NAVDAT Technology Review & Modulation Demo

Wednesday, Oct 2
9:00 am EST, 15:00 CET

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Agenda

- Introduction
- NAVDAT Review
- Digital & NAVDAT Modulation
- Introducing NAV Series
  - ***New*** NAVDAT/NAVTEX MF Transmitters
  - ***New*** NAVDAT/NAVTEX Modulator
- NAVDAT Modulation
  - Simulations
  - Modulation Demo
- Questions

John Whyte
Head of Marketing &
Product Strategy
Nautel

Hermann ZENSEN
Sales Manager Europe
NAUTEL

Gary Galbraith
Sales Manager Navigation
NAUTEL

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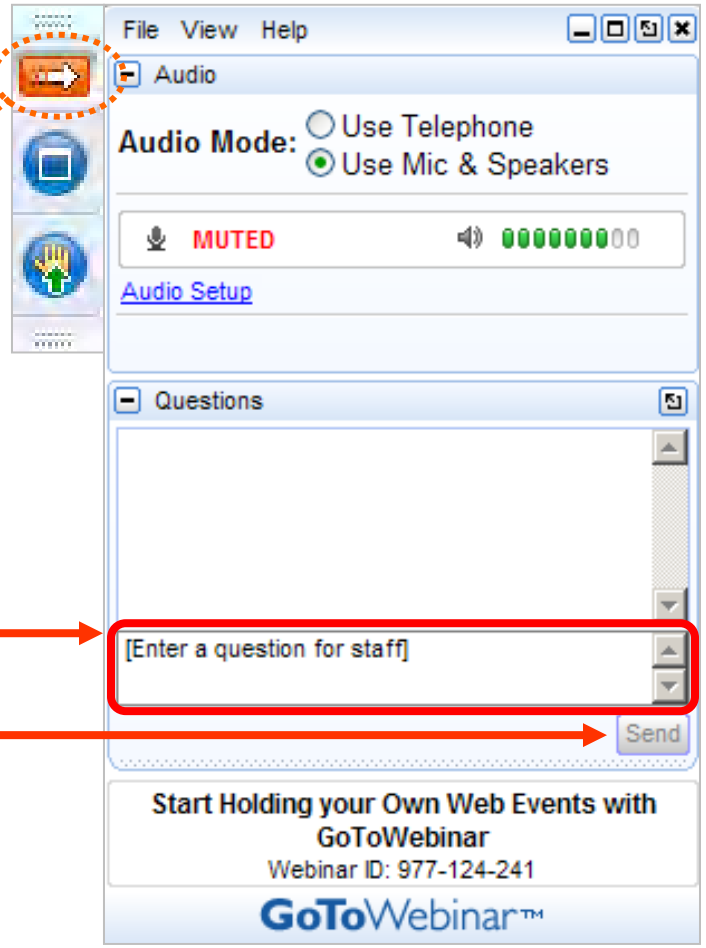
Questions & Answers

Click on  *to open/close webinar panel*



Enter questions here

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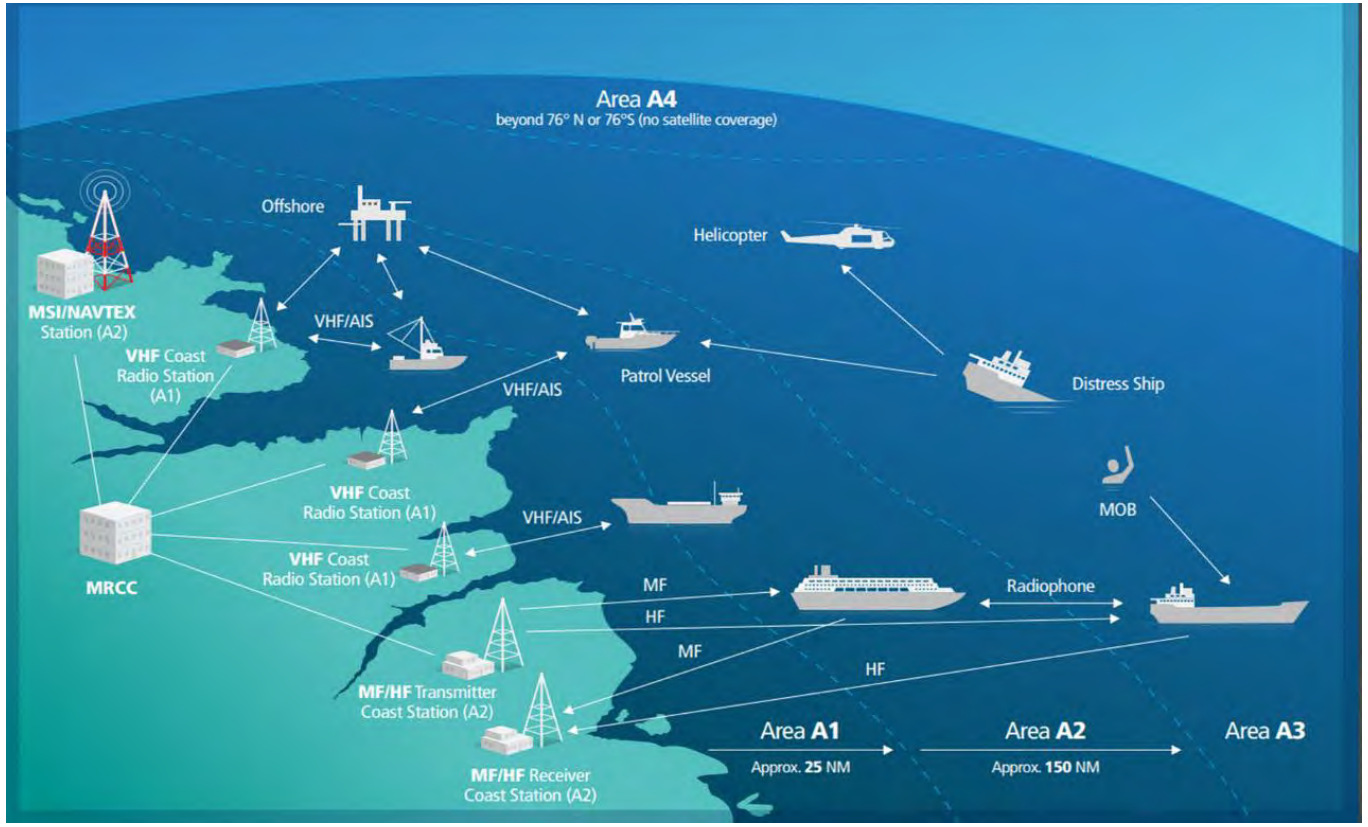
KENTA Technologies & NAUTEL:

Shared passion for maritime communications



Nautel HQ, Halifax, Canada

Nautel Maine, Bangor, US

Kenta Technologies, France

20,000 Deployments

Five Decades

CIRM

IALA

RTCM

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Nautel + Kenta Expertise

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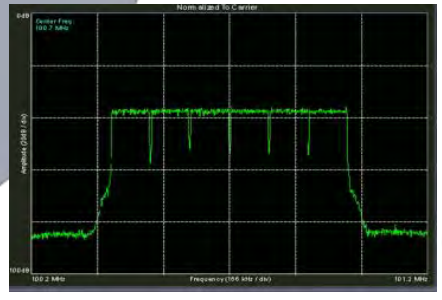
World's Largest
NAVTEX Supplier

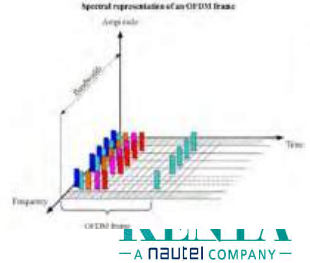
NAVDAT

High Power
Transmitters

Digital
Transmission

dab+ drm HD Radio Digital AM & FM





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NAVDAT

2 Minute Overview

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The promise of NAVDAT: Better data and content

The way forward now, and in line with the strategic implementation plan on e-navigation*, is to introduce **digital communications**.

The gap-analysis of e-navigation identified the need to present information in **graphical format**.

* See MSC.1/Circ.1595

Understanding NAVDAT

- **NAVDAT (Navigational Data)**
  - modern digital broadcasting system designed to transmit navigational and safety information to ships.
- **Development:**
  - Developed as a successor to the traditional NAVTEX system, catering to the evolving digital needs in maritime communication.
- **Technology:**
  - Utilizes advanced digital radio broadcasting technology, to ensure rapid dissemination of maritime safety information (MSI).

Possible content:

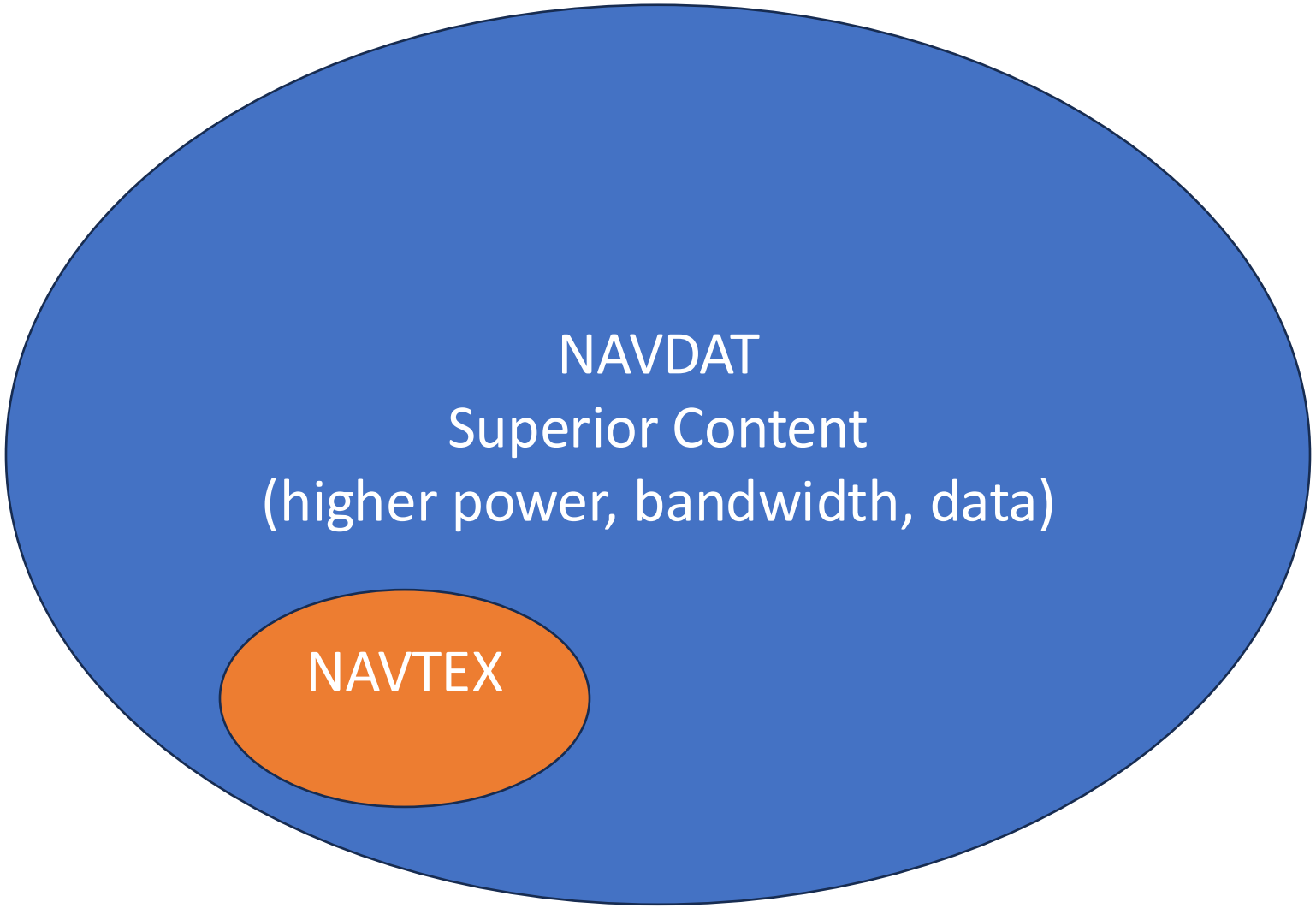
- navigation safety;
- security ;
- piracy ;
- Urgent notice to mariners ;
- Ice and Iceberg ;
- Search and rescue ;
- weather messages;
- currents and tides;
- messages from pilotage or port authorities;
- maritime traffic service file transfer;
- AIS information

Advantages of NAVDAT

- **Enhanced Range & Reliability:**
  - Offers greater transmission range and reliability compared to NAVTEX.
- **Higher Data Capacity:**
  - Capable of transmitting a larger volume of data, allowing for more comprehensive safety messages.
- **Multimedia Capability:**
  - Supports various data formats, including text, images, and potentially video, enhancing the clarity and understanding of safety messages.
- **Flexibility:**
  - Adaptable to various frequency bands and can be integrated with existing maritime communication systems.

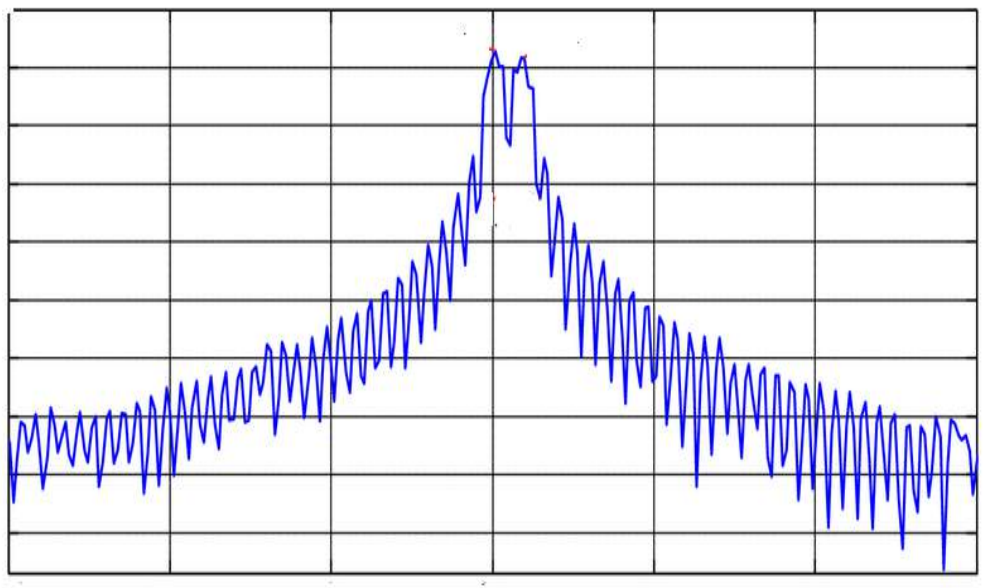
NAVTEX - NAVDAT

NAVTEX NAVDAT relationship

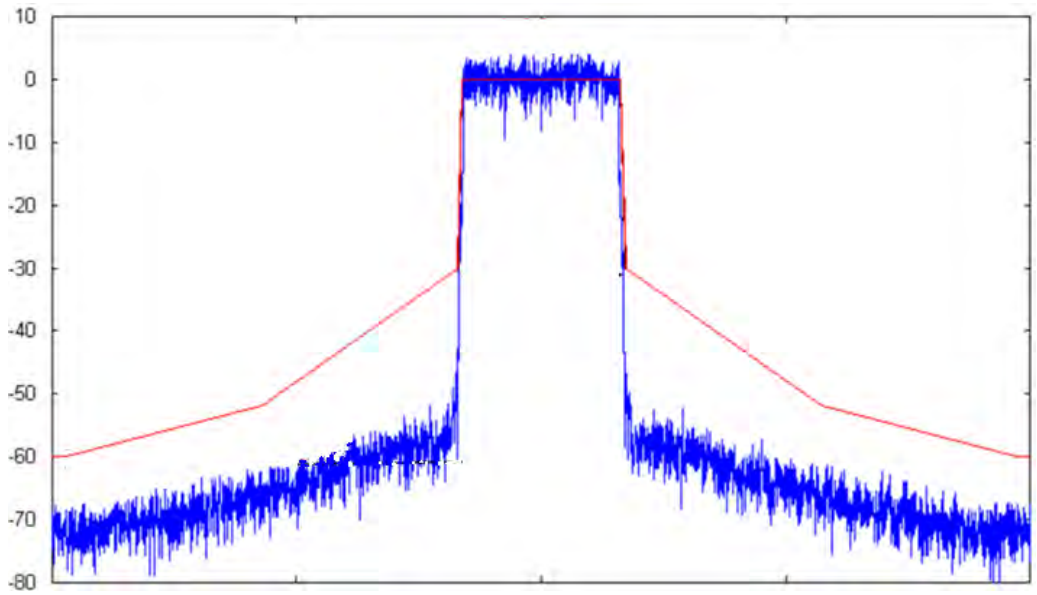


Typical Spectra: NAVTEX and NAVDAT

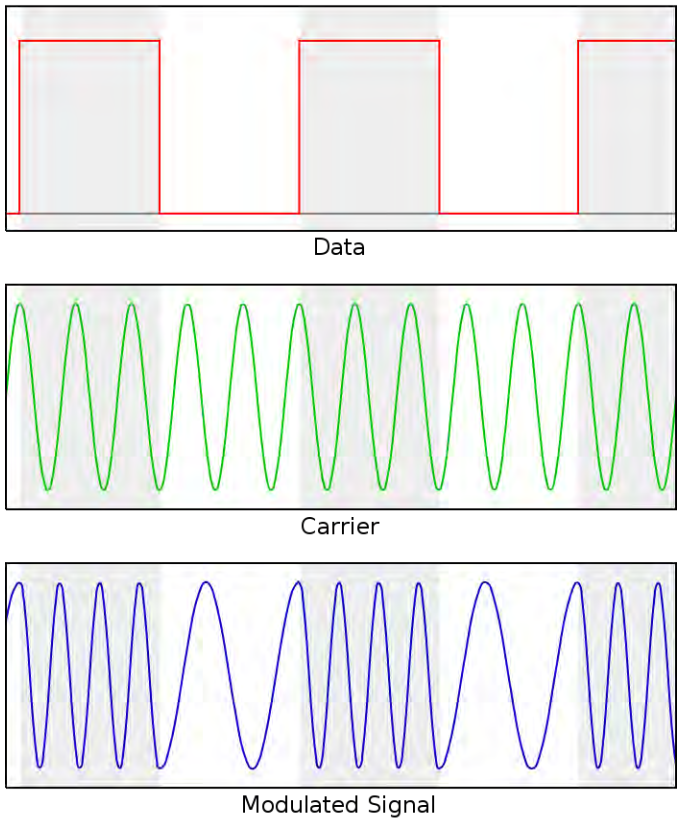
300 Hz NAVTEX



10 kHz NAVDAT

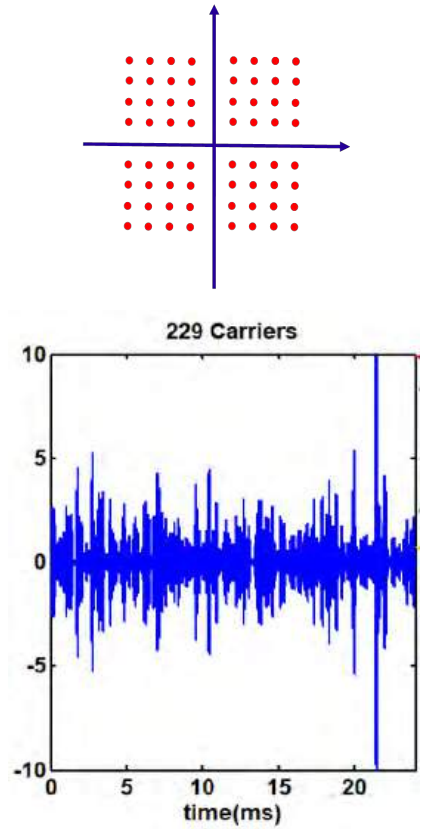


NAVTEX Simple Signal vs NAVDAT Complex Digital



Constant power envelope

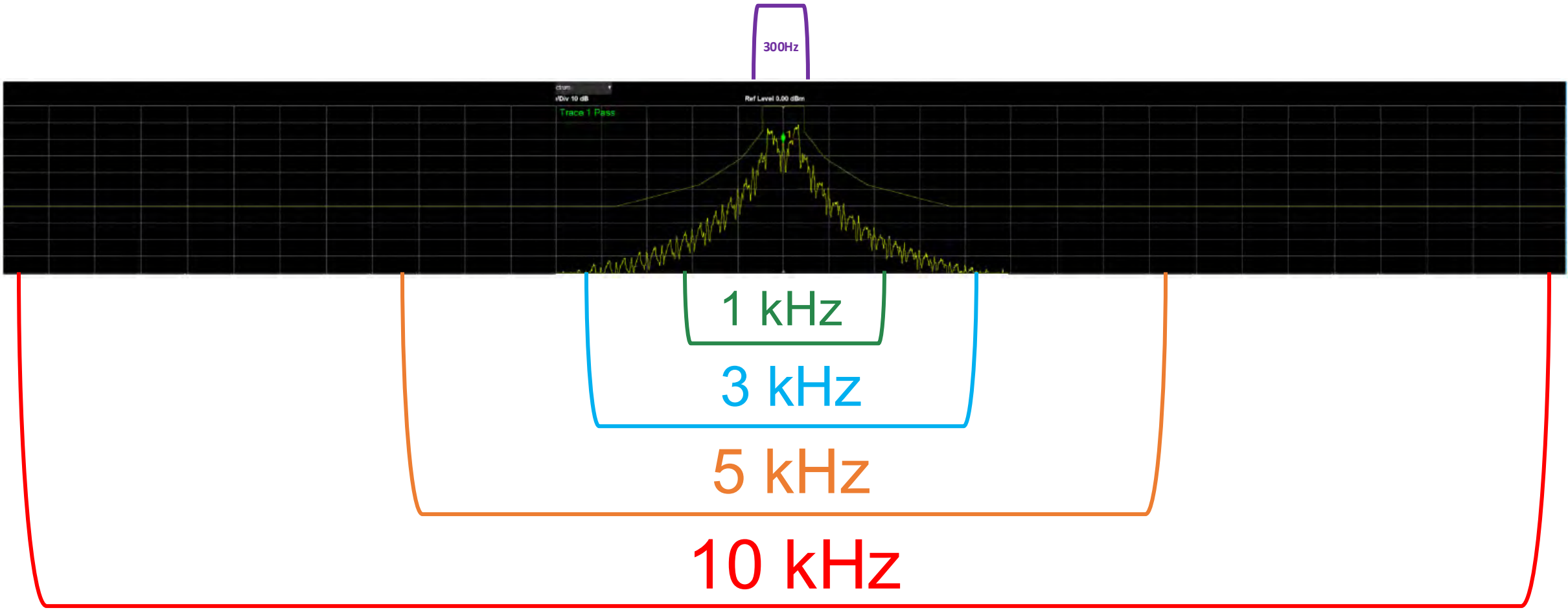
TX Power == PEP Power



Complex Signal

High Signal Peaks

NAVTEX vs NAVDAT Bandwidth Requirements

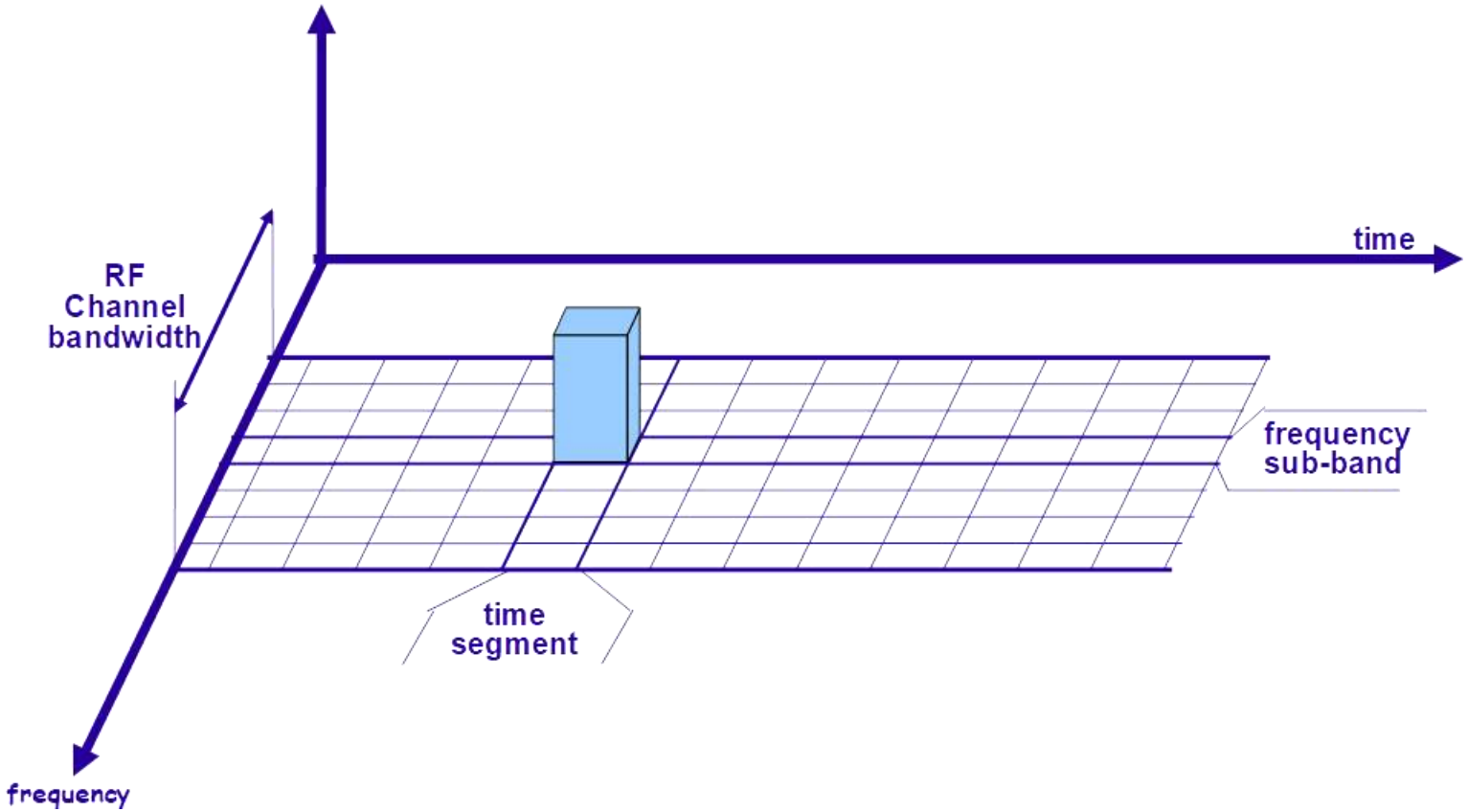


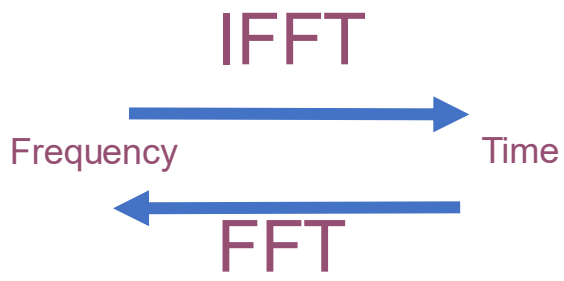
Significant implications for transmission chain:

- Transmitter, Antenna Tunning Unit, Antenna

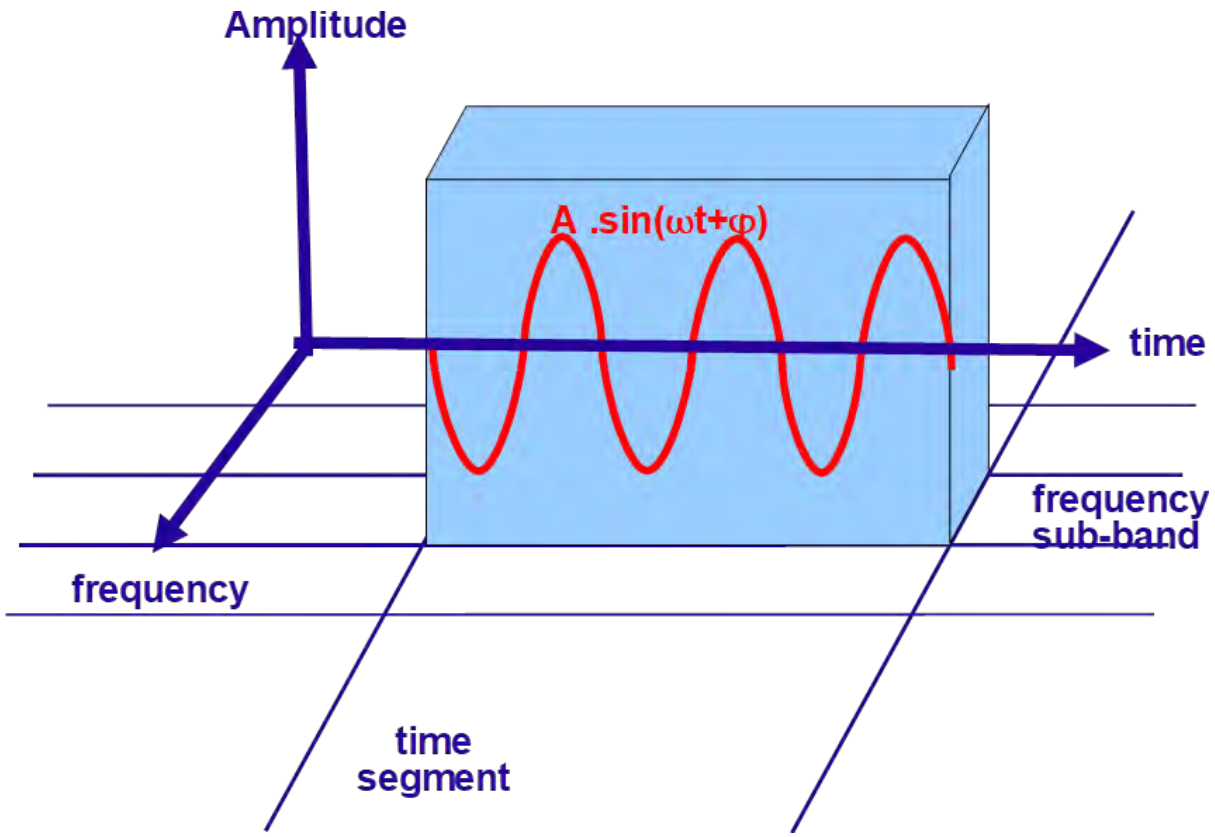
Digital Modulation - Principles

COFDM Technology:
Coded Orthogonal Frequency Division Multiplex

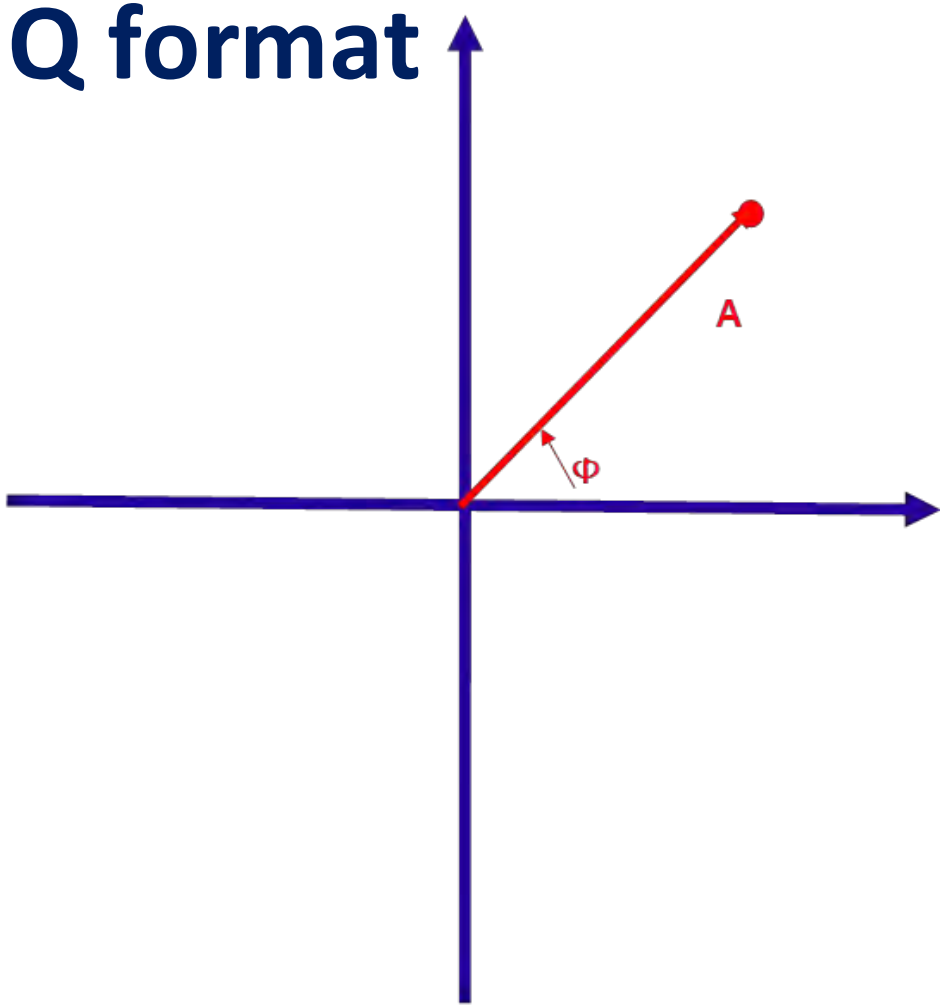


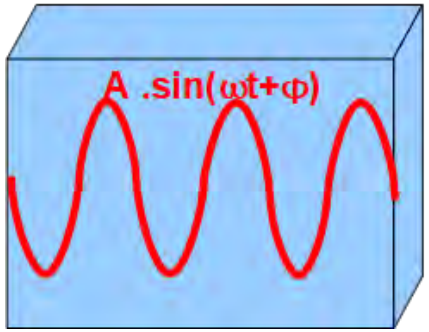


Sine Signal in time and frequency



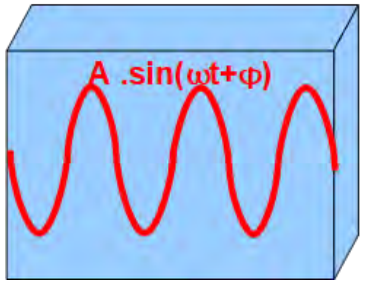
Sine Signal in IQ format

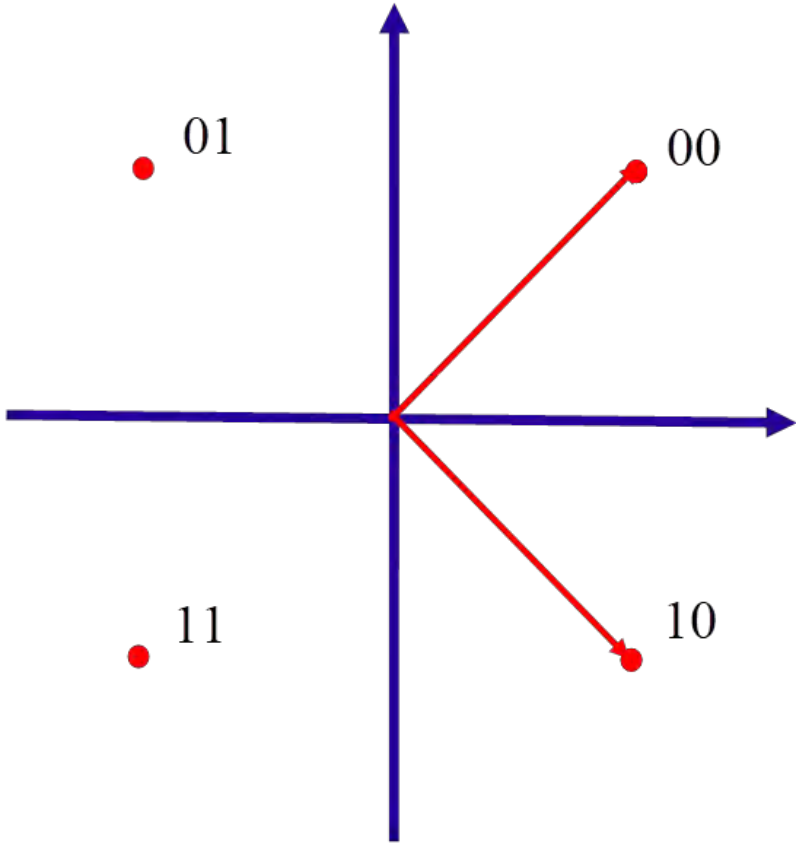




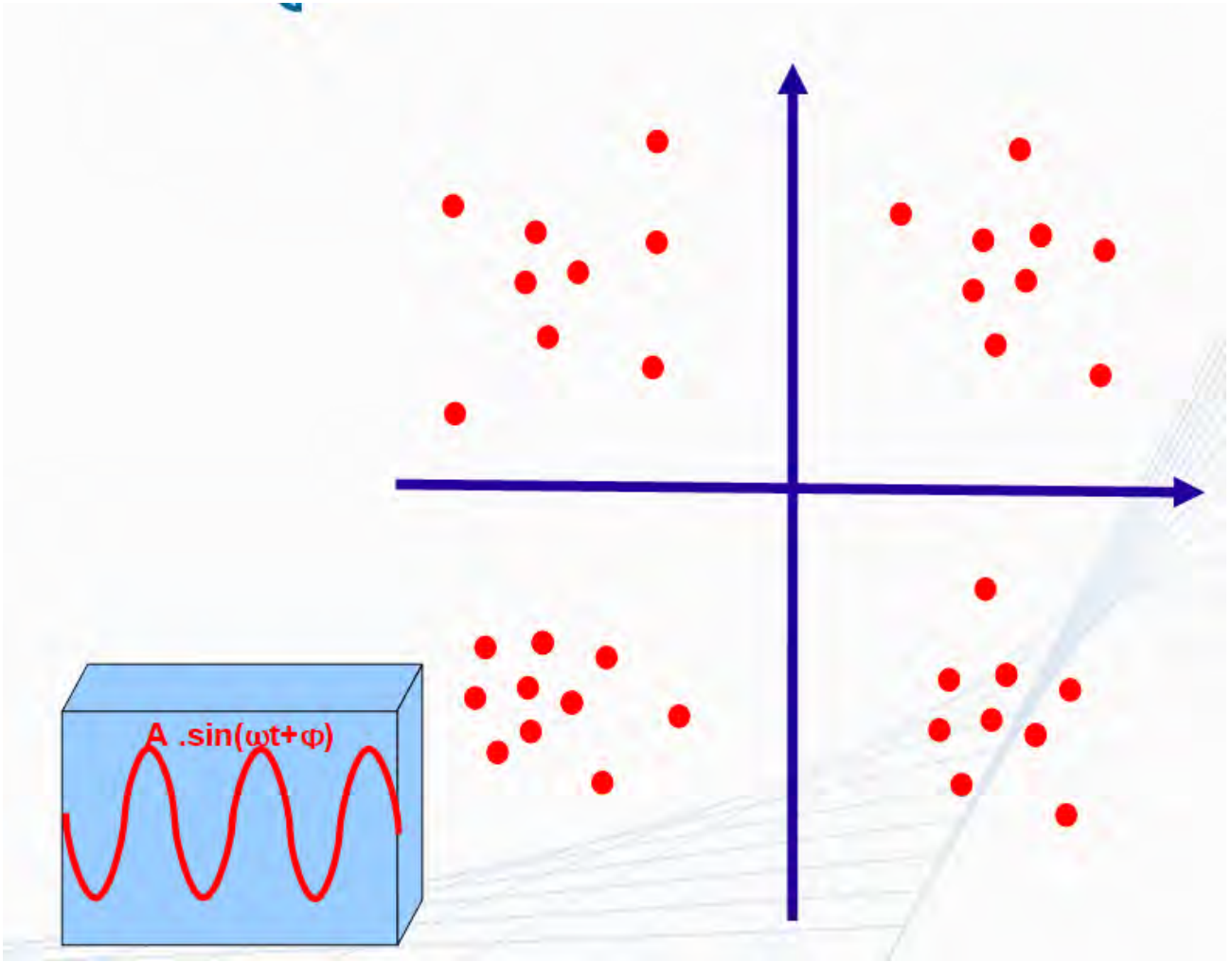
4 QAM in IQ in a perfect transmission channel

4 QAM





4 QAM in IQ in a disturbed transmission channel

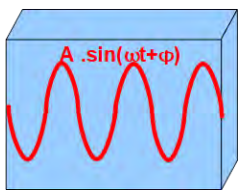


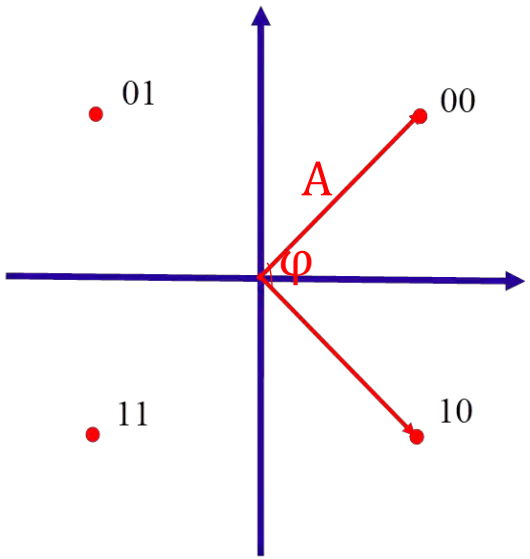
MER- Modulation Error Rate

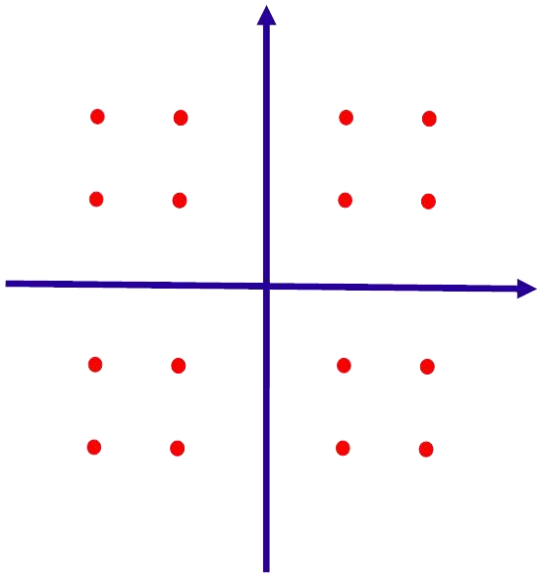
Ratio of ideal vector compared to error vector in the IQ diagram expressed in dB

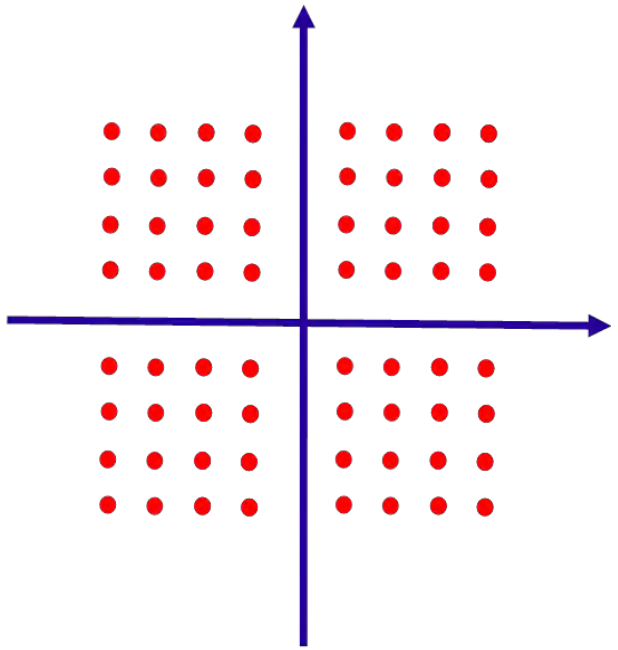
Low, Medium, High Data Rate Modes

Up to 229 carriers (sine waves)









4 QAM
2 bits per carrier/symbol
Robust waveform
~14 dB SNR
6.4-9.6 kbps

16 QAM
4 bits per carrier/symbol
~18 dB SNR
12.7-19.1 kbps

64 QAM
6 bits per carrier/symbol
Highest data rate
~22 dB SNR
19-29 kbps

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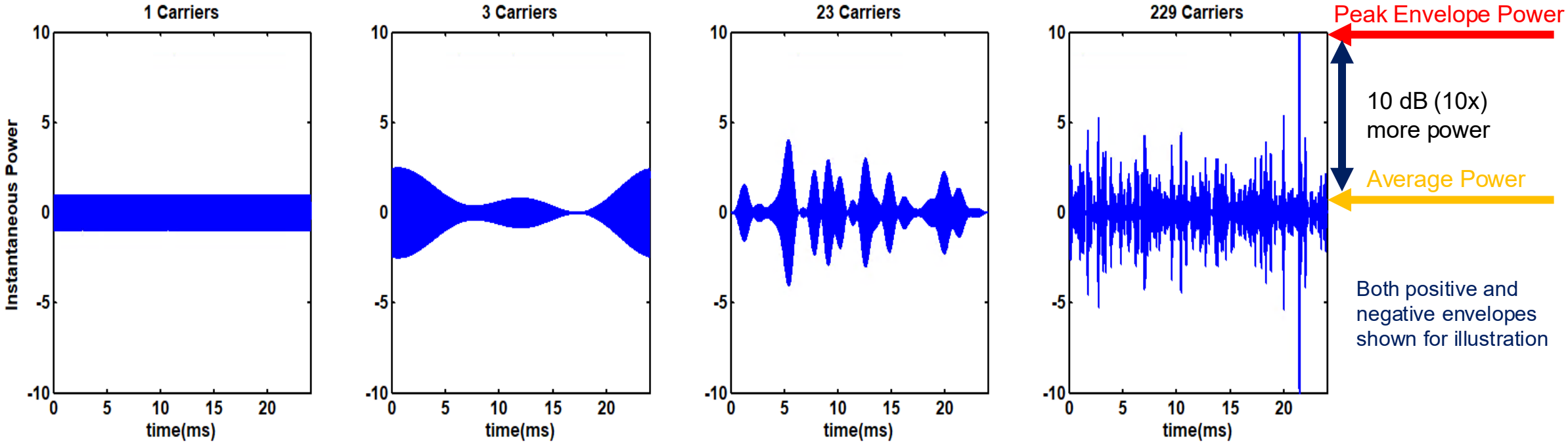
NAVDAT Transmitters Must be Sized for Peak Power



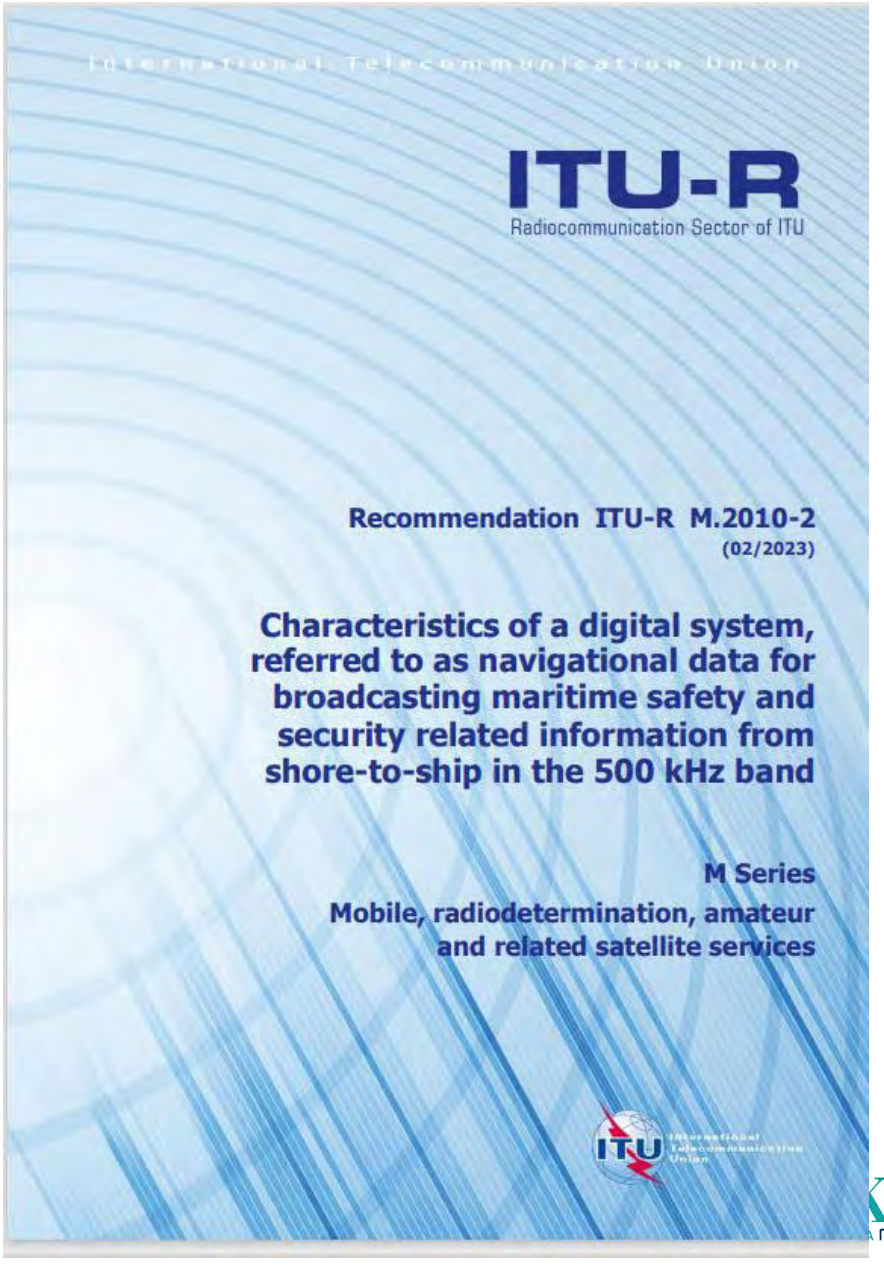
- Size transmitter for varying power envelope up to 10 dB (10x) - conservative
  - Carriers with random phase and amplitude add constructively and destructively
  - Peak to average power reduction algorithms will be optimized in the future
- NAVTEX is a single carrier system: Average Envelope Power == Peak Envelope Power

Also ensure ATU and antenna can handle peak power

PAPR and MER

- **PAPR – Peak Average Power Ratio**
  - Typical value: 10dB reduction of the PAPR leads to higher average power and better coverage
  - PAPR can be configured in the modulator
- **MER- Modulation Error Rate**
  - Ratio of ideal vector compared to error vector in the IQ diagram expressed in dB
- **Trade off PAPR and MER**
  - A reduced PAPR also leads to a reduced MER

MF NAVDAT Modulation



OFDM NAVDAT Parameter Values 1

Propagation mode	T_u (ms)	$1 / T_u$ (Hz)	T_d (ms)	$T_s = T_u + T_d$ (ms)	N_s	T_f (ms)
A: surface wave	24	41.666	2.66	26.66	15	400
B: surface wave + sky wave	21.33	46.875	5.33	26.66	15	400

The purpose of the guard interval is to introduce immunity to propagation delays, echoes and reflections.

T_u: duration of the useful part of an OFDM symbol

$1/T_u$: carrier spacing

T_d: duration of the guard interval

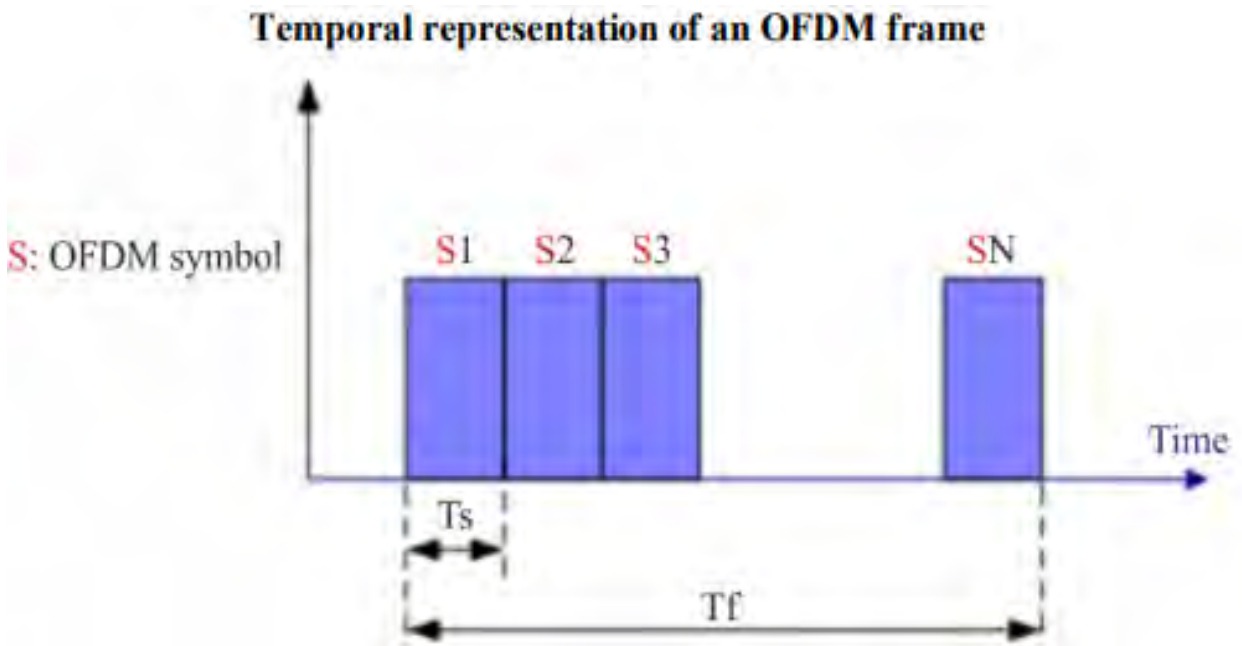
T_s: duration of an OFDM symbol

N_s: the number of symbols per frame

T_f: duration of the transmission frame.

Transmission frame

- Duration: 400 ms
- Starts with a synchronization symbol
- 15 OFDM symbols in one frame



OFDM NAVDAT Parameter Values 2

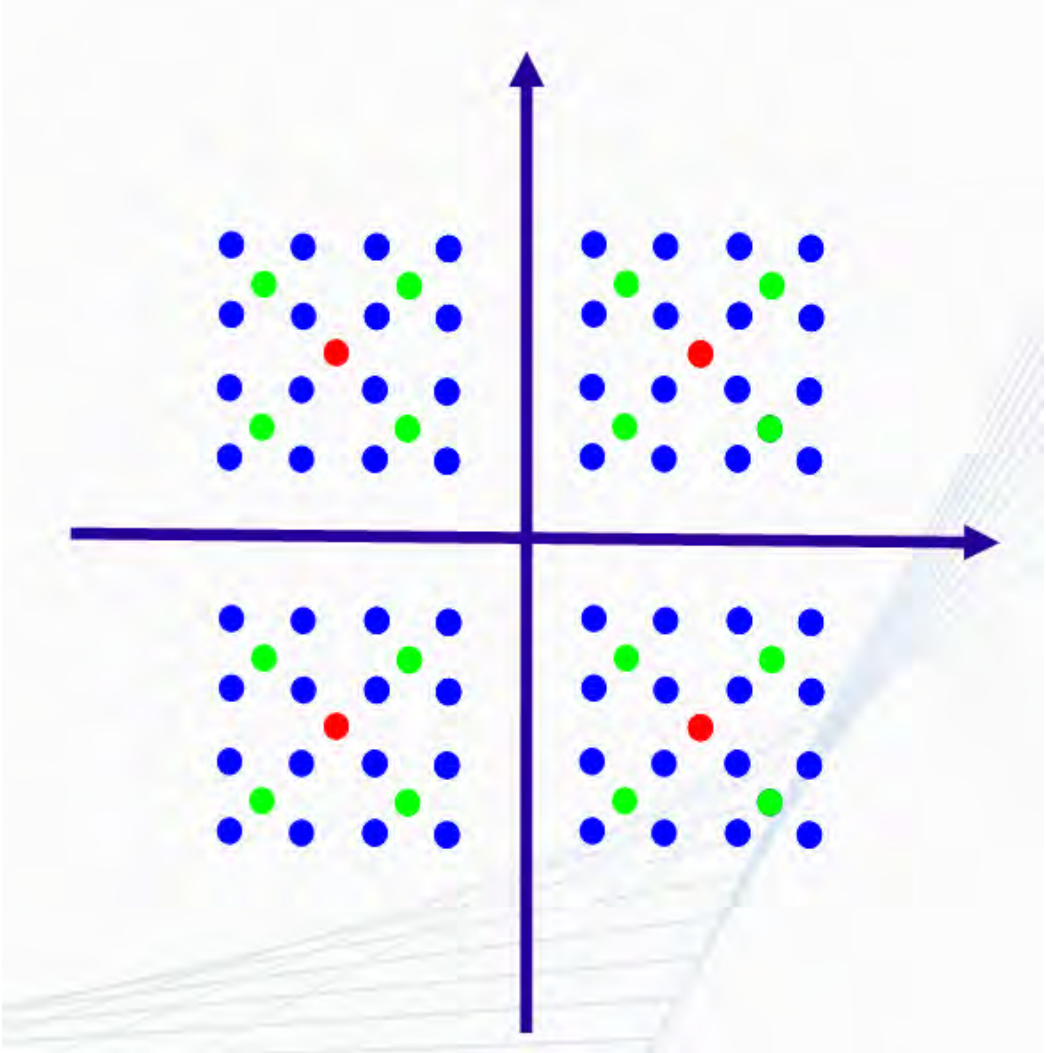
Relationship between channel bandwidth and OFDM sub-carrier numbers

Propagation mode	Case	1	2	3	4
	Channel bandwidth	1 kHz	3 kHz	5 kHz	10 kHz
A: surface wave	Number of subcarriers	23	69	115	229
	Number of subcarriers	K −11 to 11	K −34 to 34	K −57 to 57	K −114 to 114
B: surface wave + sky wave	Number of subcarriers	19	61	103	207
	Number of subcarriers	K −9 to 9	K −30 to 30	K −51 to 51	K −103 to 103

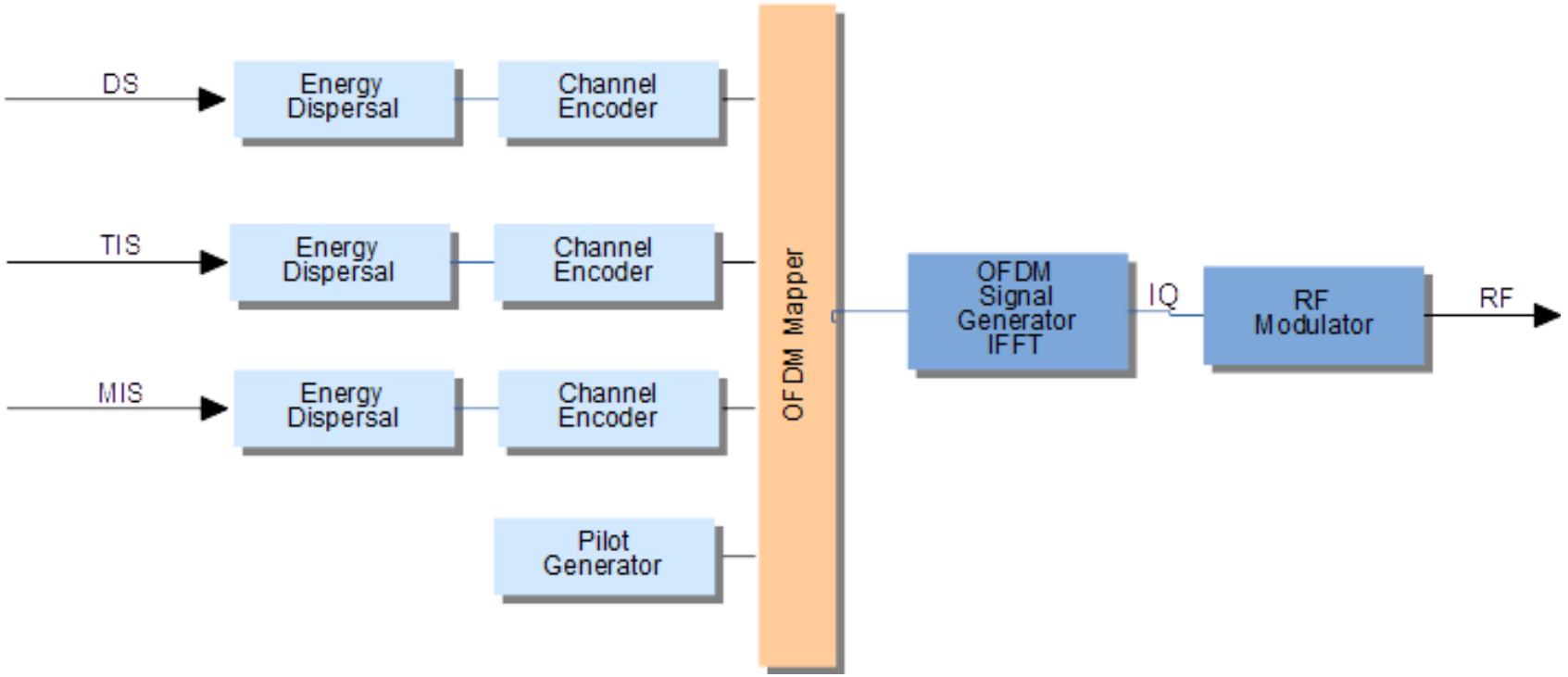
NAVDAT Input Streams

- **MIS: Modulation Information Stream**
  - channel bandwidth (1, 3, 5 or 10 kHz)
  - modulation for transmission information stream and data stream (4, 16 or 64-QAM)
  - always 4-QAM
- **TIS: Transmission Information Stream**
  - error coding for data stream (Mode A or B)
  - identifier of the transmitter
  - Time
  - 4 or 16-QAM
- **DS: Data Stream**
  - Navdat Message Files
  - 4,16 or 64-QAM

MIS, TIS and DS

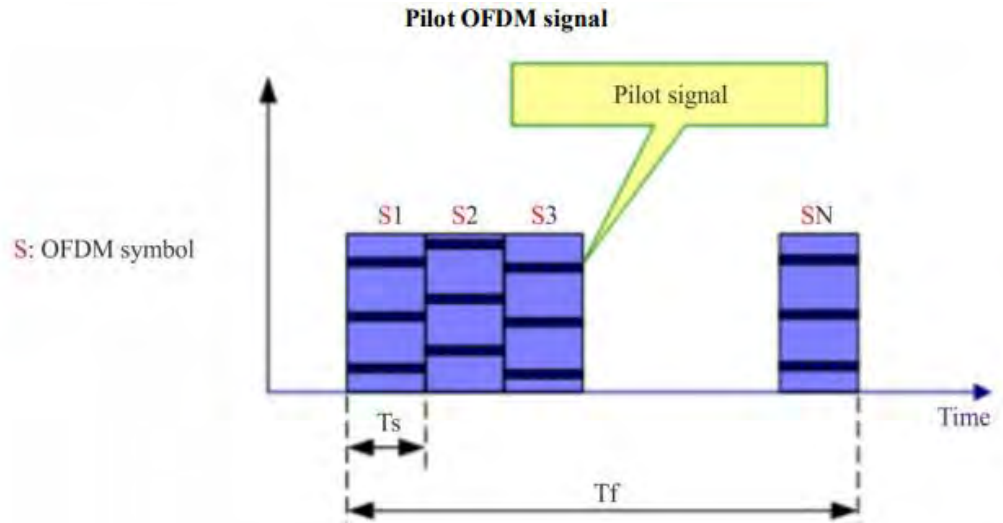


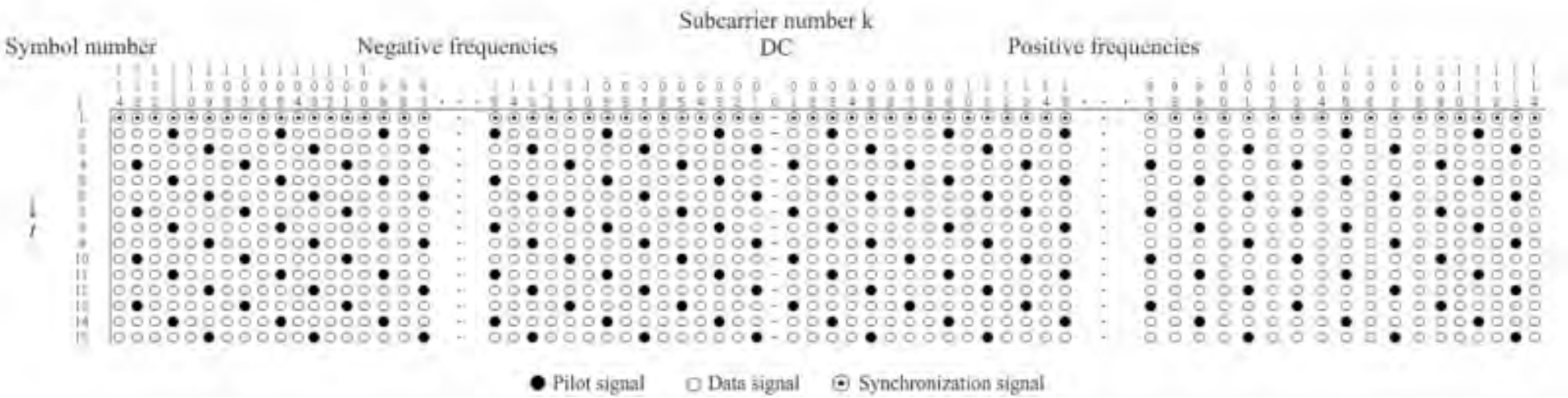
NAVDAT Modulator Diagram



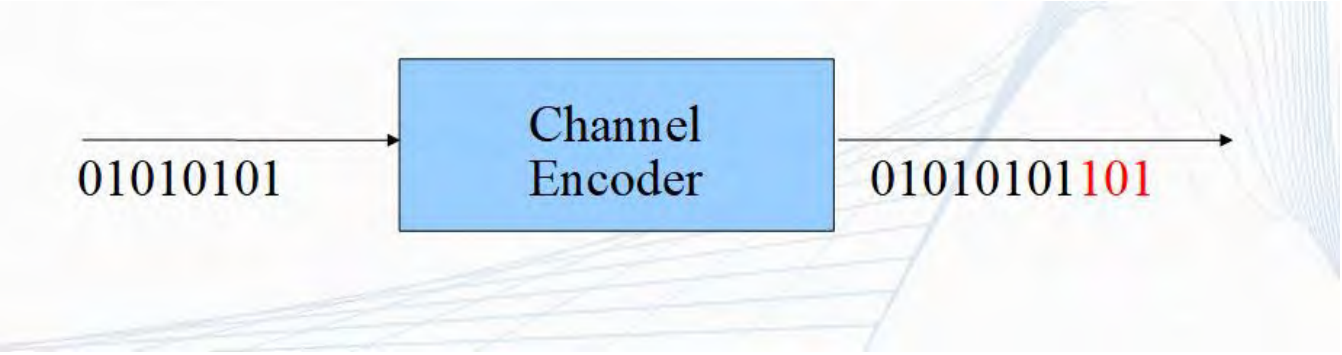
Pilots

- Used for estimation of the channel impulse response and frequency in the receiver
- BPSK/2 QAM modulated
- Gain: 2





Channel Coding



- Transmission channels are not perfect:
  They are noisy and subject to perturbations
- Idea: Add bits in advance for error correction (FEC-Forward Error Correction)
- Less errors but also less useful data rate (due to the bits needed for protection)
- Code Rate = useful data rate/total data rate
- NAVDAT uses LDPC – Low Density Parity Codes with

  2 code rates: 0.5 et 0.75

ITU-R M.2010-2 Bit rates

Flexible Configurations

TABLE 24

LDPC parameters of data stream for mode A

Bandwidth (kHz)	Number of subcarriers	Number of pilots	Number of data subcarriers	Modulation	TIS and MIS	Information bits	Channel coding	Information rate (kbits)
10	228*14	38*14	190*14	4-QAM	100	2560*2	(2560,5120)	6.36
10	228*14	38*14	190*14	4-QAM	100	2560*2	(3840,5120)	9.56
10	228*14	38*14	190*14	16-QAM	100	2560*4	(2560,5120)	12.72
10	228*14	38*14	190*14	16-QAM	100	2560*4	(3840,5120)	19.12
10	228*14	38*14	190*14	64-QAM	100	2560*6	(2560,5120)	19.08
10	228*14	38*14	190*14	64-QAM	100	2560*6	(3840,5120)	28.68
5	114*14	271	1325	4-QAM	100	1224*2	(1224,2448)	3.02
5	114*14	271	1325	4-QAM	100	1224*2	(1836,2448)	4.55
5	114*14	271	1325	16-QAM	100	1224*4	(1224,2448)	6.04
5	114*14	271	1325	16-QAM	100	1224*4	(1836,2448)	9.10
5	114*14	271	1325	64-QAM	100	1224*6	(1224,2448)	9.06
5	114*14	271	1325	64-QAM	100	1224*6	(1836,2448)	13.65
3	68*14	159	793	4-QAM	100	692*2	(692,1384)	1.69
3	68*14	159	793	4-QAM	100	692*2	(1038,1384)	2.555
3	68*14	159	793	16-QAM	100	692*4	(692,1384)	3.38
3	68*14	159	793	16-QAM	100	692*4	(1038,1384)	5.11
3	68*14	159	793	64-QAM	100	692*6	(692,1384)	5.07
3	68*14	159	793	64-QAM	100	692*6	(1038,1384)	7.665
1	22*14	4*14	252	4-QAM	100	152*2	(152,304)	0.34
1	22*14	4*14	252	4-QAM	100	152*2	(228,304)	0.53
1	22*14	4*14	252	16-QAM	100	152*4	(152,304)	0.68
1	22*14	4*14	252	16-QAM	100	152*4	(228,304)	1.06
1	22*14	4*14	252	64-QAM	100	152*6	(152,304)	1.095
1	22*14	4*14	252	64-QAM	100	152*6	(228,304)	1.59

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What TX Power Level do you Need?

Example: 220 NM (407 km) with 10 kHz Bandwidth

QAM	Data Rate	10 min data block	Weather Charts in 10 min	Average Power	Est Transmitter Size Peak Envelope Power
4 QAM	6-10 kbps	450 - 750 kB	2 - 3	0.7 kW	3.5 kW
16 QAM	12-19 kbps	900 -1425 kB	4 - 7	1.6 kW	10.1 kW
64 QAM	19-29 kbps	1425 -2175 kB	7 - 10	6.4 kW	50.8 kW

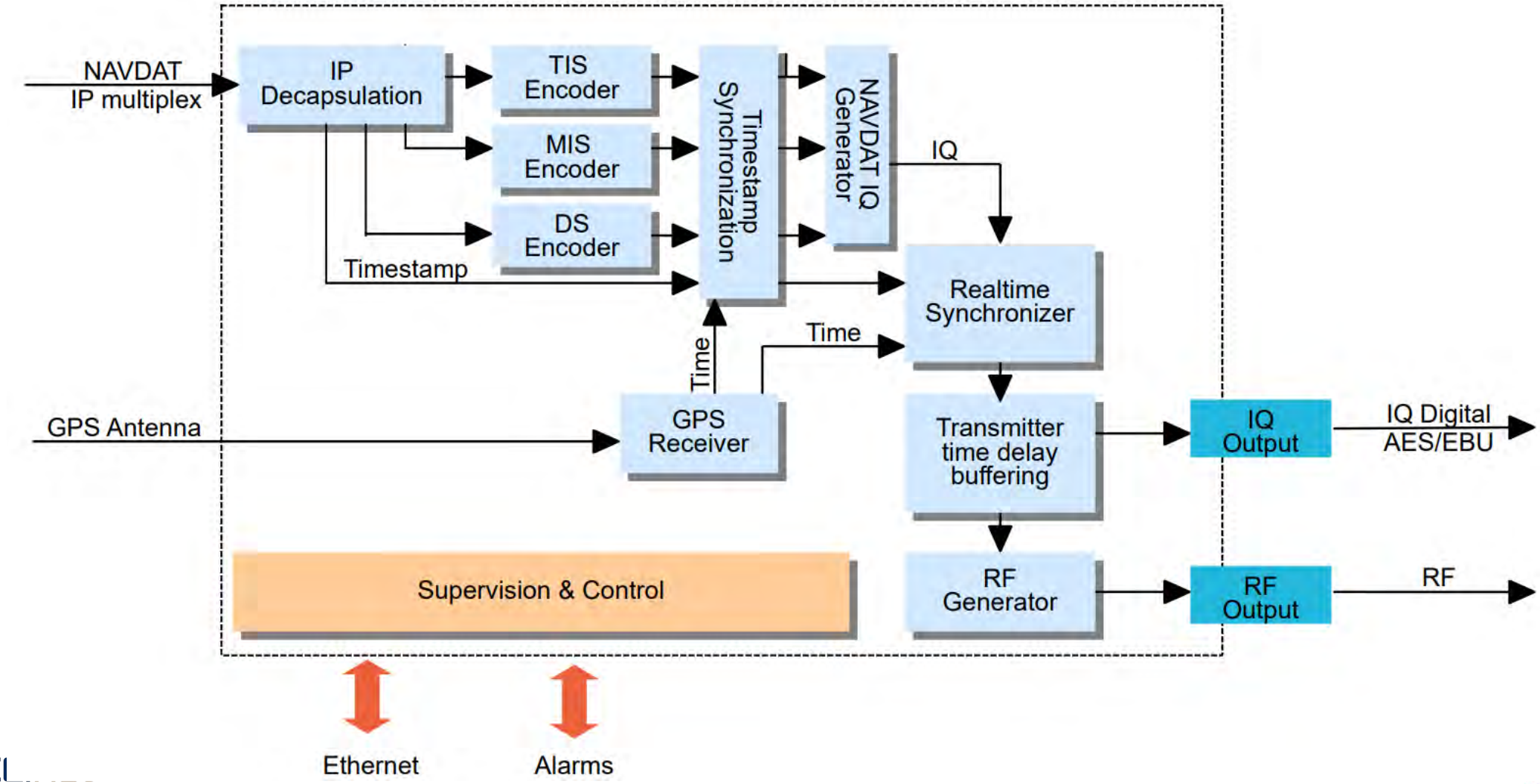
- More data requires more power
- Less bandwidth requires lower transmitter power
- Limited by atmospheric and ship-board noise
  (ITU-M.2443)

NAUTEL MF NAVDAT Solution

NEW KENTA NAVDAT Modulator

- Leverages Nautel and Kenta Decades Long Digital Modulation Expertise
- Supports all QAM modes
  - (MIS: 4 QAM, TIS:4 and-QAM, DS: 4,16 and 64 QAM)
- Supports 1,3,5,10 kHz bandwidth
  - (LDPC matrices for 1,3 and 5kHz still to be defined in the standard)
- Supports mode A and B for MF
- LDPC Channel Coding
- DCP over IP inputs for MIS, TIS and DS streams
- HTTP and SNMP interfaces
- Meets ITU Standard R-REC-M.2010

Block Diagram KENTA NAVDAT Modulator



NAV Series

NAVDAT/NAVTEX MW

NAV25 QUICK SPECS

Frequency Range
NAVDAT 500 kHz (NAVDAT)
490 kHz and 518 kHz (NAVTEX)

Weight
261 kg (573 lbs)

Dimensions
184.2 cm H x 58.7 cm W x 86.4 cm D
(72.5" H x 23.1" W x 34" D)

RF output power:
25 kW Peak Power, Ideal for NAVDAT
>3 kW Average Power

Voltage
208 Vac or 380 Vac nominal, 3-phase, 50/60 Hz

RF output connection
7/8" EIA or 1-5/8" EIA, at top of transmitter

RF power modules (2) each with:
- Digital optimized linear design
- Integrated RF amplifier/modulator
- Microcontroller for protection and monitoring
- Short circuit protection
- Hot pluggable

Control and monitoring
- Local LCD Display
- Module level monitoring

Efficiency
86%

* Specifications subject to change

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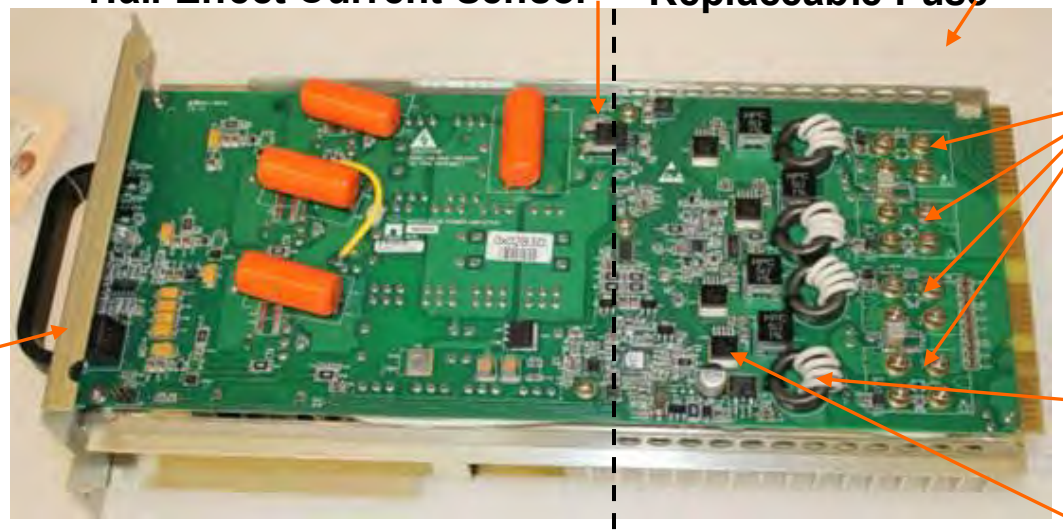
RF Amplifier / Modulator Module



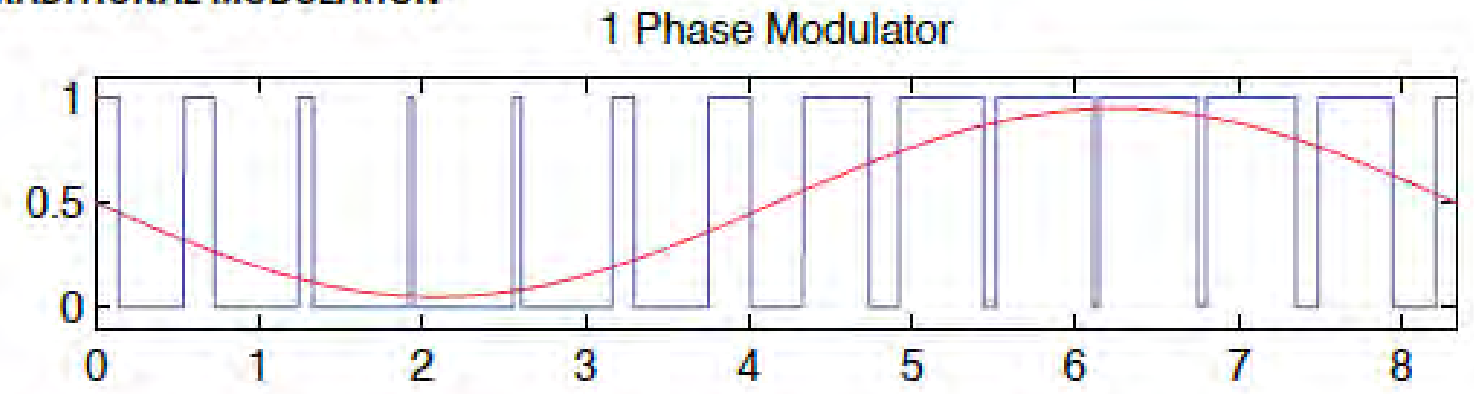
98%
PA Efficiency

12kW continuous power rating

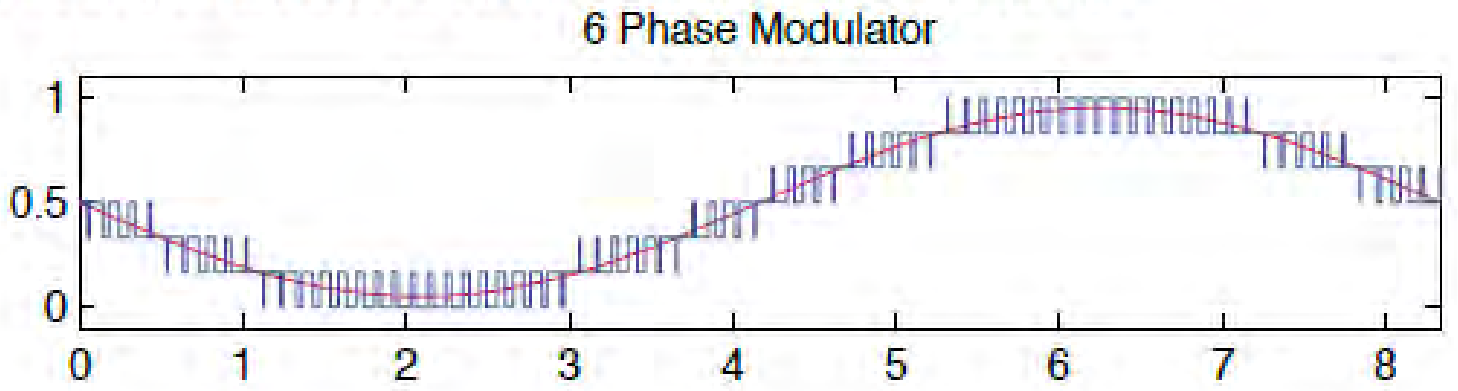
(NAV Series module operated at 2.5kW of carrier)

1.8 MHz Direct Digital Modulation

TRADITIONAL MODULATION



1.8 MEGA-SAMPLES/SECOND SIX PHASE DIRECT DIGITAL MODULATION



RF Amplifier / Modulator Module

- No adjustments – no pots
- Broad-banded – entire MF band
- Hot pluggable
- Heavy gold connectors both sides
- Heat sink: 2.5 X required size
- High Efficiency Silicon Carbide modulator diodes
- Balanced RS422 modulator and RF drive.

Lightning/Transient/AC Protection

- ~50 nS Active VSWR Shutdown
- Series Capacitor/High Pass Stage
- Carbon Adjustable Ball Gap
- Static Discharge Choke
- Calibrated Fast Spark Gap (Pressurized Tritium)
- Transient Attenuator Capacitors on AC Transformer Secondary (Common Mode)
- AC Surges Corrected by Phase Controlled B+ Rectifiers (Differential Mode)

Cooling

- 2 Ball Bearing DC Fans per RF module arranged in hot pluggable trays.
- Typical fan life is over 9 years.
- Fan operation and speed is monitored by the controller.
- In a NAV25 kW transmitter, less than 1kW of heat is produced
- Air is drawn in from the rear, through a disposable paper air filter.

NAV Series Summary

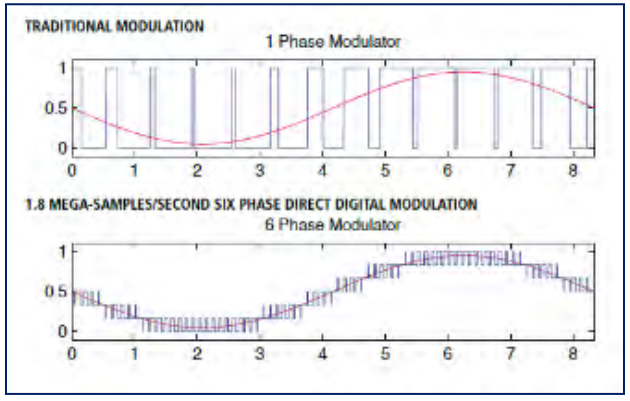
- Proven, efficient, modular.
- Advanced digital
- Linear amplification
- High peak power, ideal for NAVDAT
- NAVTEX and NAVDAT capable

NAV Series
NAVDAT/NAVTEX MW

Proven

35
Mega
Watts
Deployed

Digital

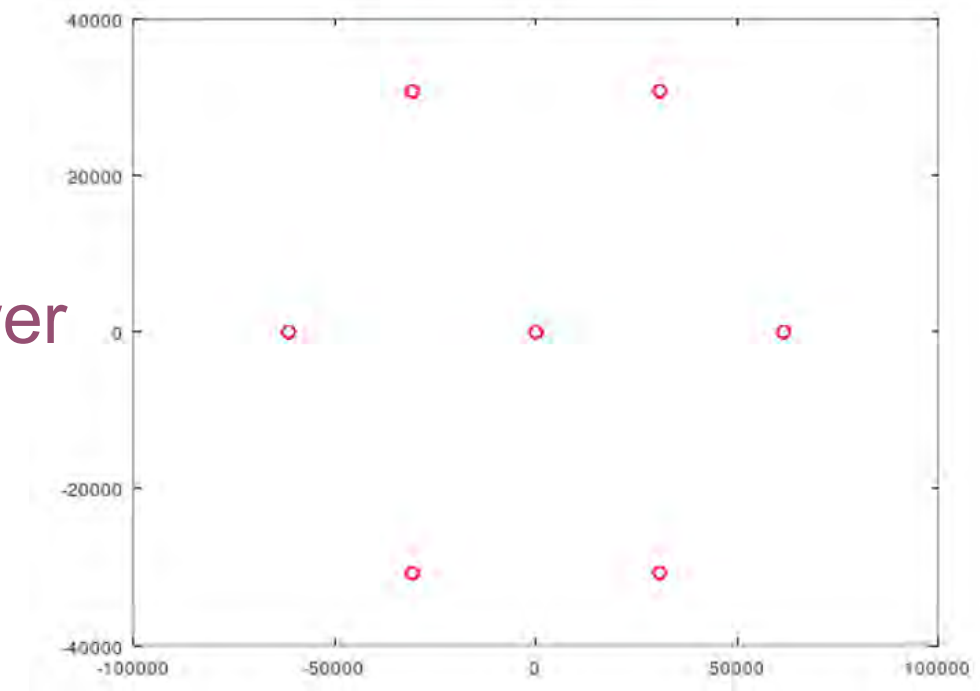


nautelnav

KENTA
A nautel COMPANY

Simulations
&
NAVDAT Modulator
Spectrum Demonstration

Constellation MIS 4QAM, TIS 4QAM, DS 4QAM,



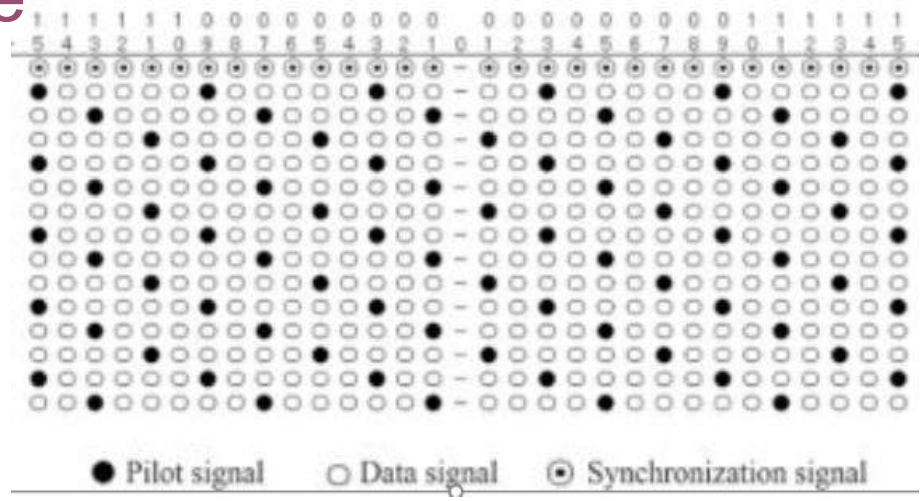
Q Power

I Power

IQ Simulation

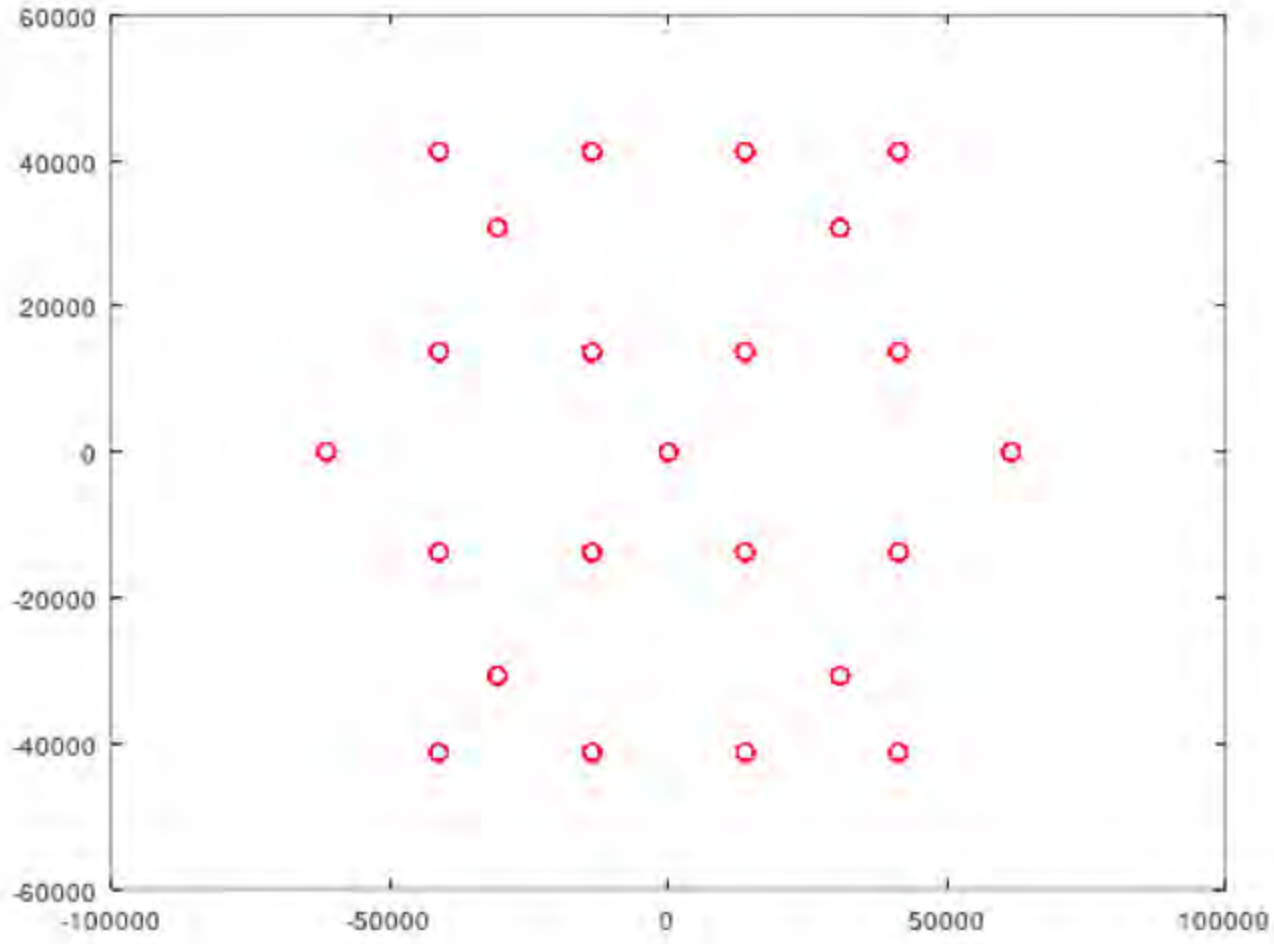
OFDM Sub-carriers

Time

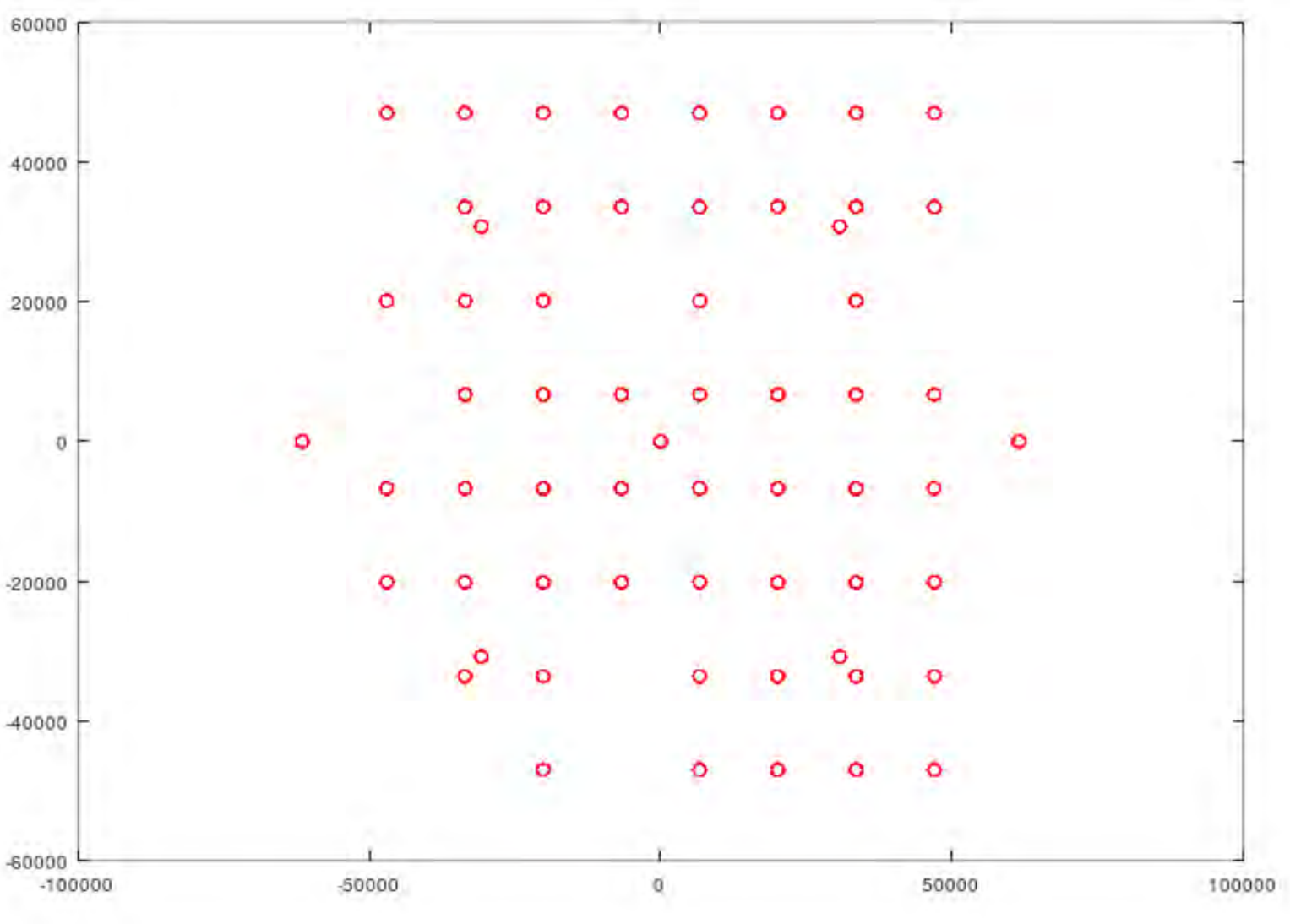


Frequency-Time
OFDM FRAME

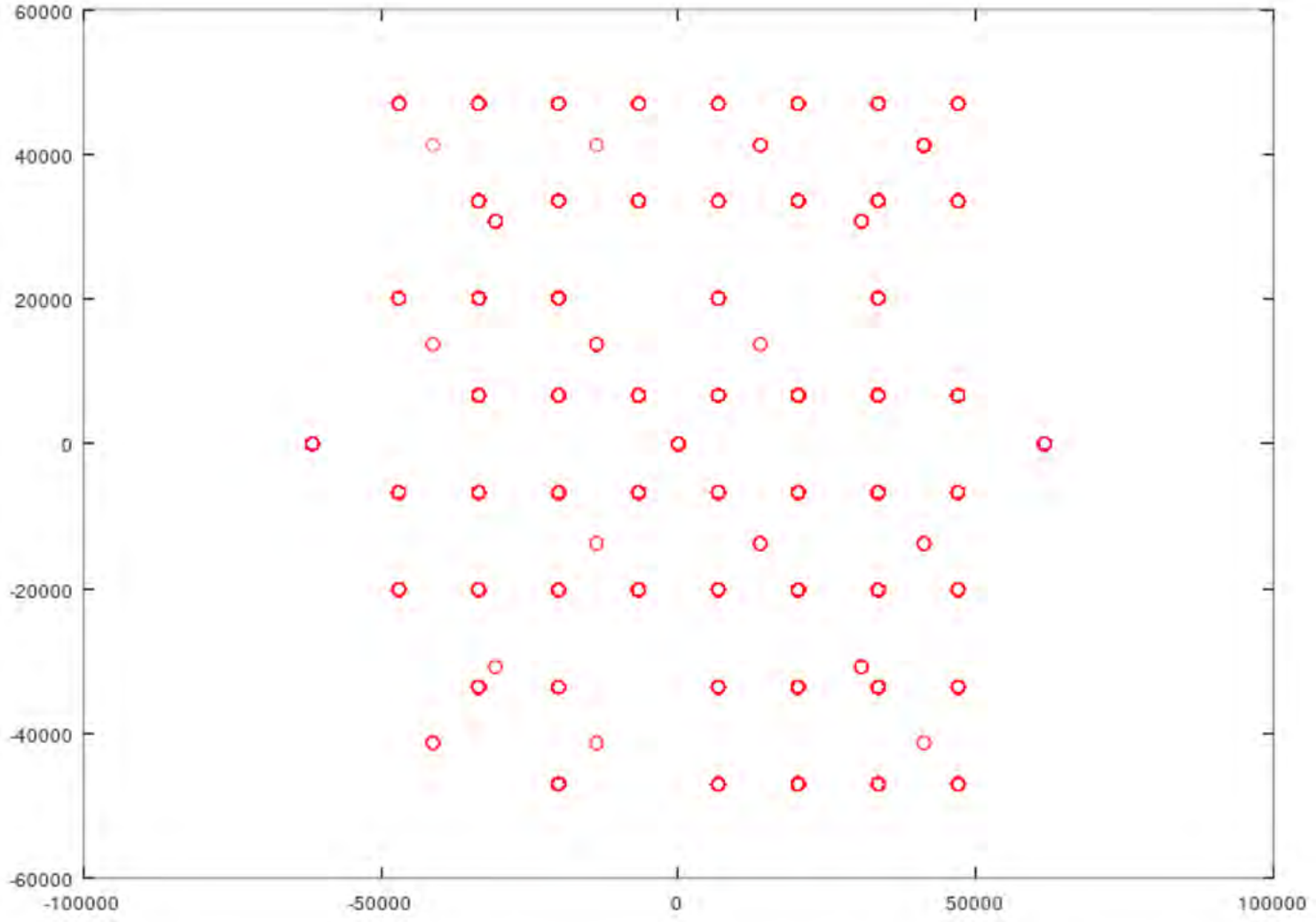
Constellation MIS 4QAM, TIS 4QAM, DS 16QAM,



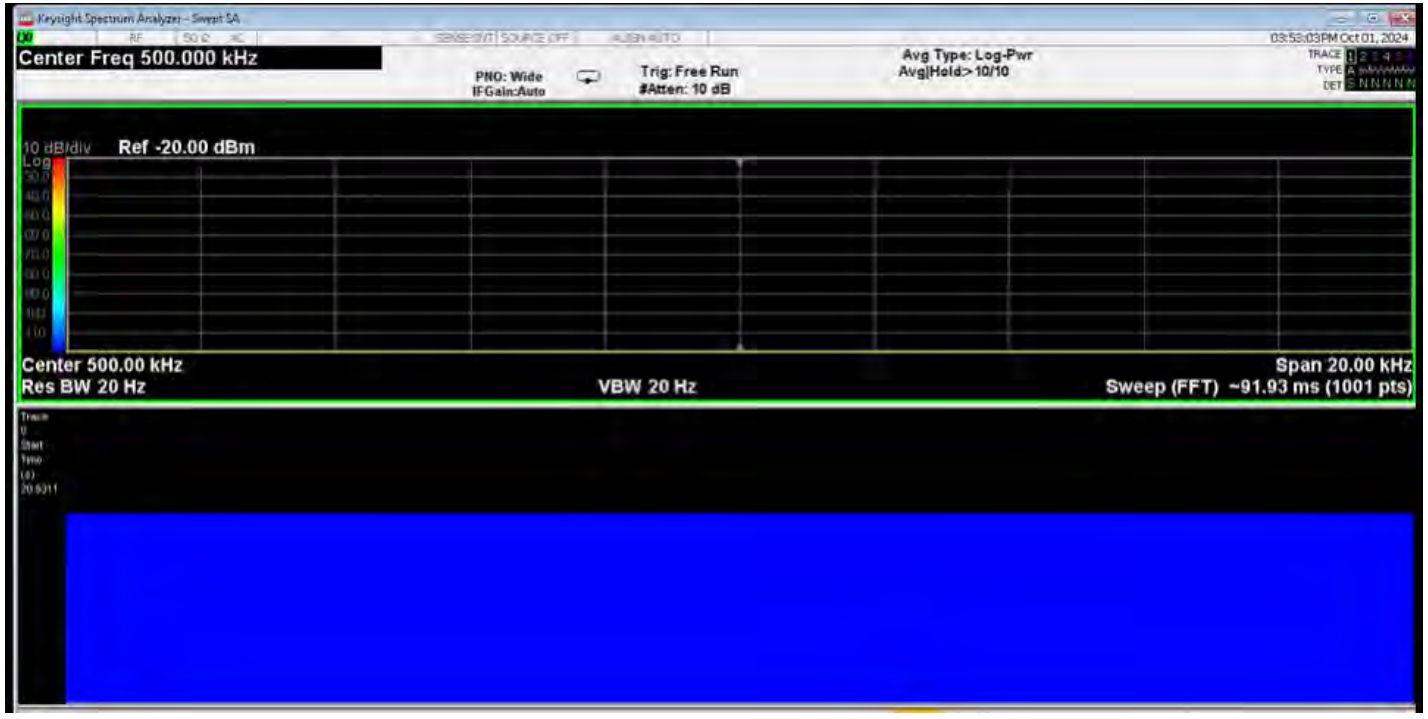
Constellation MIS 4QAM, TIS 4QAM, DS 64QAM,

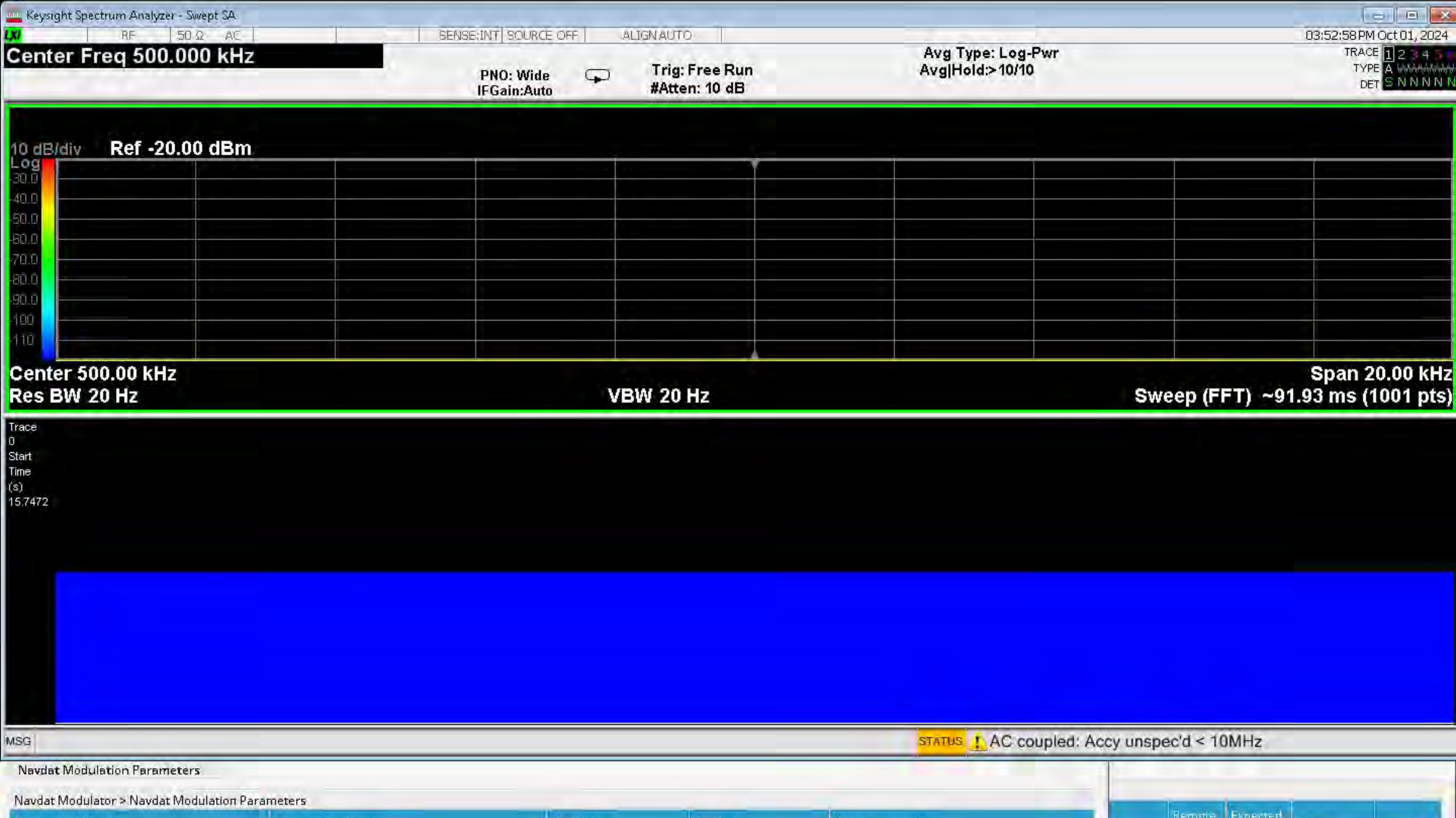


Constellation MIS 4QAM, TIS 16QAM, DS 64QAM,



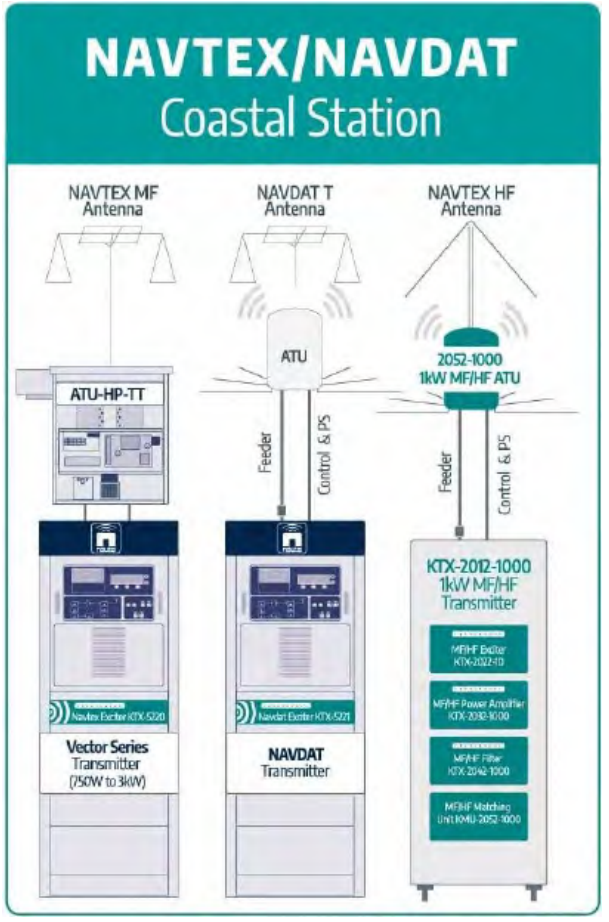
Video with measurements of the real RF signal at the NAVDAT Modulator output




Keysight Spectrum Analyzer - Swept SA
RF
50 Ω AC
SENSE:INT
SOURCE OFF
ALIGN AUTO
03:52:58 PM Oct 01, 2024
Center Freq 500.000 kHz
PNO: Wide
IFGain:Auto
Trig: Free Run
#Atten: 10 dB
Avg Type: Log-Pwr
Avg|Hold:>10/10
TRACE 1 2 3 4 5 6
TYPE A
DET S N N N N N
10 dB/div
Ref -20.00 dBm
Log
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100
-110
Center 500.00 kHz
Res BW 20 Hz
VBW 20 Hz
Span 20.00 kHz
Sweep (FFT) ~91.93 ms (1001 pts)
Trace
0
Start
Time
(s)
15.7472
MSG
STATUS
AC coupled: Accy unspec'd < 10MHz
Navdat Modulation Parameters
Navdat Modulator > Navdat Modulation Parameters

Take aways

- NAVDAT Modulation
  - Uses Digital Modulation (COFDM)
  - Channel Coding based on LDPC
  - Useful data rates vary from 0.34 to 26.64 kbit/s depending on
    - Bandwidth (1,3,5,10 kHz)
    - Code Rate (0.5 or 0.75)
    - Mode A or B (Guard Interval)
    - 4,16 or 16 QAM Modulation
  - 3 streams: MIS, TIS, DS + Pilots
- Nautel can provide a complete solution including modulator and transmitter



What's next?

- Full Transmission chain demonstrations
- Implementation of the NAVDAT modes as they become approved
  - 10 kHz mode demonstrated today
  - 5, 3, and 1 kHz modes:
    - exact LDPC channel coding is being finalized by standards body.
- Receiver development
- Transmitter and Modulator Availability:
  - 2025 for NAVTEX support
  - 2025 for NAVDAT trials and testing