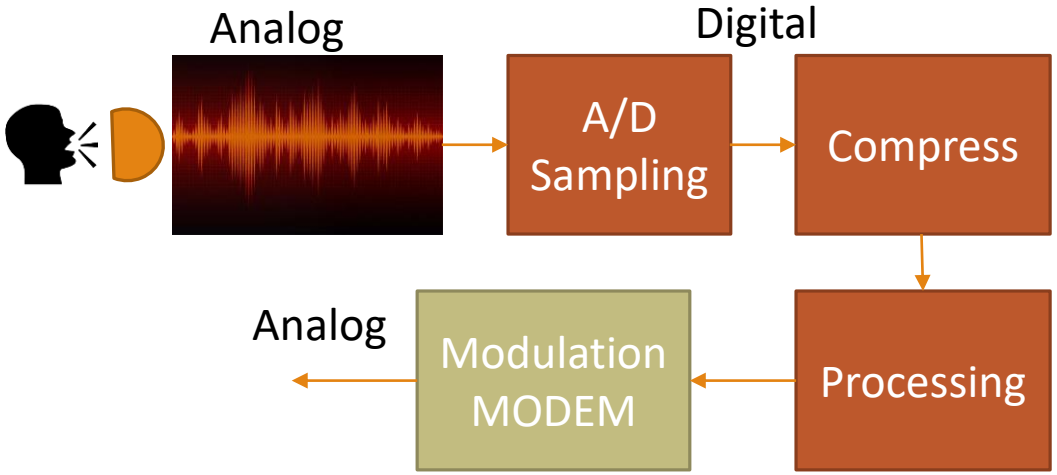
How do we make speech digital?

- Analog is “sampled” at rate = 2X of the bandwidth.
  - For 8000Hz we sample at 16KHz
  - For 16KHz we must sample at 32KHz
- We compress the digital to make it a much smaller number of bits
- Processing often adds error correction and packetizing for transmission
- It ends up back as analog through a MODEM







Ham Modes

VHF/UHF Digital Voice Modes

- DMR
- Fusion
- D-Star

A Guide to Digital Modes

Consider the Many Advantages of Working Digital

Chat Modes

Lots of fun "chat" modes like PSK31, Olivia & Feld-Hell. Olivia uses strong FEC (forward error correction) which enables excellent copy even with typically poor HF conditions.

HF Email

Send & receive e-mail on HF with the Winlink 2000 system using WinMOR. An excellent way to stay in touch or take part in public service.

RTTY Contesting

If you've never tried RTTY contesting you're missing out! Software RTTY modems like MMTTY enable you to snag the weak ones! AFSK

Free High-Performance Software Modems

Free high-performance software modems like UZ7HO & Direwolf make operating HF packet networks much more reliable and fun. Check out 14.105 MHz LSB for a true RF connected multi-user packet network!

HF Digital Voice

Talk over long distances without noise interference using a digital voice mode like FreeDV or FDMDV.

Work Real DX

Work real DX using low power and even compromise antennas with WSJT modes (JT65, JT9).

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Basic Digital Station Configuration

Software

- FLDIGI
- HRD
- WSJT-X
  - FT8
  - JT-65

Rig Control (CAT)

USB

Audio and PTT Control

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Packet Radio

- Needs TNC box or software TNC
- TNC = Terminal Node Controller
- TNC assembles the messages in to groups of data called “packets”
- The “packets” have error correction bits added for reliable transmission of the data
- Error correction adds bits that can be used to correct ones in error

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Most Popular Modes

Digital Mode	Used on	Modulation	Mode	Error Correction	Software needed
PSK-31 and faster	HF,VHF,UHF	PSK	USB	No	FLDIGI (free), HRD,
RTTY	HF,VHF,UHF	FSK	USB	No	HRD and many other RTTY packages
Packet	HF,VHF,UHF	PSK,OFDM	USB	Yes	Winlink,APRSlink, HF-APRS
JT-65A,B,C versions	HF,VHF,UHF	MFSK	USB	Yes	WSJT-X package (free)
FT8	HF,VHF,UHF	MFSK	USB	Yes	WSJT-X package (free)
Olivia	HF	MFSK	USB	Yes	FLDIGI, HRD and others
D-Star	VHF,UHF	GMSK	NFM	Yes	Digital phone. Proprietary for ICOM
Fusion	VHF,UHF	4FSK	FM	Yes	Digital phone. Proprietary for Yaesu
DMR	VHF,UHF	4FSK	FM	Yes	Digital phone. Open standard

PSK = Phase Shift Keying
OFDM = Orthogonal Frequency Division Multiplexing
MFSK = Multi-Frequency Shift Keying
GMSK = Gaussian Minimum Shift Keying
4FSK = 4-Level Frequency Shift Keying

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Why Run Digital Modes?

- Conditions are poor and I don't know Morse code.
  - Actually CW works as well as most digital modes, maybe better
  - Digital modes work well in poor propagation conditions
  - Modes like FT-8 work at levels below the noise floor
- Want to work DX stations in poor conditions
- It is a fun mode for contesting
- You need to send data to another party.
  - ARES deployments like GA Death Race – send race info forms back to race HQ
  - Deployment where ICS forms need to be sent.
  - Email using Winlink

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How do I get started?

- Most radios will support digital modes, but may need a external sound card, like the SignaLink® box to interface to the radio.
- Seek out one of our Elmers (mentors) and ask for help!
- Learn more at Field Day 2020 and get to run digital modes
- Get your station equipped to run digital
  - Some of the newer transceivers have it built in, like the ICOM 7300
- Lots of resources online as well as books on the topic.
  - Look at the WSJT-X site for some good info

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Thanks for listening
Questions?

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