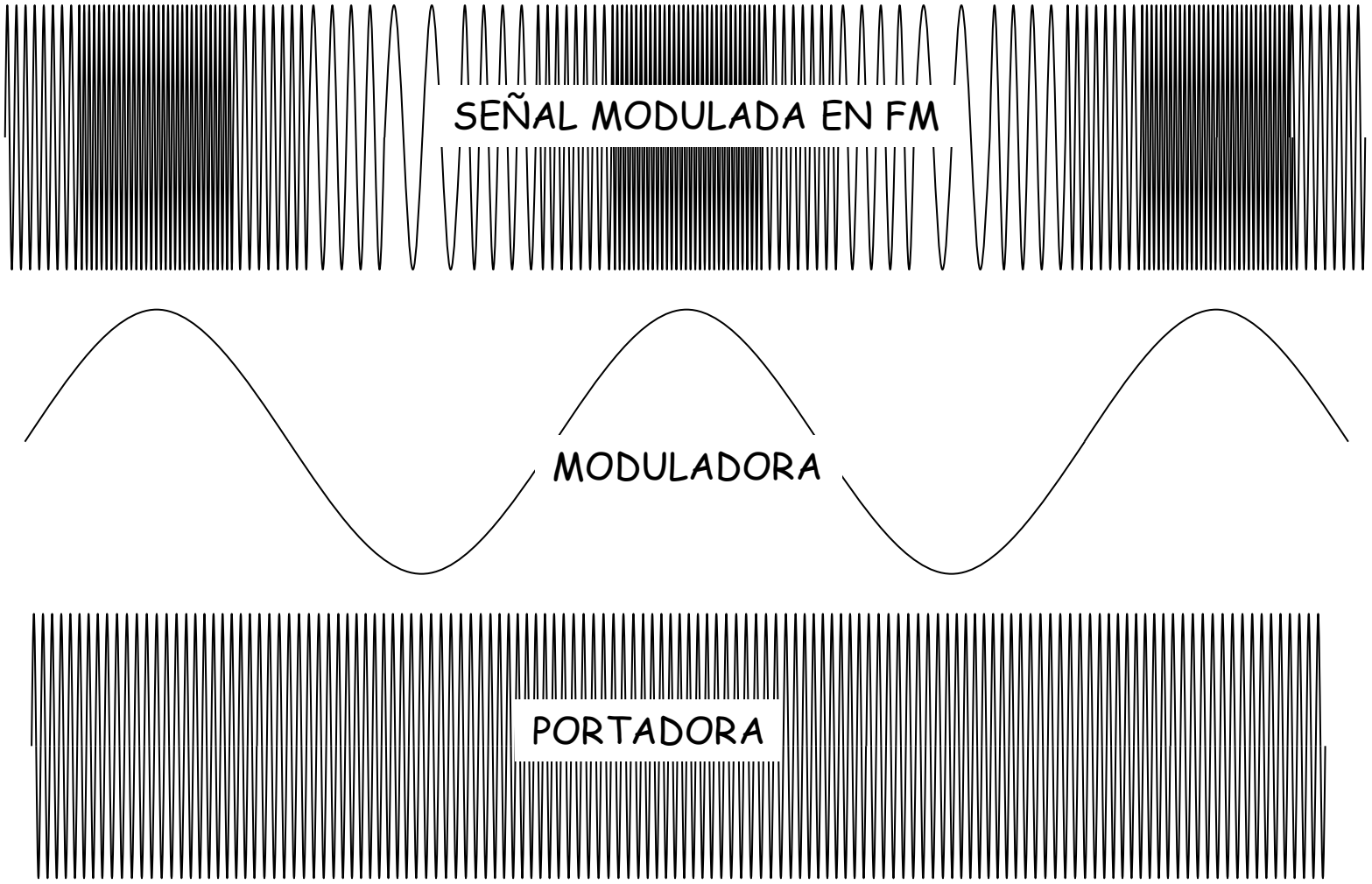
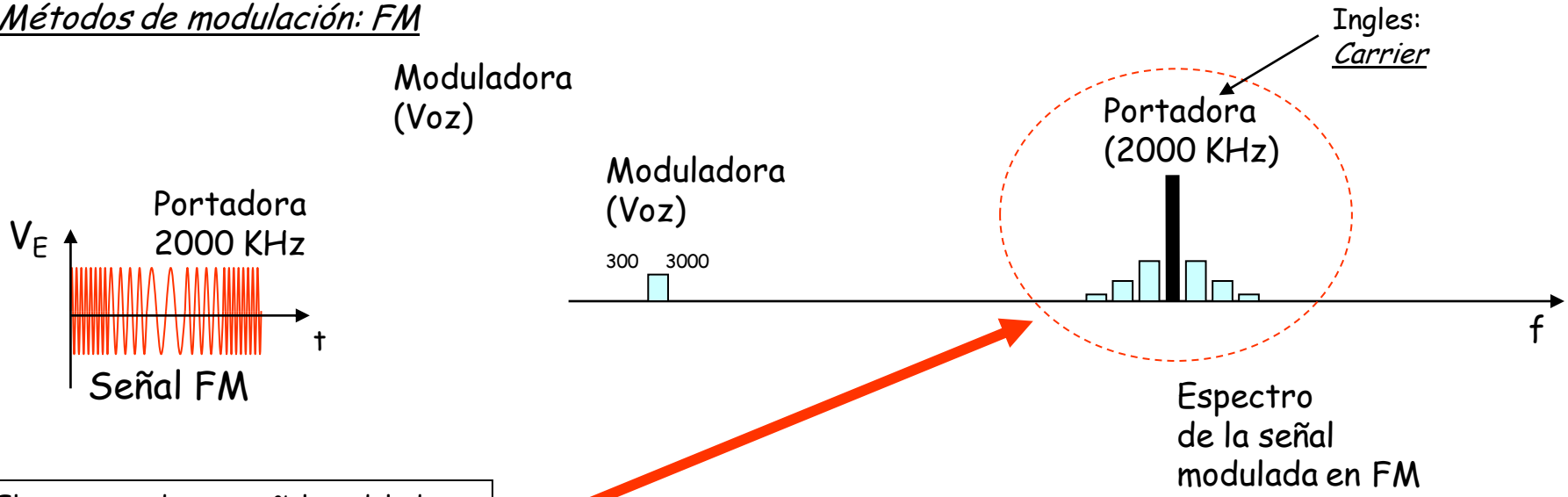
Modulación en Frecuencia (FM)

La frecuencia de la señal portadora varia de acuerdo con el valor instantáneo de la señal moduladora



Métodos de modulación: FM



El espectro de una señal modulada en FM tiene infinitas componentes.

(Las amplitudes de las distintas componentes se llaman funciones de Bessel)

El ancho de banda depende del índice de modulación (n) y de la frecuencia moduladora.

El espectro es simétrico respecto a la portadora.

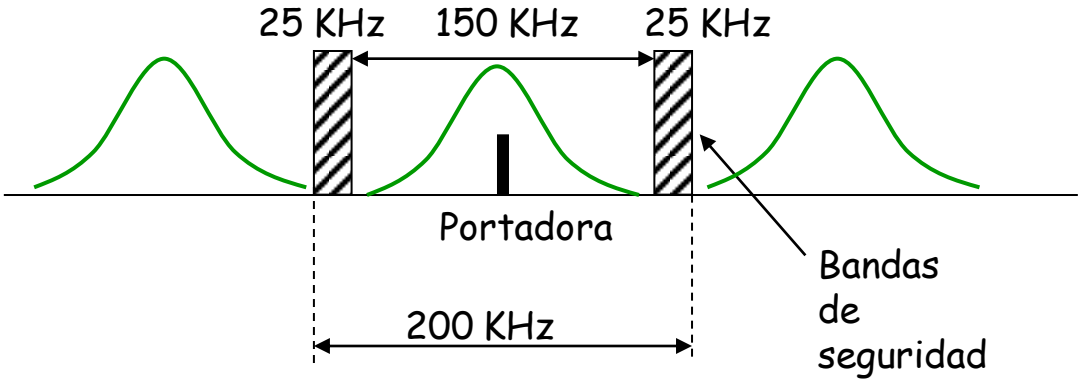
Si el índice de modulación (n) es mayor de 0.3 tenemos una modulación con banda ancha (WBFM).

Si el índice de modulación es pequeño tenemos una Modulación de banda estrecha (NBFM).

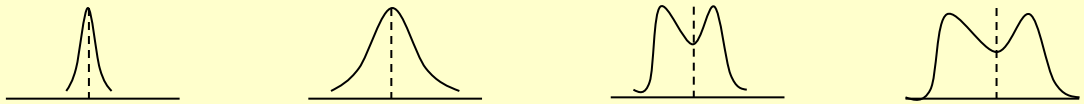
Métodos de modulación: FM

La FCC ha asignado a cada emisora de radiofrecuencia FM estándar un ancho de banda de 200 KHz.

Desviación máxima de la portadora ± 75 KHz
Banda de Seguridad 25 KHz



Aspecto del espectro de FM para varios índices de modulación (n)



Métodos de modulación: FM

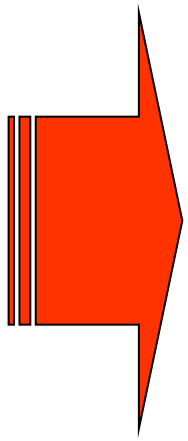
Matemáticamente:

Portadora

$$f_C(t) = A_C \cdot \cos\left[2 \cdot \pi \cdot f_C \cdot t\right]$$

Moduladora (p.e. senoidal)

$$f_M(t) = A_M \cdot \cos\left[2 \cdot \pi \cdot f_M \cdot t\right]$$



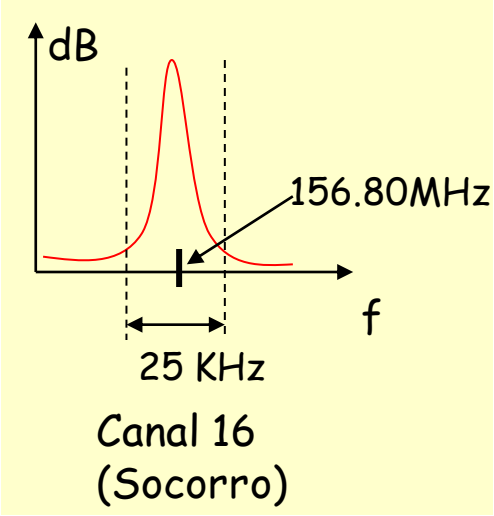
Señal modulada en FM

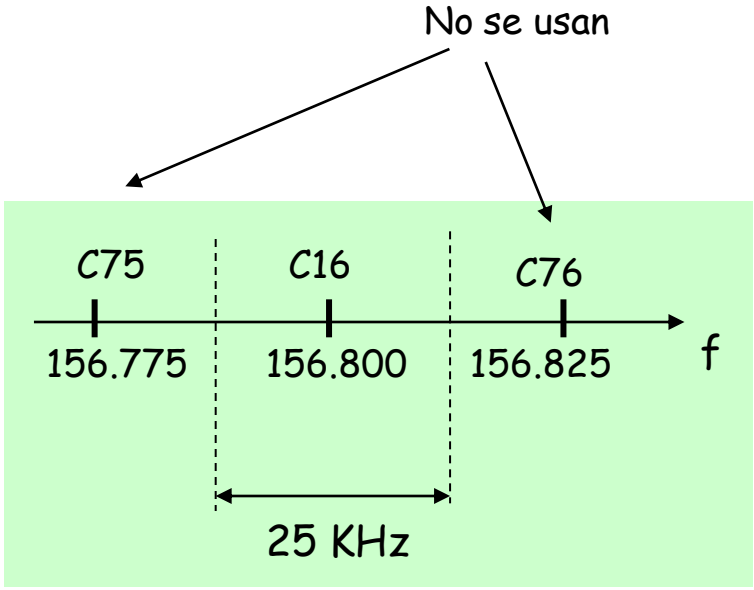
$$f_{FM}(t) = A_C \cdot \cos\left[2 \cdot \pi \cdot f_C \cdot t + n \cdot sen\left(2 \cdot f_M \cdot t\right)\right]$$

$$\boxed{n = \frac{k \cdot A_M}{2 \cdot \pi \cdot f_M}}$$ Índice de modulación

Métodos de modulación: FM

Un ejemplo de un canal marino



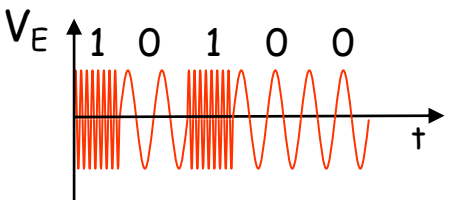


Canales marinos 55

28 iniciales (del 1 al 28)
27 posteriores (del 60 hasta el 88 intercalados)

Métodos de modulación: FM

Utilizando este sistema se puede enviar información digital. Se utilizan solo dos frecuencias una para el "0" y otra para el "1"



Señal FSK

La modulación digital utilizando modulación de frecuencia se llama FSK ("Frequency Shift Keying").

Método de transmisión F1B.

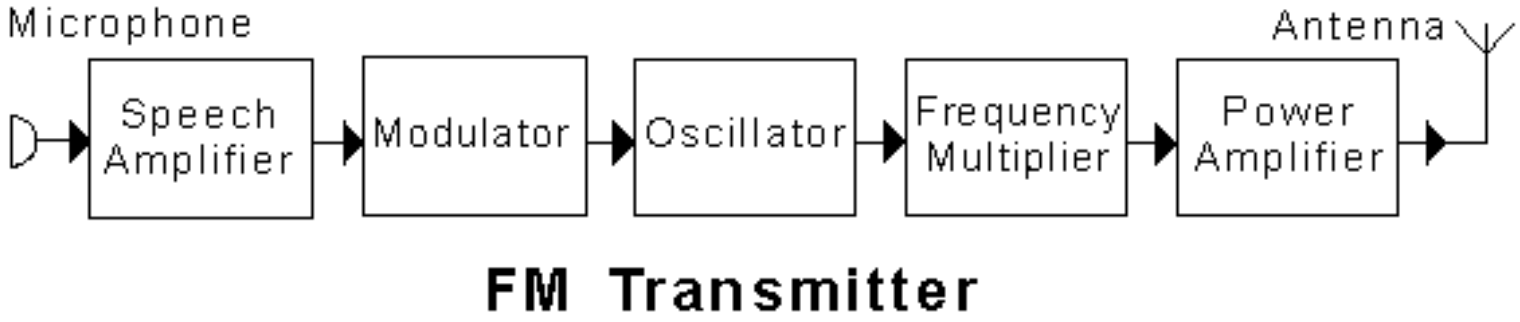
Los canales que transmiten información digital en VHF emplean este método.

Ejemplos:

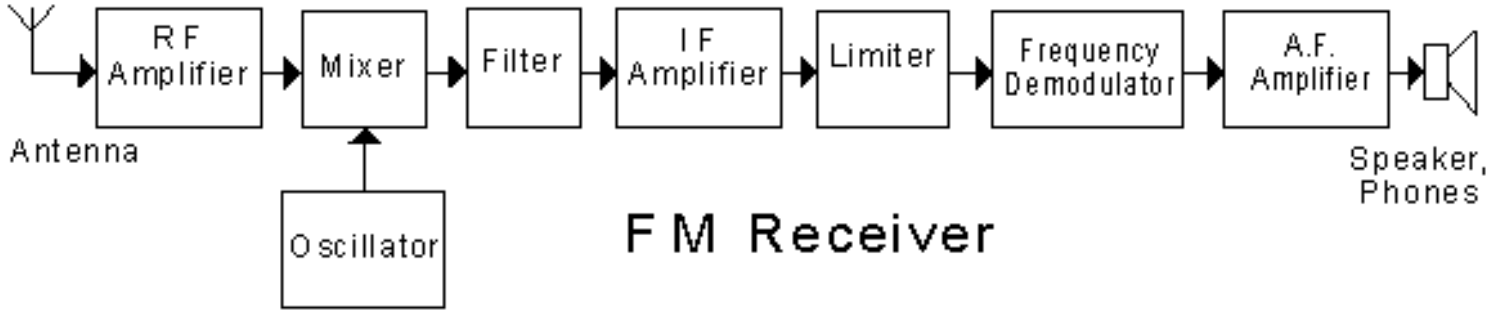
DSC en canal 70
AIS en canales 87B y 88B

Métodos de modulación: FM

Transmisor FM



Receptor FM



Métodos de modulación: FM

La modulación en FM se utiliza en náutica en la banda de VHF (30-300 MHz).

Los enlaces de realizan por medio de la onda directa y la onda reflejada en tierra.

La onda de superficie está totalmente amortiguada a poca distancia del emisor.

La ionosfera es transparente a este margen de frecuencias.

El alcance VHF es corto (30 a 50 millas).

VHF MARINO

Dentro de la banda de VHF el rango de frecuencia de 156 hasta 162 MHz está dedicado al uso marítimo.

Está dividida en 55 canales separados 25 KHz.

Inicialmente existían 28 canales separados 50 KHz (desde el 1 hasta el 28).

En el año 1972 se añadieron de forma intercalada los nuevos canales numerados del 60 hasta el 88.

(Nota: los canales 29 al 59 ya estaban asignados. Uso Privado).

Métodos de modulación: FM

Canales VHF

Iniciales

01	156.050	160.650	IC	Ship/shore - telephone
02	156.100	160.700	IC	Ship/shore - telephone
03	156.150	160.750	IC	Ship/shore - telephone
04	156.200	160.800	I	Ship/shore - telephone
04A	156.200		C	Canadian Coast Guard - authorized stations
05	156.250	160.850	I	*Ship/shore - telephone
06	156.300			Intership - Safety
07	156.050	160.650		*Ship/shore - telephone
07A	156.350			Intership-Ship/shore - commercial
08	156.400			Intership - commercial
09	156.450			Intership-Ship/shore
10	156.500			Intership-Ship/shore - commercial
11	156.550			Vessel Traffic Management
12	156.600			Vessel Traffic Management
13	156.650			Bridge to bridge - 1 watt - Safety of Nav.
14	156.700			Vessel Traffic Management
15		156.750		EPIRB Buoy
16	156.800			International Distress/Safety/Calling
17	156.850			Pilotage - vessel docking/manoeuvers
18	156.900	161.500	I	*Port Operation
18A	156.900			Intership-Ship/shore - commercial
19	156.950	161.550	I	*Port Operation
19A	156.950			*Port Operation
20	157.000			*Port Operation
21	157.050	161.650	I	*Port Operation
21A	157.050		A	US Coast Guard - authorized stations
21B		161.650	C	Canadian Coast Guard - Weather Broadcasts
22	157.100	161.700	I	*Port Operation
22A	157.100		CA	US/Canadian Coast Guard - Public Working Freq.
23	157.150	161.750	IC	Ship/shore - telephone (in Canada)
23A	157.150			*Port Operation (USCG)
24	157.200	161.800		Ship/shore - telephone
25	157.250	161.850		Ship/shore - telephone
26	157.300	161.900		Ship/shore - telephone
27	157.350	161.950		Ship/shore - telephone
28	157.400	162.000		Ship/shore - telephone

Ampliación (1972)

60	156.025	160.625	IC	Ship/shore - telephone
61	156.075	160.675	I	*Ship/shore - telephone
61A	156.075		C	Intership-S/S - Can. Coast Guard Private
62	156.125	160.725	I	*Ship/shore - telephone
62A	156.125		C	Intership-S/S - Can. Coast Guard Private
63	156.175	160.775	I	*Ship/shore - telephone
63A	156.175		C	Intership-Ship/shore - commercial
64	156.225	160.825	IC	Ship/shore - telephone
65	156.275	160.875	I	*Ship/shore - telephone
65A	156.275		CA	Port Operation (Canadian Coast Guard Private)
66	156.325	160.925	I	*Ship/shore - telephone, Port Operation
67	156.375			Intership-Ship/shore
68	156.425			Intership-Ship/shore - non-commercial
69	156.475			Intership-Ship/shore
70	156.525			Digital Selective Calling - Distress and Safety
71	156.575			Vessel Traffic Management
72	156.625			Intership
73	156.675			Intership-Ship/shore
74	156.725			Vessel Traffic Management
(75 and 76 not used)				
77	156.875			Pilotage - vessel docking/manoeuvers
78	156.925	161.525		*Port Operation
78A	156.925			Intership-Ship/shore - commercial
79	156.975	161.575	I	*Port Operation
79A	156.975			Intership-Ship/shore - commercial
79B		161.575	C	Commercial Fishing - Receive only
80	157.025	161.625	I	*Port Operation
80A	157.025			Intership-Ship/shore - commercial
81	157.075	161.675	I	*Port Operation
81A	157.075		A	*Port Operation (USCG) (CCG anti-pollution)
82	157.125	161.725	I	*Port Operation, s/s telephone
82A	157.125		A	*Port Operation (USCG) (CCG)
83	157.175	161.775	I	*Ship/shore - telephone (CCG)
83A	157.225		A	*Intership, Port Operation (USCG)
84	157.225	161.825		Ship/shore - telephone
85	157.275	161.875		Ship/shore - telephone
86	157.325	161.925		Ship/shore - telephone
87	157.375	161.975		Ship/shore - telephone
88	157.425	162.025	IC	*Ship/shore - telephone
88A	157.425		A	*Intership

Métodos de modulación: FM

Canales VHF

Channel number			Frequency (MHz)	
USA	INT	CAN	Transmit	Receive
	01	01	156.050	160.650
01A			156.050	156.050
	02	02	156.100	160.700
	03	03	156.150	160.750
03A			156.150	156.150
	04		156.200	160.800
		04A	156.200	156.200
	05		156.250	160.850
05A		05A	156.250	156.250
06	06	06	156.300	156.300
	07		156.350	160.950
07A		07A	156.350	156.350
08	08	08	156.400	156.400
09	09	09	156.450	156.450
10	10	10	156.500	156.500
11	11	11	156.550	156.550
12	12	12	156.600	156.600
13†	13	13†	156.650	156.650
14	14	14	156.700	156.700
15†	15†	15†	156.750	156.750
16	16	16	156.800	156.800
17†	17	17†	156.850	156.850
	18		156.900	161.500
18A		18A	156.900	156.900
	19		156.950	161.550

Channel number			Frequency (MHz)	
USA	INT	CAN	Transmit	Receive
19A		19A	156.950	156.950
20	20	20†	157.000	161.600
20A			157.000	157.000
	21	21	157.050	161.650
21A		21A	157.050	157.050
		21b	Rx only	161.650
	22		157.100	161.700
22A		22A	157.100	157.100
	23	23	157.150	161.750
23A			157.150	157.150
24	24	24	157.200	161.800
25	25	25	157.250	161.850
		25b	Rx only	161.850
26	26	26	157.300	161.900
27	27	27	157.350	161.950
28	28	28	157.400	162.000
		28b	Rx only	162.000
	60	60	156.025	160.625
	61		156.075	160.675
61A		61A	156.075	156.075
	62		156.125	160.725
		62A	156.125	156.125
	63		156.175	160.775
63A			156.175	156.175
	64	64	156.225	160.825

Channel number			Frequency (MHz)	
USA	INT	CAN	Transmit	Receive
64A		64A	156.225	156.225
	65		156.275	160.875
65A	65A	65A	156.275	156.275
	66		156.325	160.925
66A	66A	66A†	156.325	156.325
67†	67	67	156.375	156.375
68	68	68	156.425	156.425
69	69	69	156.475	156.475
70‡	70‡	70‡	156.525	156.525
71	71	71	156.575	156.575
72	72	72	156.625	156.625
73	73	73	156.675	156.675
74	74	74	156.725	156.725
77†	77	77†	156.875	156.875
	78		156.925	161.525
78A		78A	156.925	156.925
	79		156.975	161.575
79A		79A	156.975	156.975
	80		157.025	161.625
80A		80A	157.025	157.025
	81		157.075	161.675
81A		81A	157.075	157.075
	82		157.125	161.725
82A		82A	157.125	157.125
	83	83	157.175	161.775

Channel number			Frequency (MHz)	
USA	INT	CAN	Transmit	Receive
83A		83A	157.175	157.175
		83b	Rx only	161.775
84	84	84	157.225	161.825
84A			157.225	157.225
85	85	85	157.275	161.875
85A			157.275	157.275
86	86	86	157.325	161.925
86A			157.325	157.325
87	87	87	157.375	161.975
87A			157.375	157.375
88	88	88	157.425	162.025
88A			157.425	157.425

WX channel	Frequency (MHz)	
	Transmit	Receive
1	RX only	162.550
2	RX only	162.400
3	RX only	162.475
4	RX only	162.425
5	RX only	162.450
6	RX only	162.500
7	RX only	162.525
8	RX only	161.650
9	RX only	161.775
10	RX only	163.275

Métodos de modulación: FM

Canales VHF: Comentarios

Nota: Algunas veces a las frecuencias VHF se les pone una letra (A ó B) para diferenciar la frecuencia de barco y la de costa.

Canal 87A = 157.375 MHz Canal 87B = 161.925 MHz

Los canales que tienen una sola frecuencia son "Simplex" se usa el mismo canal para emitir y para recibir.

Los otros son canales "Duplex"

Métodos de modulación: FM

Canales VHF

canales marinos mas significativos

Canal 16: 156.800 MHz Socorro y Seguridad

Canal 70: 156.525(barco) - 161.125 (costa) Llamada selectiva digital (DSC) "Digital Selective Calling"

Canal 87: 157.375 (barco) - 161.925 (Costa) AIS ("Automatic identification System")
Canal 88: 157.425 (barco) - 162.025 (Costa) AIS ("Automatic identification System")

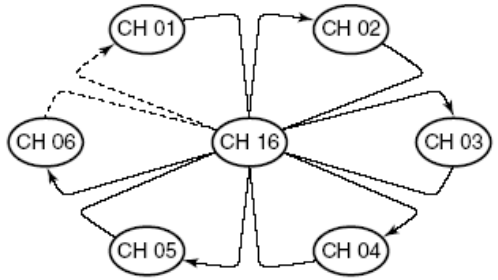
Canal 15: 156.750 Radiobalizas clase C (VHF EPIRB clase C). En desuso desde 1999

Métodos de modulación: FM

VHF MARINE TRANSCEIVER

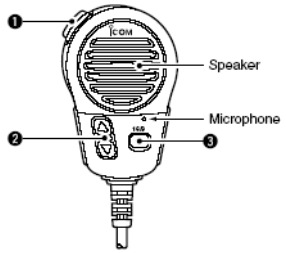
IC-M602

PRIORITY SCAN



Priority scan searches through all tag channels in sequence while monitoring Channel 16. When a signal is detected on Channel 16, scan pauses until the signal disappears; when a signal is detected on a channel other than Channel 16, scan becomes dualwatch until the signal disappears.

■ Microphone (HM-136)



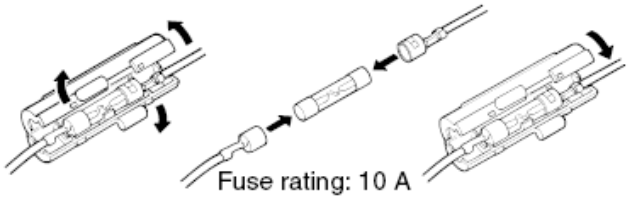
❶ PTT SWITCH [PTT] (p. 10)
Push and hold to transmit; release to receive.

❷ CHANNEL UP/DOWN SWITCHES [▲]/[▼] (P. 10)
Push either switch to change the operating channel, set mode contents, etc.

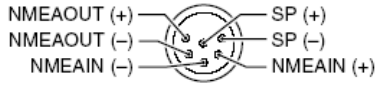
❸ CHANNEL 16/CALL CHANNEL SWITCH [16/9]
- ➥Push to select Channel 16; push for 1 sec. to Channel 9. (p. 8)
- ➥While pushing [16/9], turn power ON to toggle the lock function ON or OFF. (p. 43)

■ Fuse replacement

One fuse is installed in the supplied DC power cable. If a fuse blows or the transceiver stops functioning, track down the source of the problem, if possible, and replace the damaged fuse with a new, rated one.



❹ GPS RECEIVER/EXTERNAL SPEAKER JACK
- ➥Connects to a GPS receiver for position and time indications.
  - •An NMEA0183 ver. 2.0 (sentence formatters RMC, GGA, GNS, GLL) compatible GPS receiver is required. Ask your dealer about suitable GPS receivers.



- ➥Connects to a PC or navigation equipment (NMEA0183 ver. 3.01 sentence formatters DSC, DSE compatible) for plotting received other ships position data.
- ➥Connects to an external speaker.

5.5 Distress Call

A Distress call should be transmitted, if in the opinion of the Master, the ship or a person is in distress and requires immediate assistance.

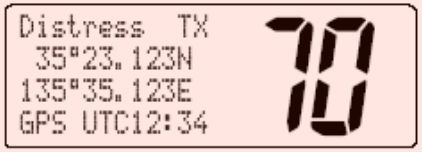
Note: ***DO NOT*** *USE THE DISTRESS CALL WHEN YOUR SHIP IS NOT IN AN EMERGENCY. A DISTRESS CALL CAN BE USED ONLY WHEN IMMEDIATE HELP IS NEEDED.*

5.5.1 Simple call

① Confirm no Distress call is being received.

② While lifting up the switch cover, push **[DISTRESS]** for 5 sec. to transmit the Distress call.

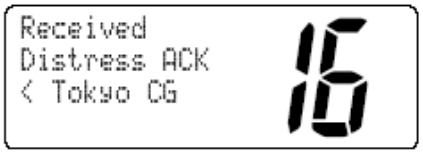
- Emergency channel (Ch 70) is automatically selected and the Distress call is transmitted.
- When no GPS is connected, input your position and UTC time, if possible.



③ After transmitting the call, the transceiver waits for an acknowledgment call on Ch 70.

- The Distress call is automatically transmitted every 3.5 to 4.5 minutes.

④ When receiving the acknowledgment, reply using the microphone.



1. A distress alert contains (default);
   - Kind of distress : Undesignated distress
   - Position data : GPS or manual input position data held for 23.5 hrs or until the power is turned OFF.
2. The Distress call is repeated every 3.5–4.5 min., until receiving an 'acknowledgement.'
3. Push **[DISTRESS]** to transmit a renewed Distress call, if required.
4. Push any key (except **[DISTRESS]**) to cancel the 'Call repeat' mode.
5. "??" may blink instead of position and time indications when the GPS data is invalid, or has not been manually updated after 4 hours.

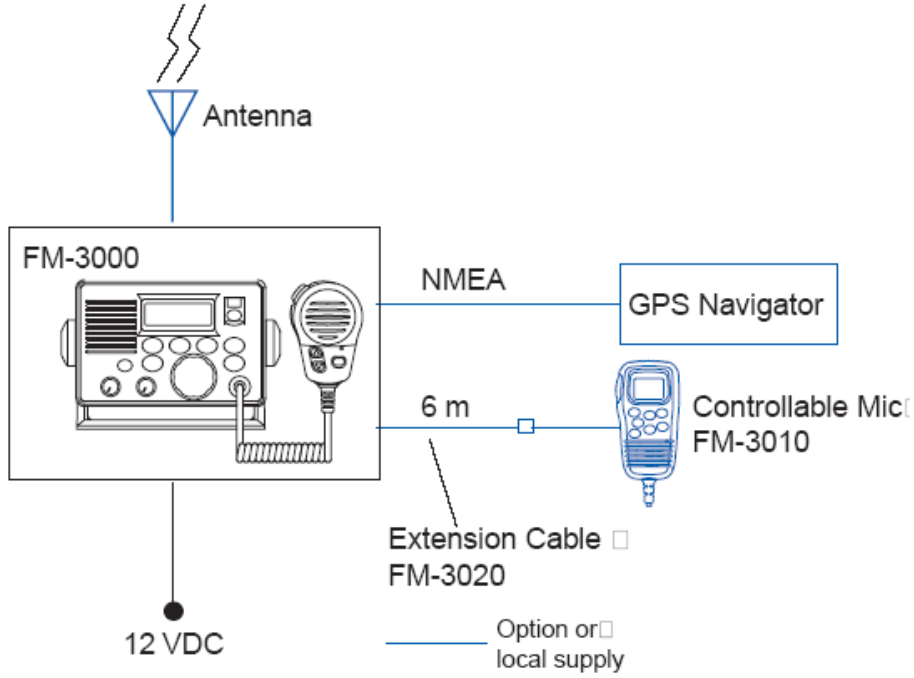
FURUNO

VHF MARINE TRANSCEIVER

With DSC modem and CH70 watch receiver

Model **FM-3000**

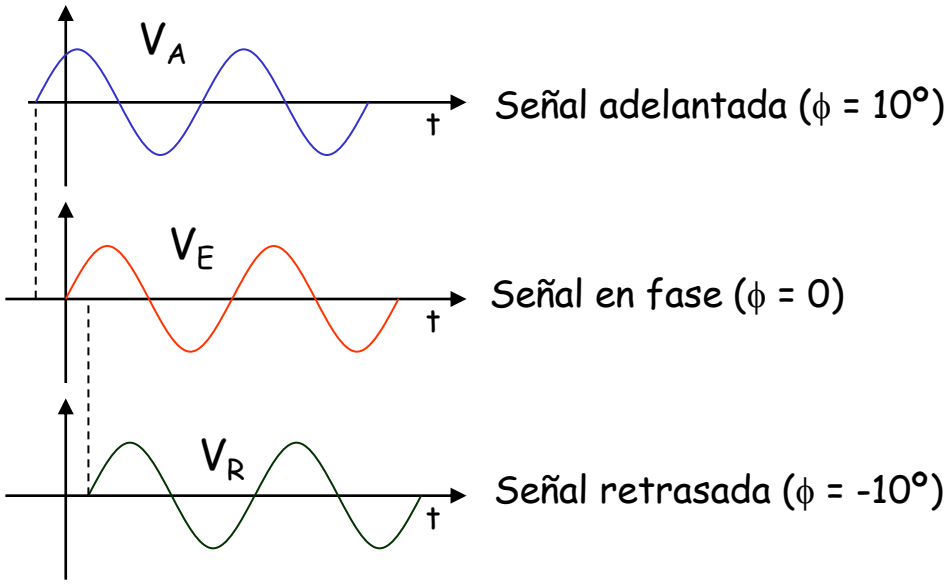
INTERCONNECTION DIAGRAM



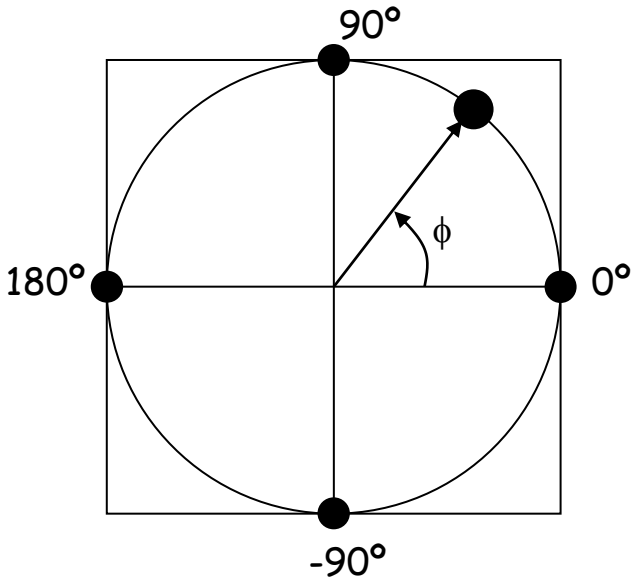
Métodos de modulación: PM

Modulación de fase.

Se mantiene amplitud y frecuencia y se cambia la fase de la señal



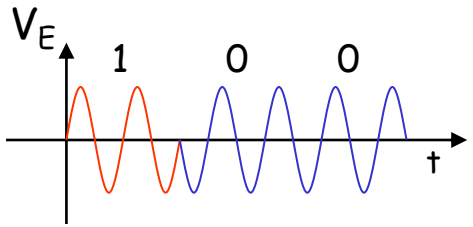
El desfase de la señal portadora se va cambiando al ritmo de la señal portadora



Métodos de modulación: PM

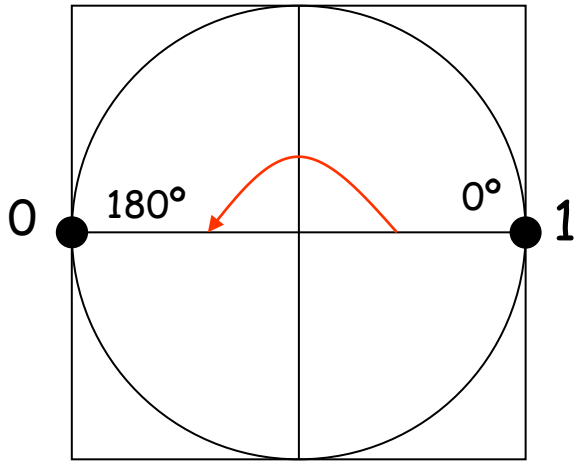
Se puede también transmitir información digital, asignando una fase al "1" otra fase al "0".

Por ejemplo 0° y 180°



La modulación digital de fase se conoce con la siglas:

PSK ("Phase Shift Keying")



Métodos de modulación: PM

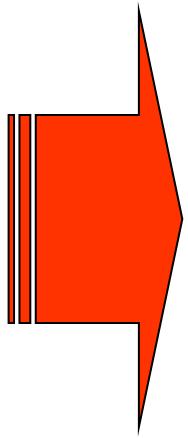
Matemáticamente:

Portadora

$$f_C(t) = A_C \cdot \cos\left[2 \cdot \pi \cdot f_C \cdot t\right]$$

Moduladora (p.e. senoidal)

$$f_M(t) = A_M \cdot \cos\left[2 \cdot \pi \cdot f_M \cdot t\right]$$



Señal modulada en PM

$$f_{PM}(t) = A_C \cdot \cos\left[2 \cdot \pi \cdot f_C \cdot t + n \cdot sen\left(2 \cdot f_M \cdot t\right)\right]$$

$$\boxed{n = k \cdot A_M}$$ Índice de modulación

El espectro de una señal PM se obtiene como el de FM con las funciones de Bessel.

La distribución espectral depende de la moduladora.

Si n < 0.3 se tiene modulación de banda estrecha (NBPM, Narrow Band Phase Modulation)