



PERÚ

Ministerio
del Ambiente

Instituto
Geofísico del Perú

Radio Observatorio
de Jicamarca

I+D+i en el Radio Observatorio de Jicamarca

Marcos Inoñán Morán

1. Introducción
2. Conceptos de Radar
3. Sistema de Radar del ROJ
4. Procesamiento Digital de señales
5. Programa de prácticas de estudiantes para el ROJ

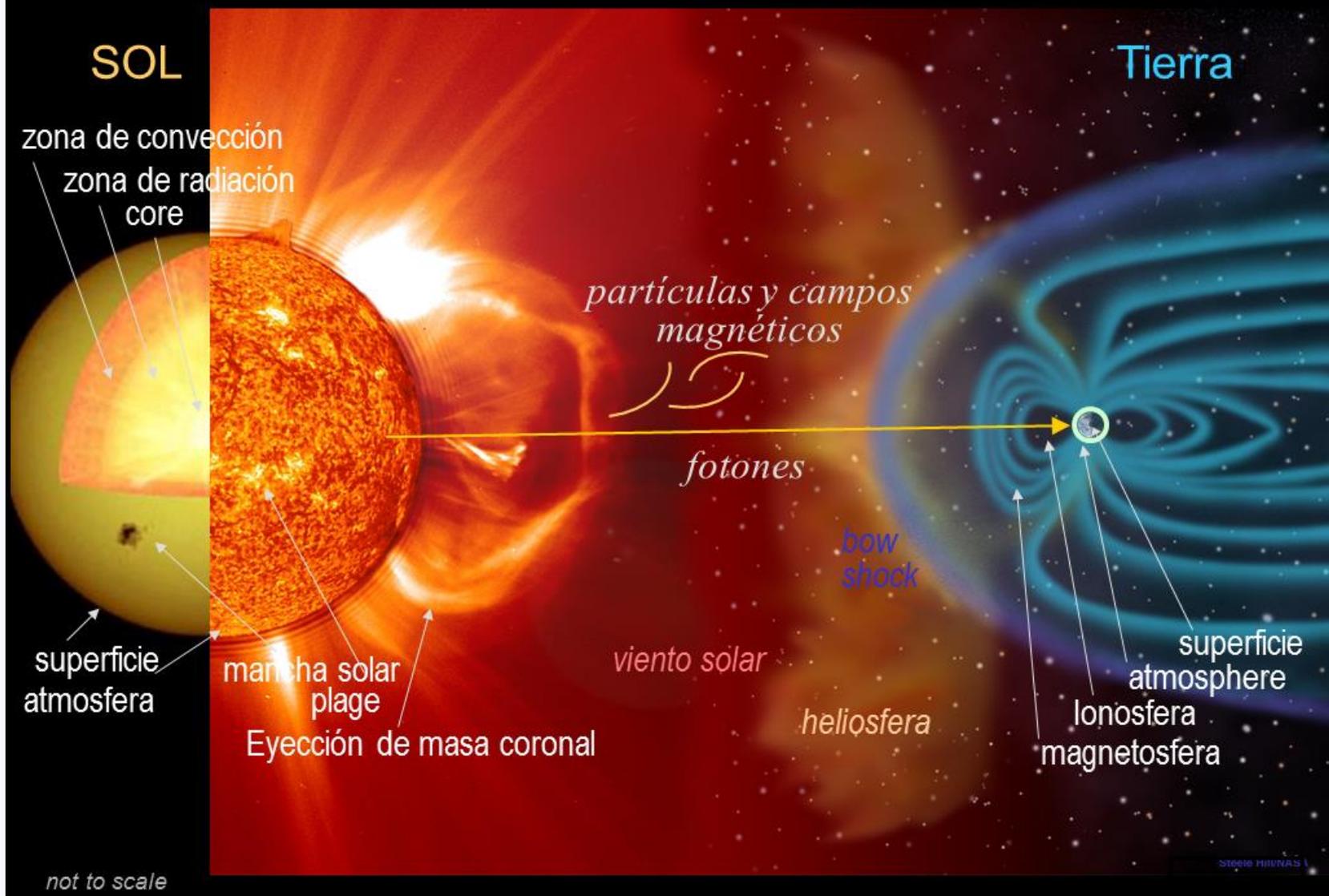
Principales características

- Ubicado a 20 Km de Lima
- 18,432 dipolos
- Área: 85,000 m²
- Trabaja a una frecuencia de 49.92 MHz
- Potencia de 6MW (4 Tx de 1.5 MW c/u)



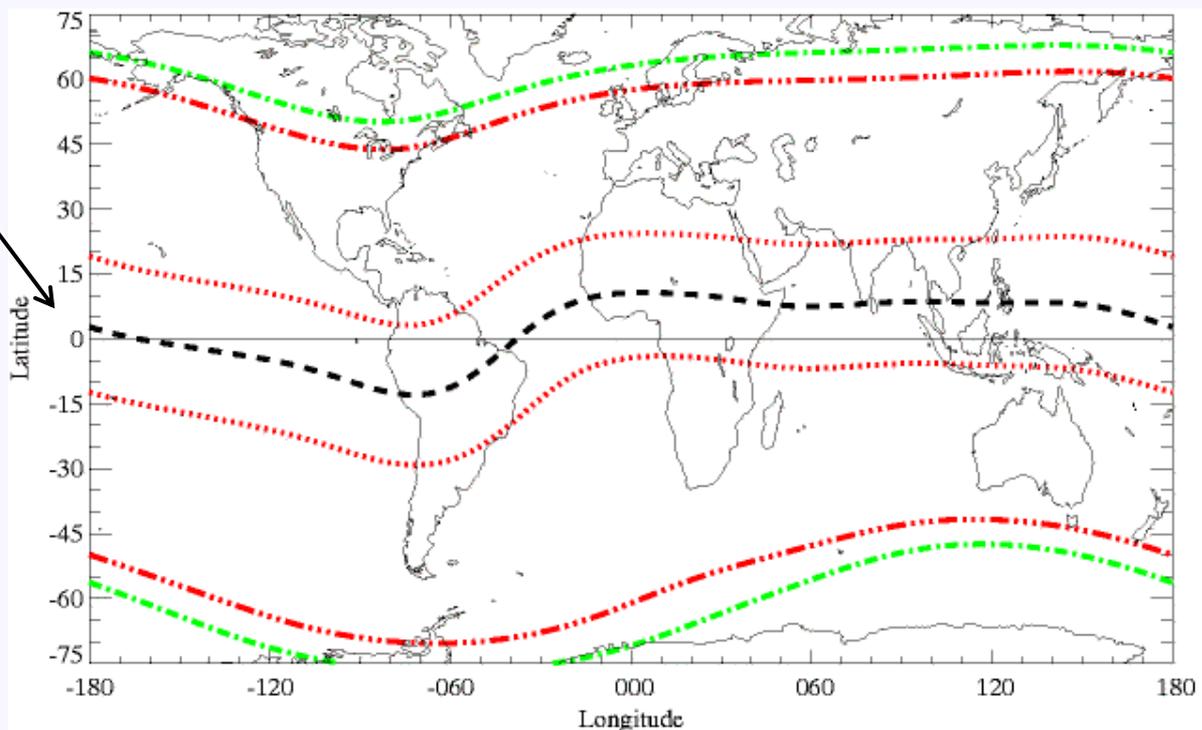
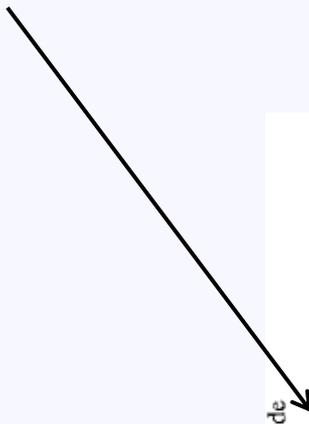
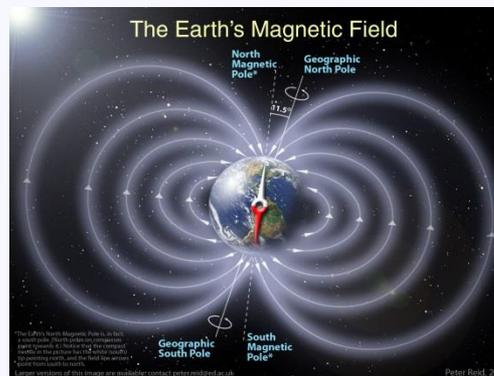
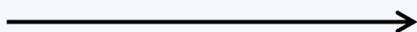
Principales características

Systema Sol-Tierra: Acoplamiento de Energía

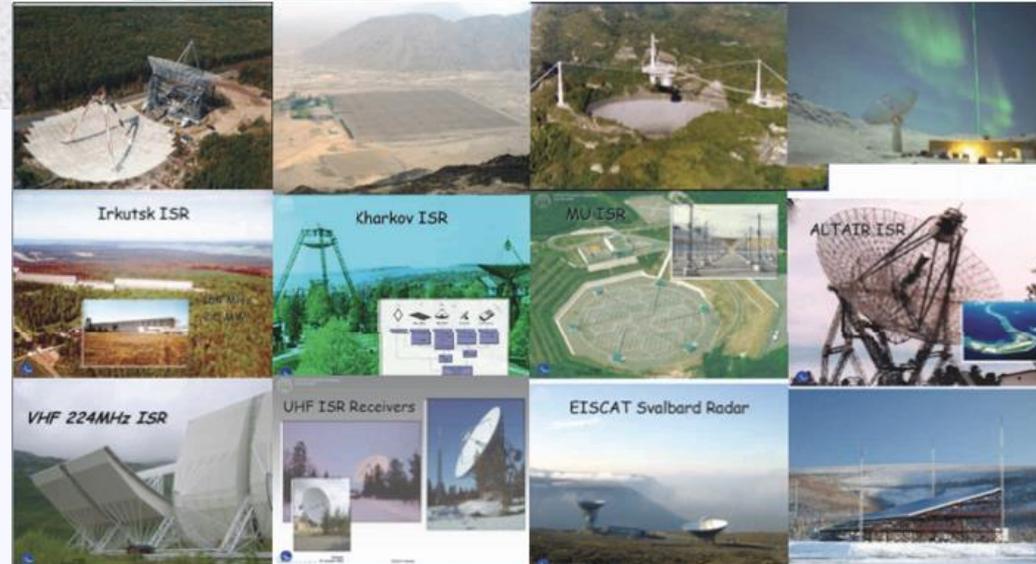


¿Porqué en Lima?

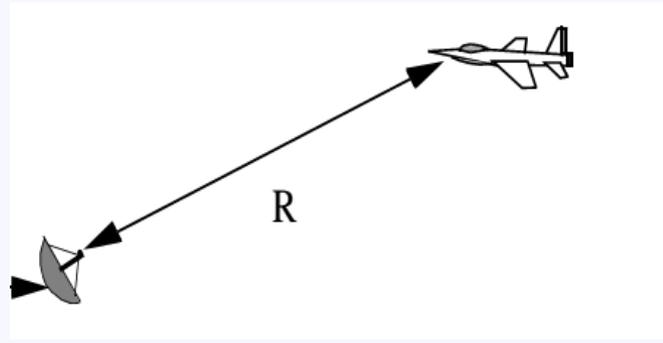
Ecuador
Magnético



Radars de dispersión incoherente



Rango y Frecuencia Doppler



Rango

$$R = \frac{c \Delta t}{2}$$

Señal transmitida

$$\cos(2\pi f_0 t)$$

Señal recibida

$$\cos \left[2\pi f_0 \left(t + \frac{2R}{c} \right) \right] \dots(1)$$

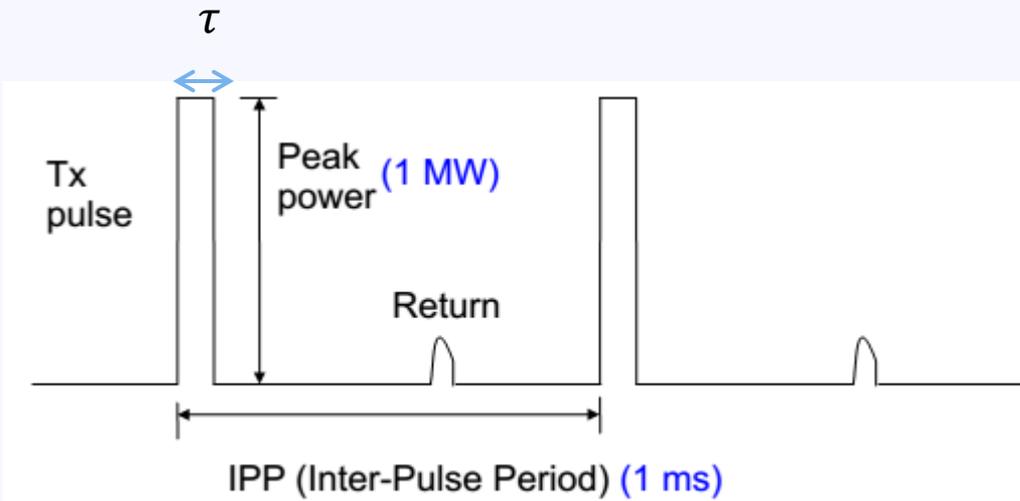
Asumimos $R = R_0 + vt \dots(2)$

Operando (2) en (1) $\cos \left[2\pi \left(f_0 + \underbrace{f_0 \frac{2v}{c}}_{-f_d} t + \underbrace{\frac{2R_0}{c}}_{constant} \right) \right]$

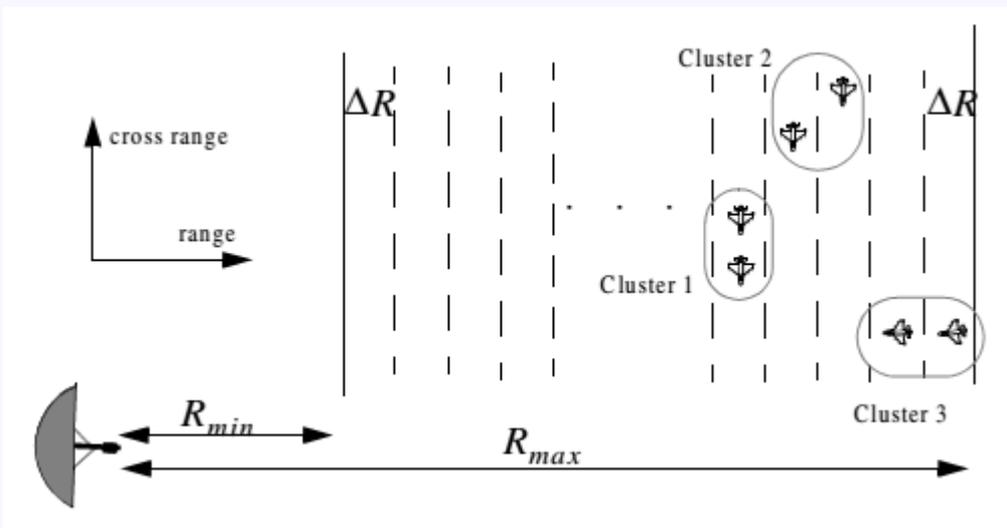
$$f_d = -2f_0 \left(\frac{v}{c} \right) = -2 \left(\frac{v}{\lambda_0} \right)$$

$$v = -\lambda_0 f_d / 2$$

IPP y Resolución

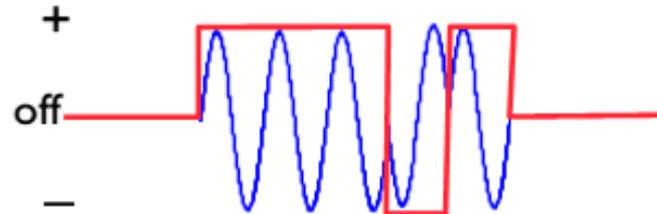


$$Duty\ cycle = \frac{\tau}{IPP}$$

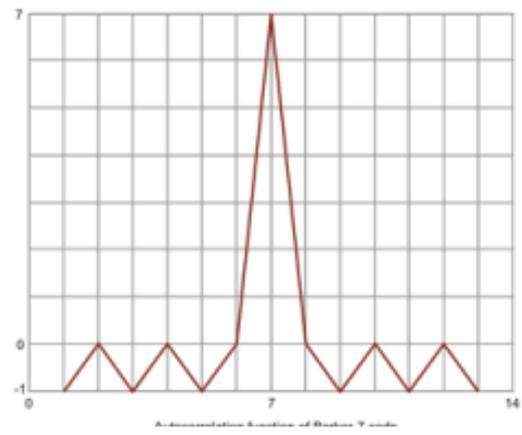


$$\Delta R = \frac{c\tau}{2}$$

Potencia vs. Resolución

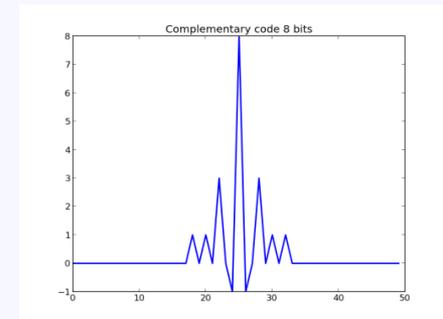
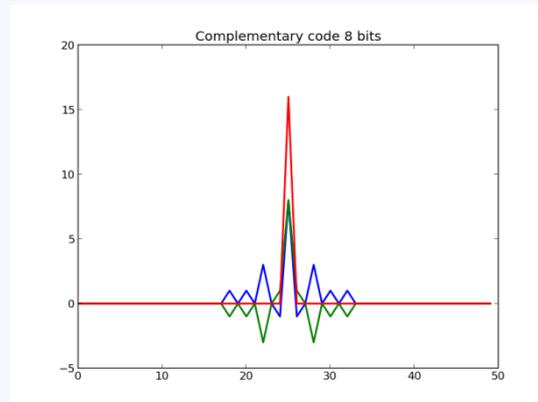
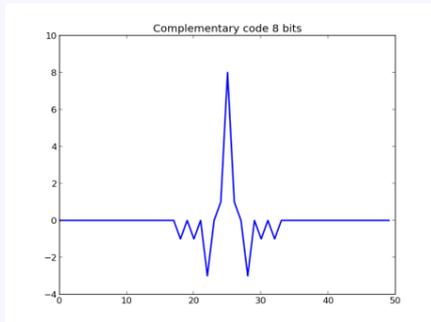
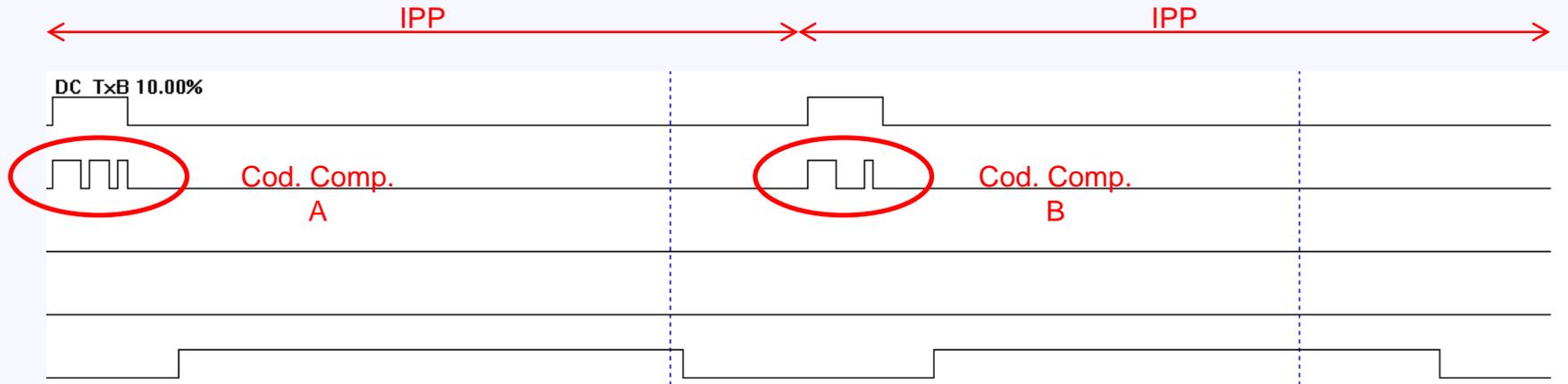


					+	+	+	-	+	correlator output
+	+	+	-	+						1
	+	+	+	-	+					$-1+1=0$
		+	+	+	-	+				$1-1+1=1$
			+	+	+	-	+			$1+1-1-1=0$
				+	+	+	-	+		$1+1+1+1+1=5$



Código
 Barker 5

Codificación



Método
Formal

$$R_x(k) = \sum_{j=0}^{N-k-1} x_j x_{j+k}$$

$$R_a(k) + R_b(k) = 0,$$

Método
práctico

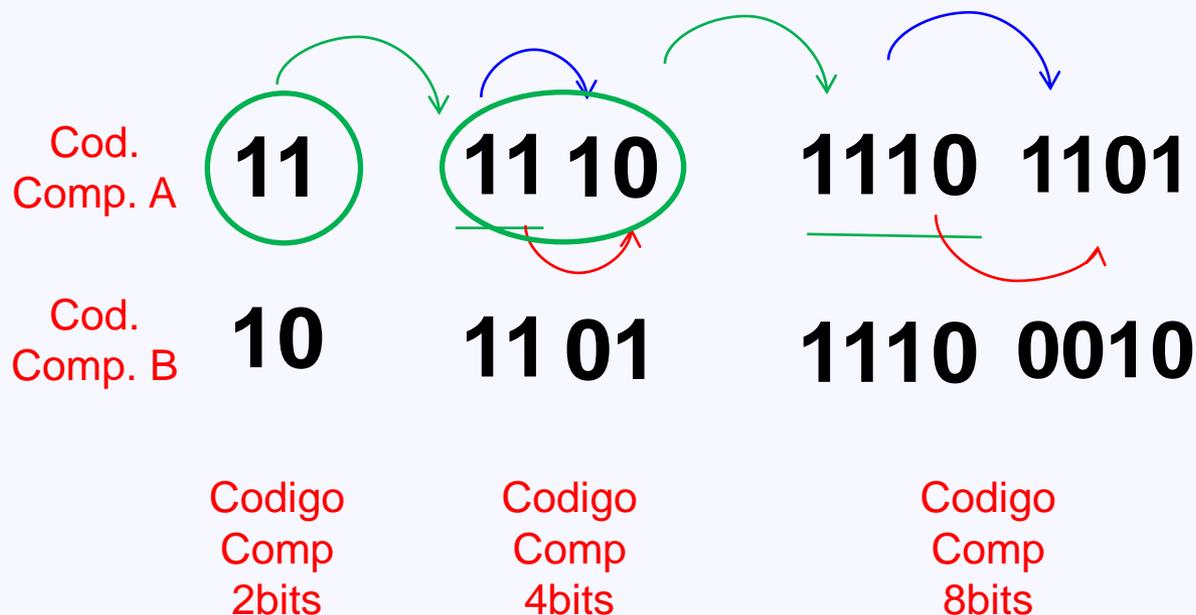


Diagrama de bloques

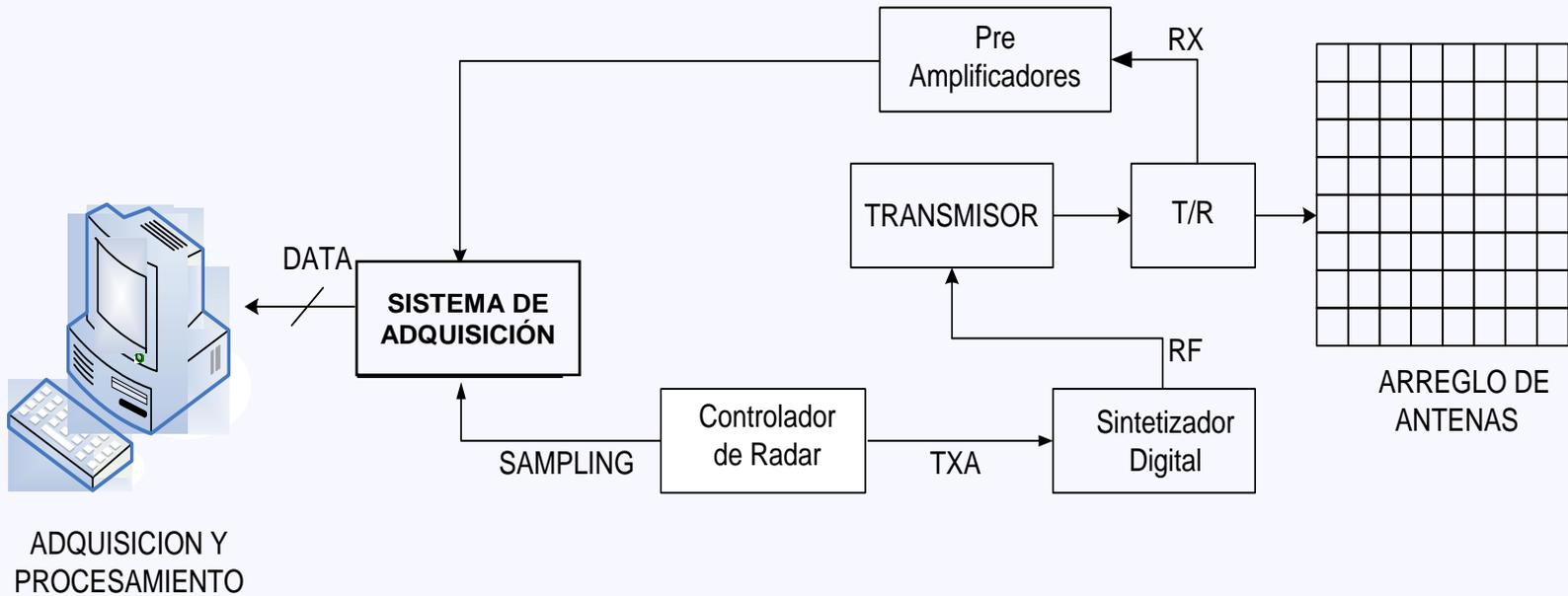
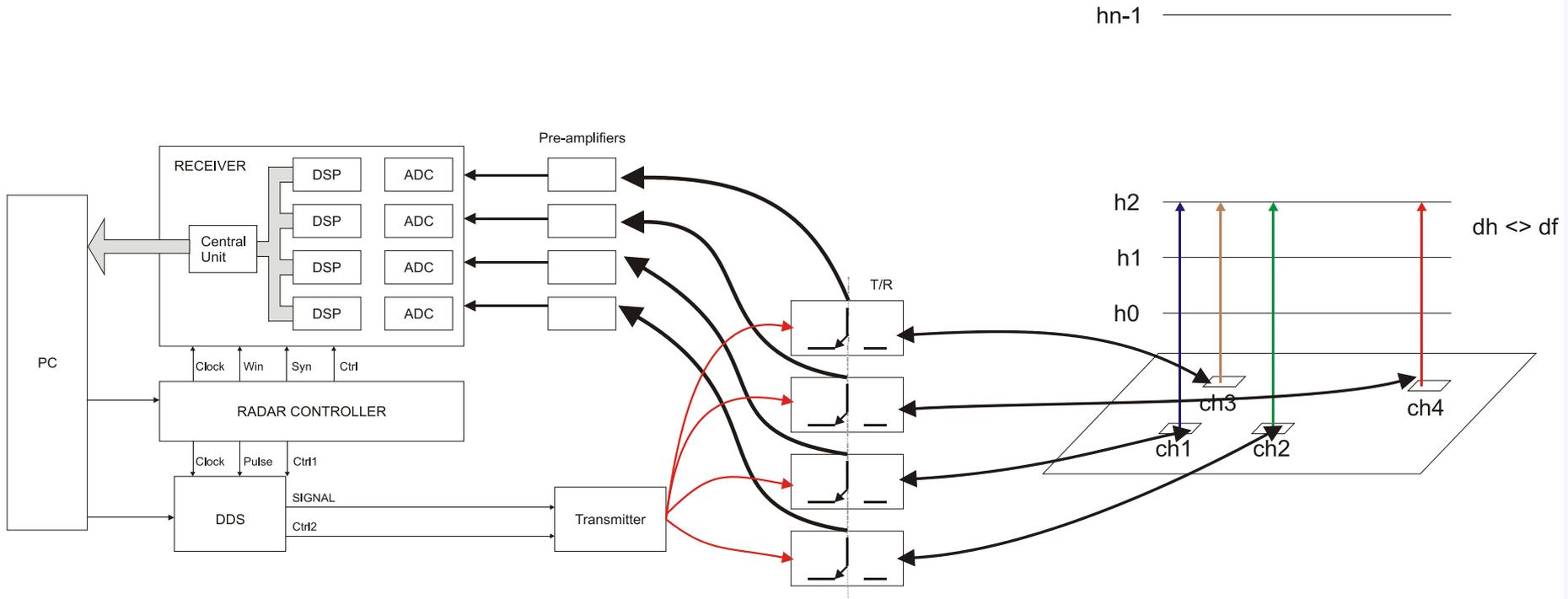
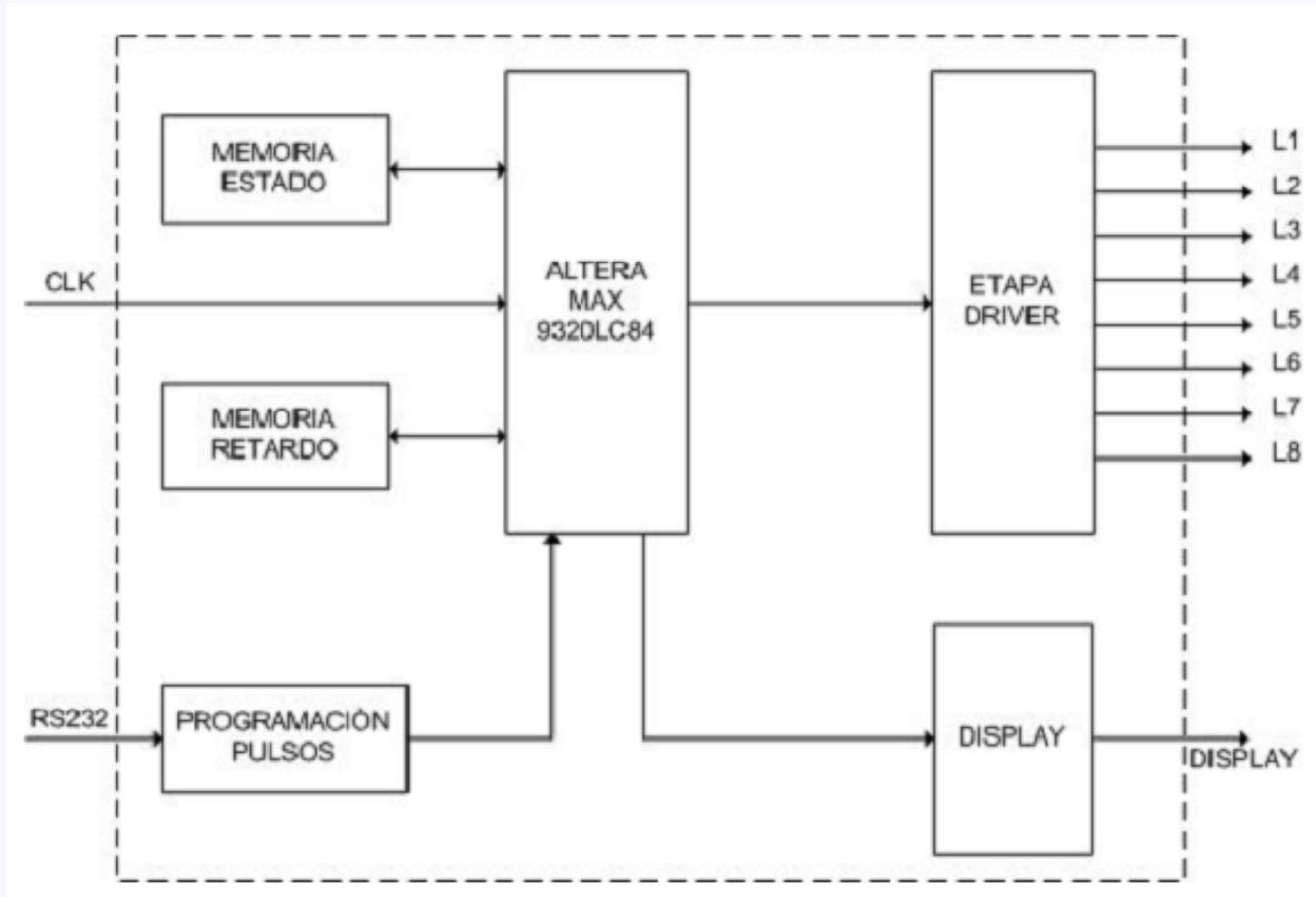


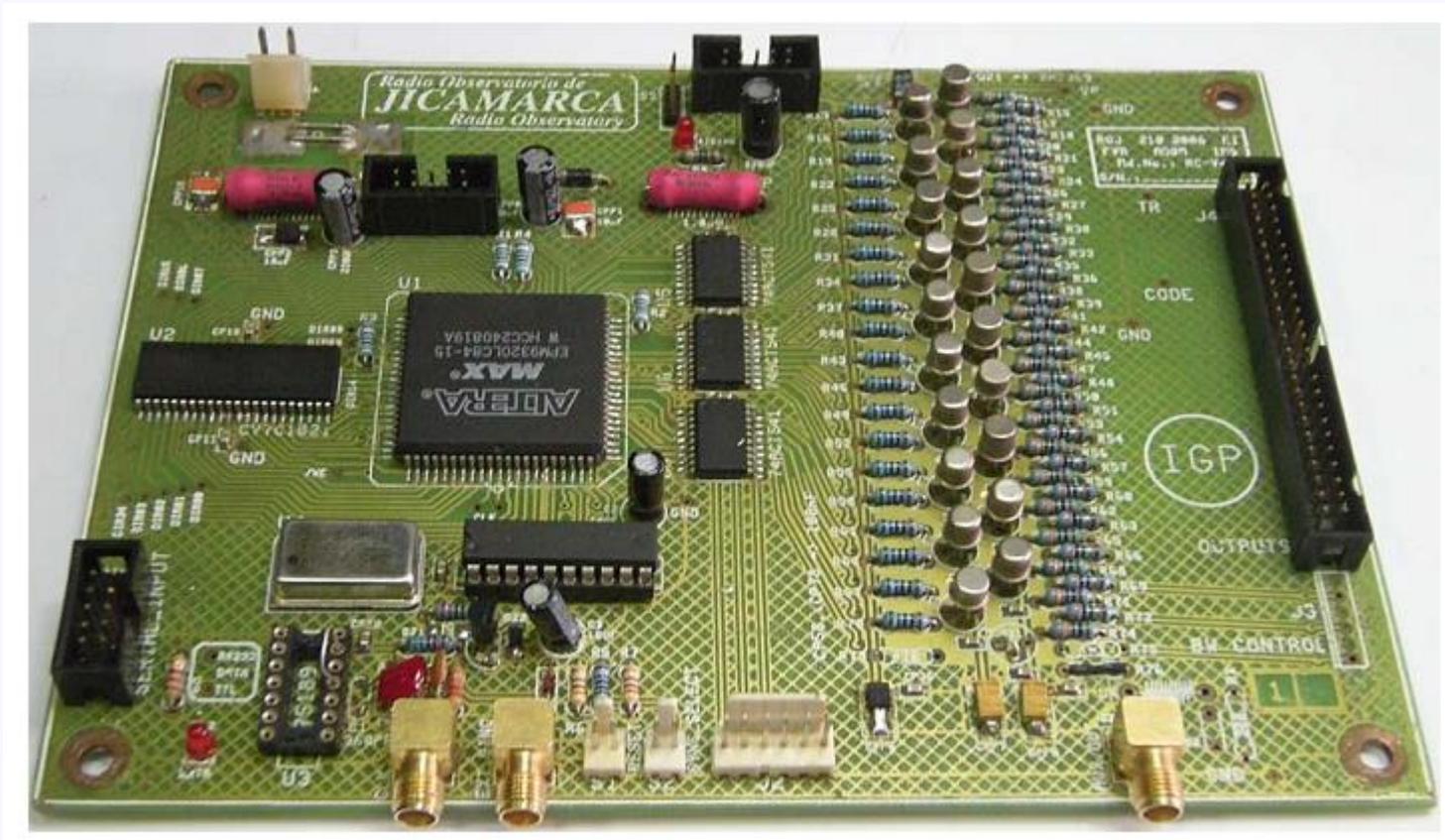
Diagrama de bloques



Controlador de Radar



Controlador de Radar

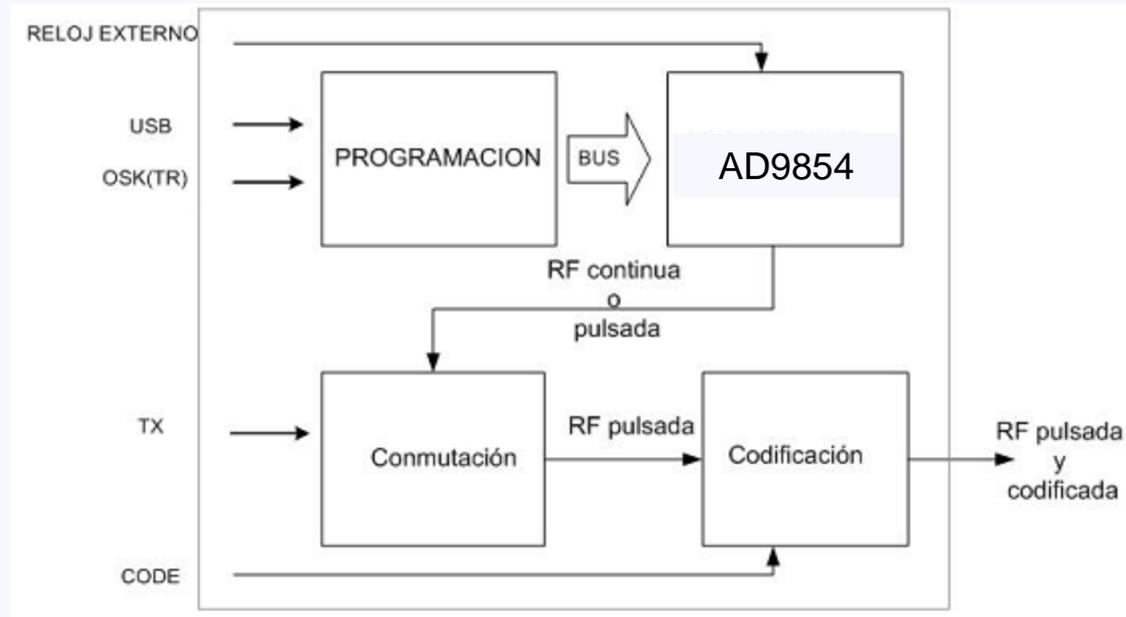


Controlador de Radar



- Basado en Spartan 6
- 16 canales
- Más capacidad de memoria
- Programado por ethernet
- Monitoreo

Direct Digital Synthesizer



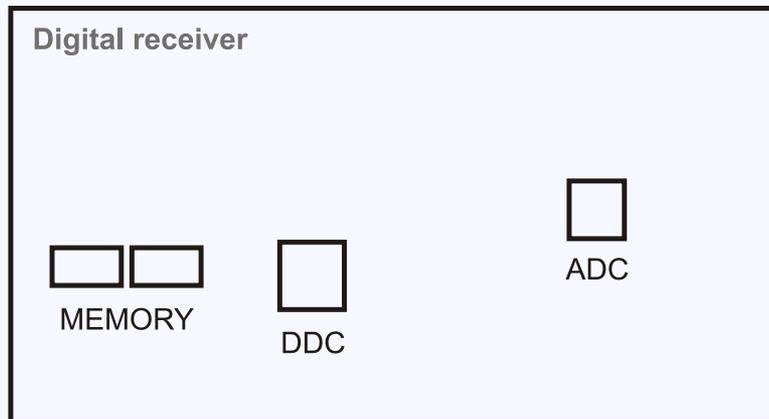
$$FTW = F \times 2^N / \text{SystemClock}$$

Direct Digital Synthesizer



- Resolución 48 bits
- Multiplicador x 4
- 2 canales
- 60 dB de crosstalk
- Programado por USB

Jicamarca Acquisition Radar System (JARS)



ADC

- 14 bits
- 500ps aperture delay

DDC

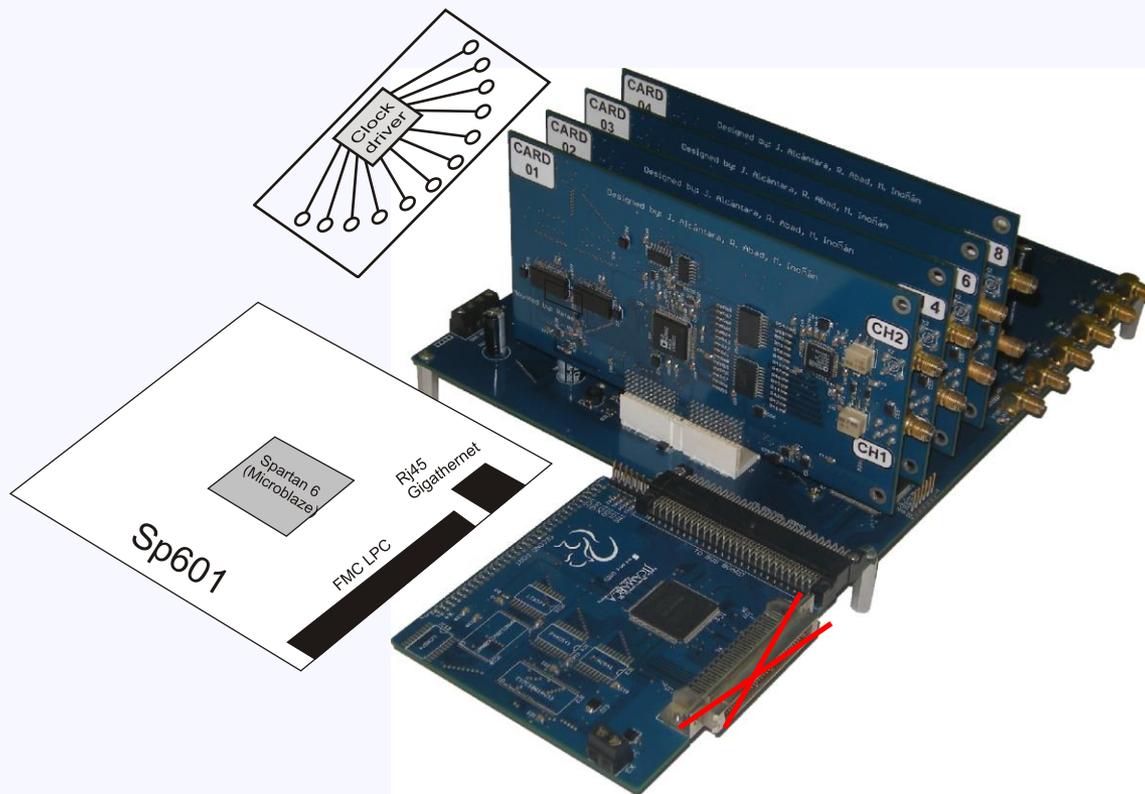
- 32 bits NCO
- 2 CIC and 1 FIR

JARS highlights



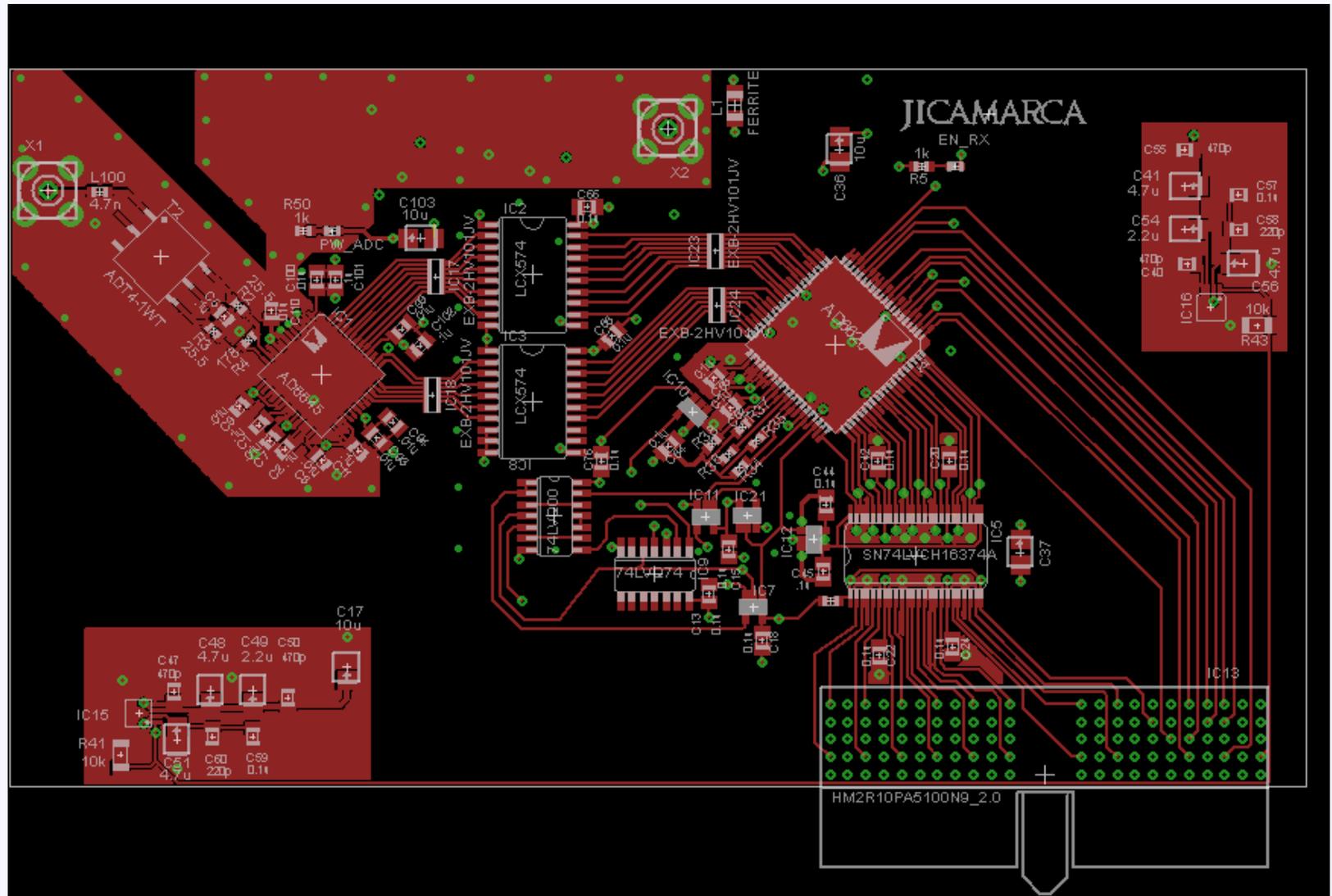
Number of ADC	8
ADC's resolution	14 bits
Dynamic range	80 dB
Maximum input signal level	1.41 Vpp @ 50 ohm
Maximum rate transfer per channel	1 MHz
Decimation range	4 to 16384
Size	19" x 7" x 13"
Interface with PC	NIDAQ 653X
Acquisition mode	Burst or continuous

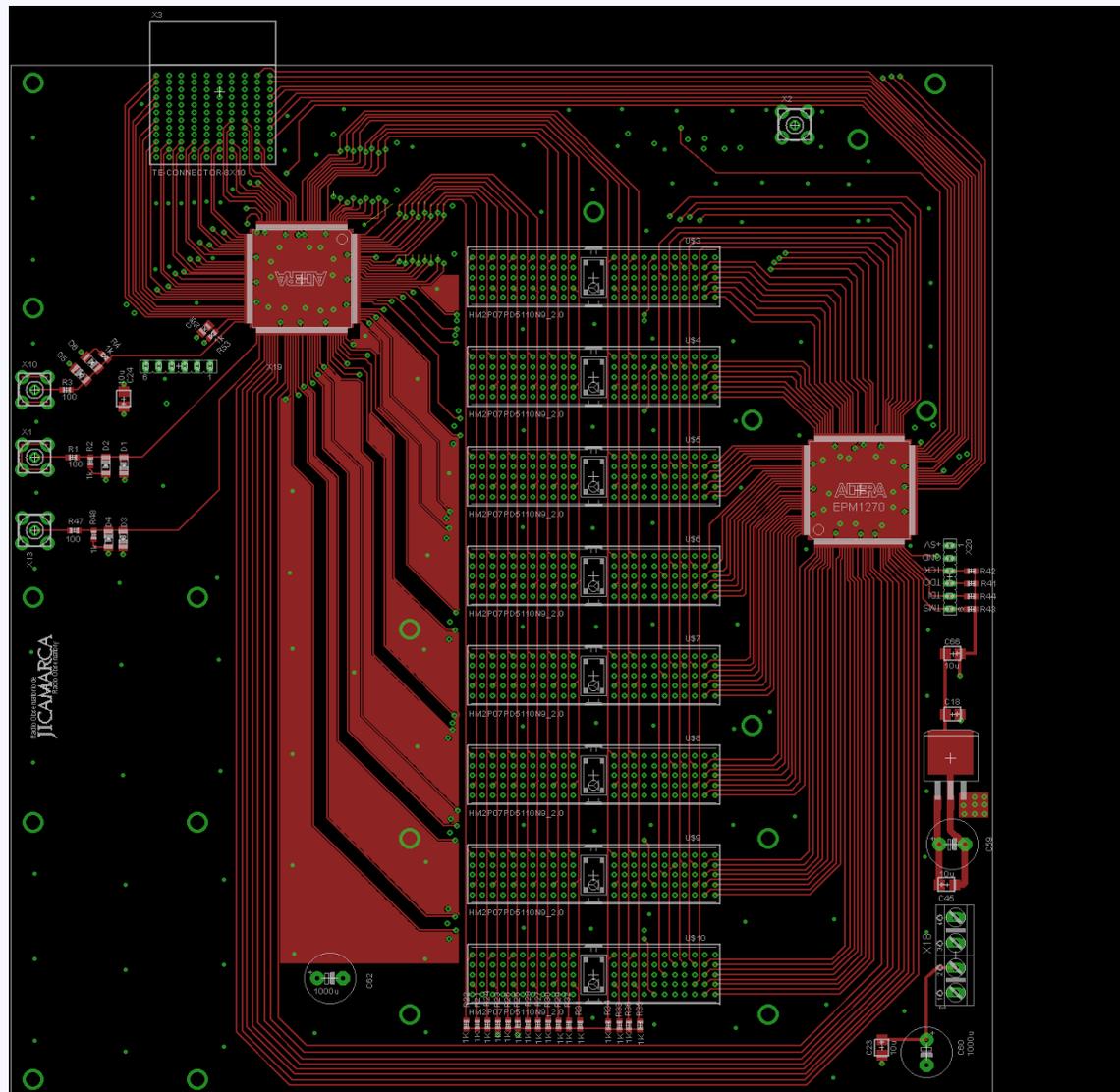
JARS 2.0



- Basado en Spartan 6
- Transferencia por GigaEthernet
- Sistema de adquisición bajo OS Linux

JARS 2.0

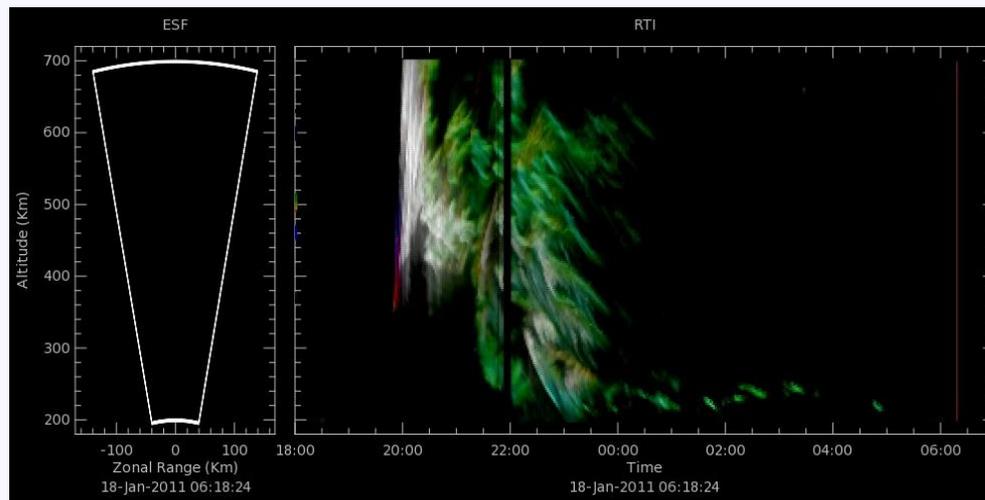




Resultados

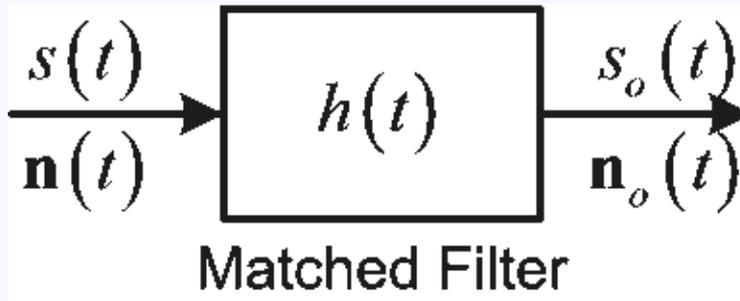


Sistema de Radar de 8 canales



RTI de Spread F adquirido con JARS en experimento de Imágenes

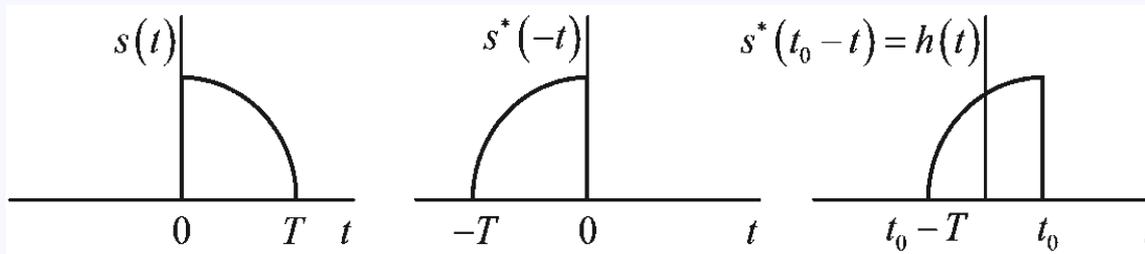
Match Filter



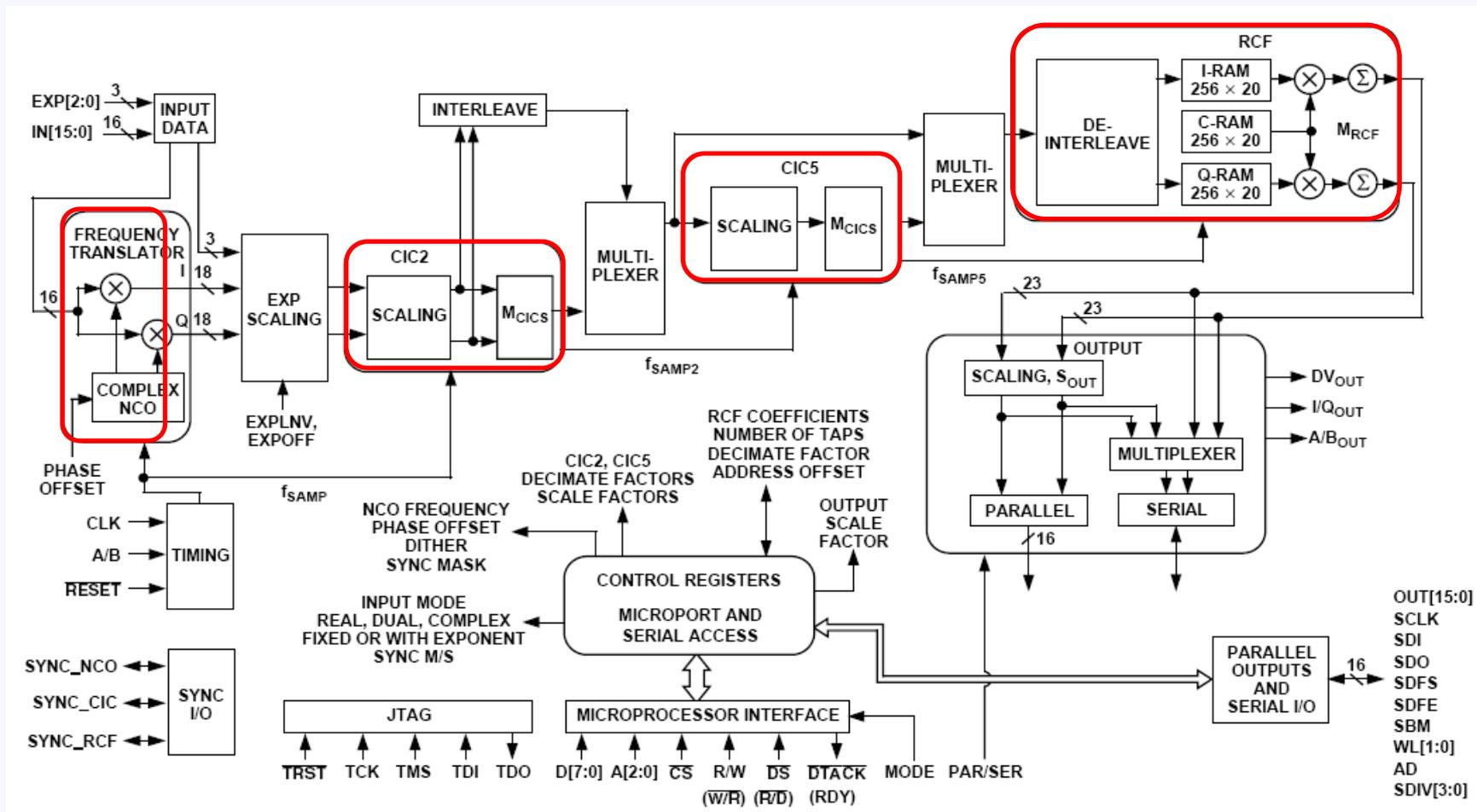
$$h(t) : \max_{h(t)} \frac{P_S}{P_n}$$

$$h(t) = \mathfrak{F}^{-1} \left[K S^*(f) e^{-j2\pi f t_0} \right] = \int_{-\infty}^{\infty} K S^*(f) e^{-j2\pi f t_0} e^{j2\pi f t} df$$

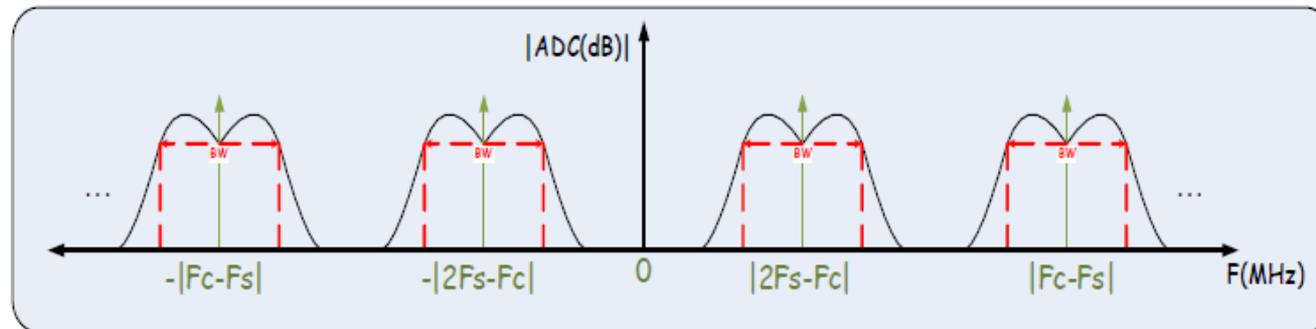
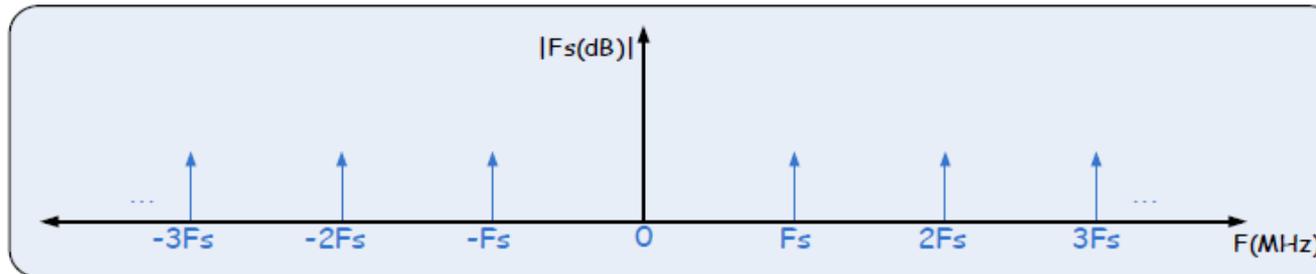
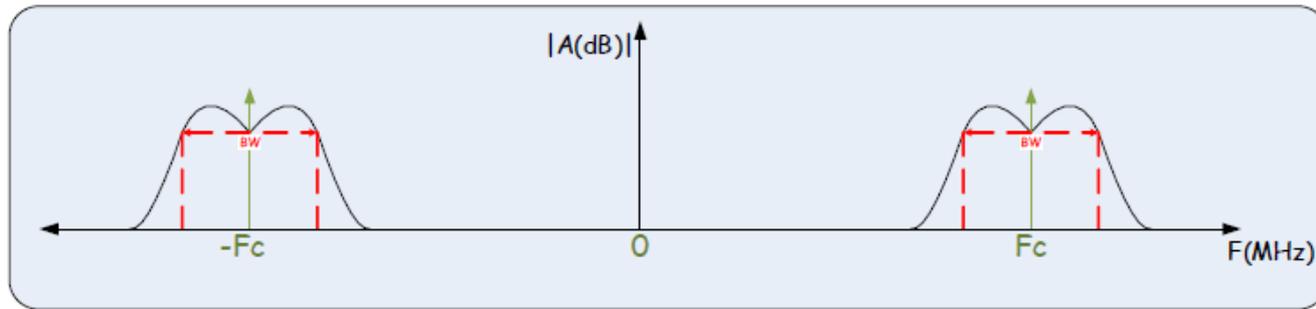
$$= K \int_{-\infty}^{\infty} S^*(f) e^{-j2\pi f (t_0 - t)} df = K \left[\int_{-\infty}^{\infty} S(f) e^{j2\pi f (t_0 - t)} df \right]^* = K s^*(t_0 - t)$$



Digital Down Converter (AD6620)



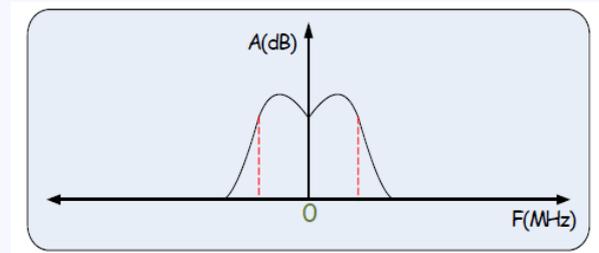
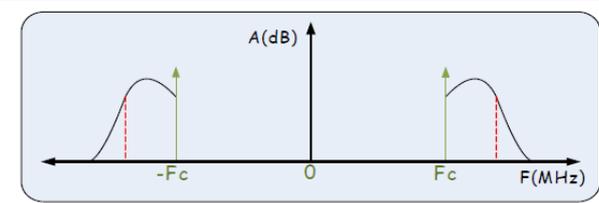
AD6620: Frequency translator



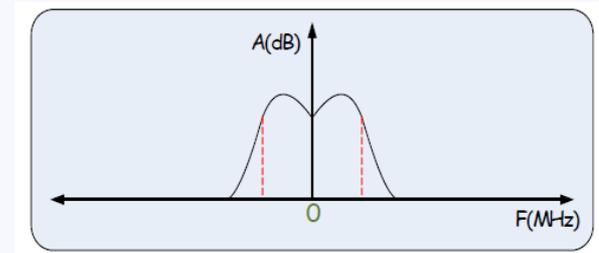
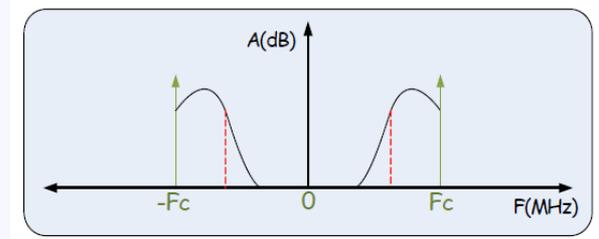
AD6620: Frequency translator

Si solo se utilizara Coseno

Objeto que se acerca



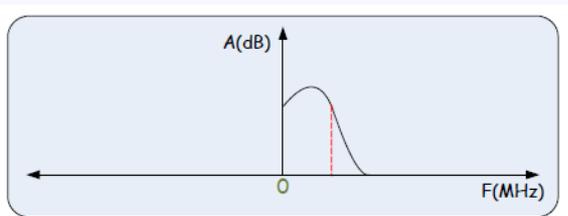
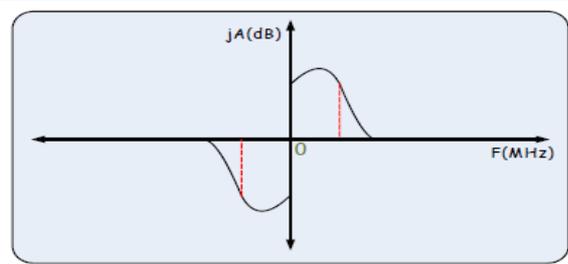
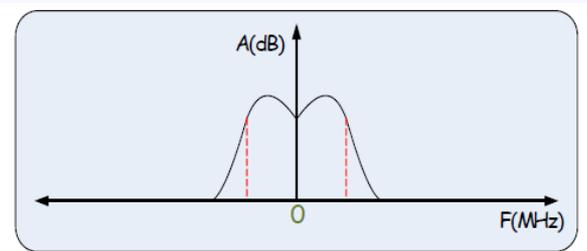
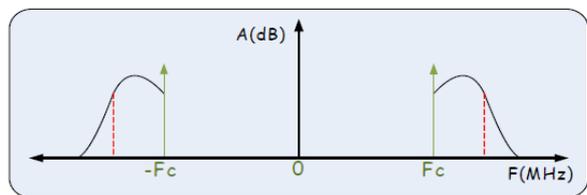
Objeto que se aleja



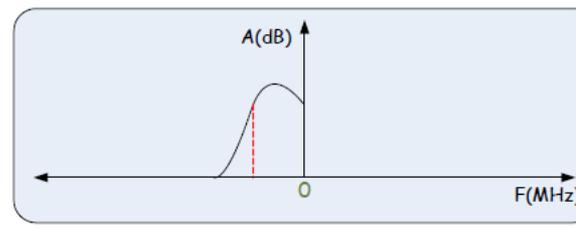
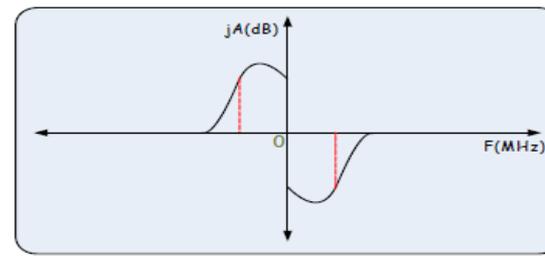
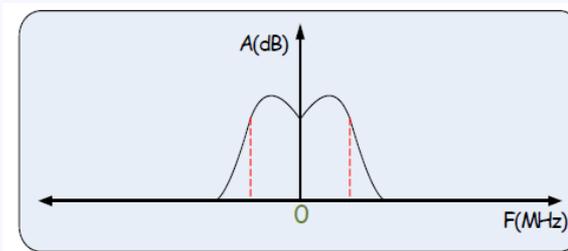
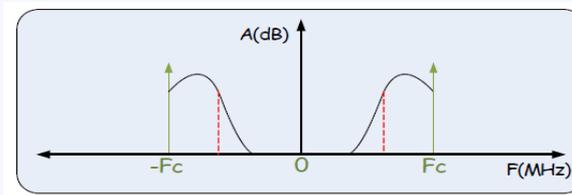
AD6620: Frequency translator

Se necesita Seno y Coseno

Objeto que se acerca



Objeto que se aleja



AD6620: CIC Filter

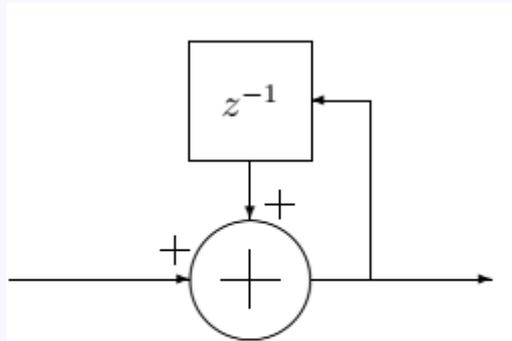


Figure 1: Basic Integrator

$$y[n] = y[n - 1] + x[n]$$

$$H_I(z) = \frac{1}{1 - z^{-1}}$$

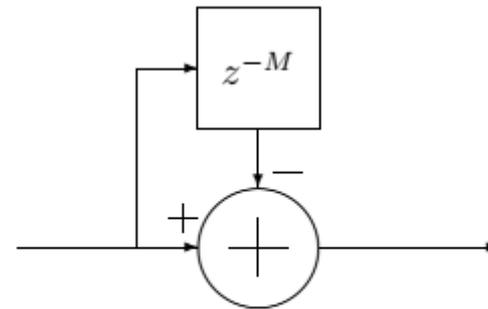


Figure 2: Basic Comb

$$y[n] = x[n] - x[n - RM]$$

$$H_C(z) = 1 - z^{-RM}$$

AD6620: Frequency translator

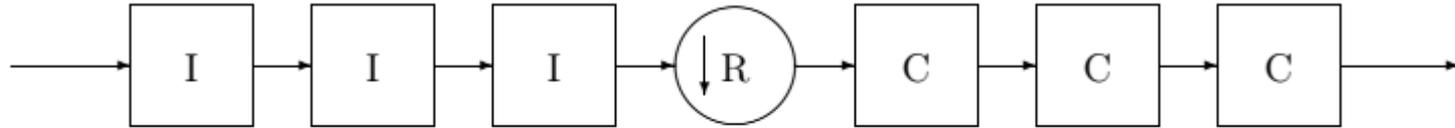


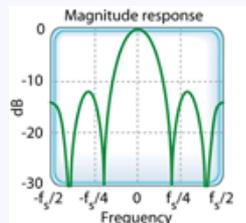
Figure 3: Three Stage Decimating CIC Filter

$$H(z) = H_I^N(z)H_C^N(z) = \frac{(1 - z^{-RM})^N}{(1 - z^{-1})^N}$$

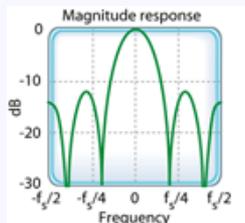
$$H_{cic}(e^{j2\pi f}) = \frac{1 - e^{-j2\pi f D}}{1 - e^{-j2\pi f}} = \frac{e^{-j2\pi f D/2} (e^{j2\pi f D/2} - e^{-j2\pi f D/2})}{e^{-j2\pi f /2} (e^{j2\pi f /2} - e^{-j2\pi f /2})}$$

$$|H(f)| = \left| \frac{\sin \pi M f}{\sin \frac{\pi f}{R}} \right|^N$$

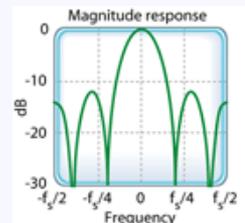
$$|H(f)| \approx \left| RM \frac{\sin \pi M f}{\pi M f} \right|^N$$



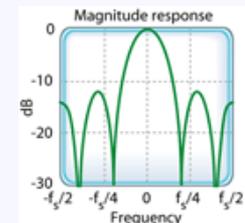
$(RM)^N$



$\text{sinc}(\pi M f)$



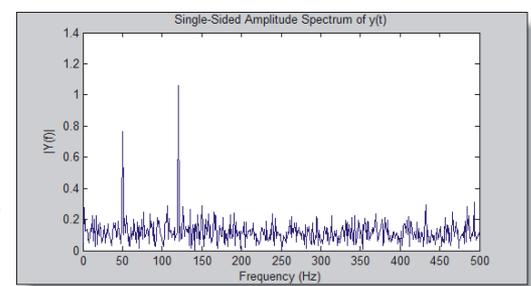
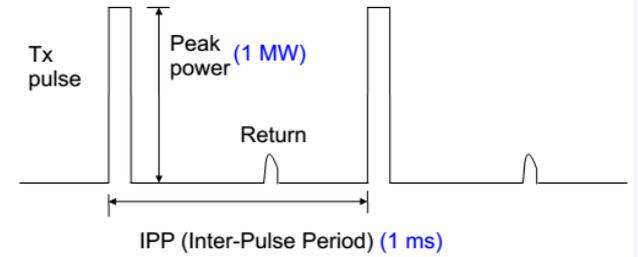
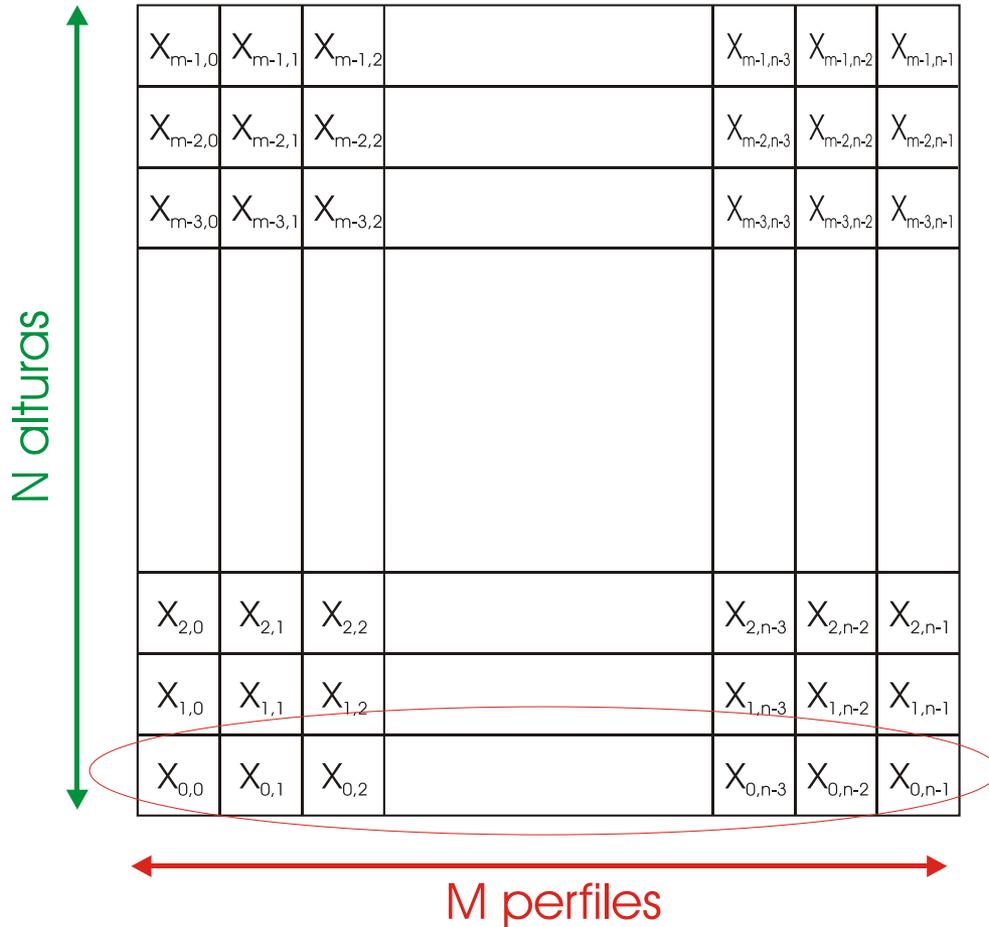
$\text{sinc}(\pi M f)$



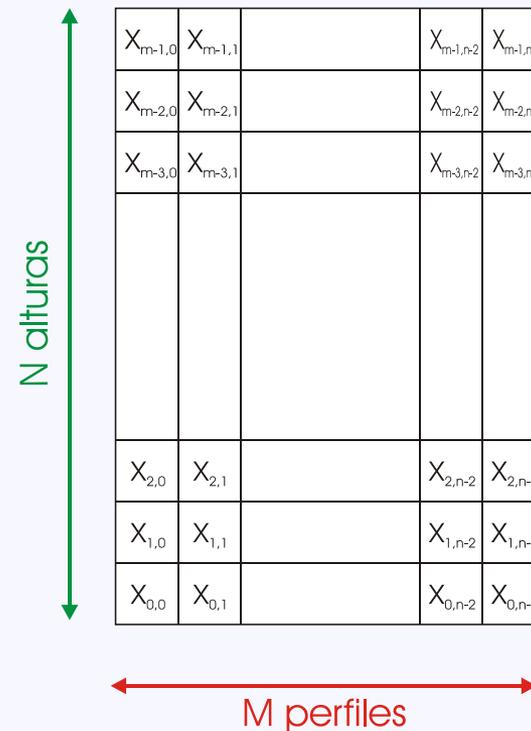
$\text{sinc}(\pi M f)$

$\text{sinc}(\pi M f)$

Transformada de Fourier en Radares



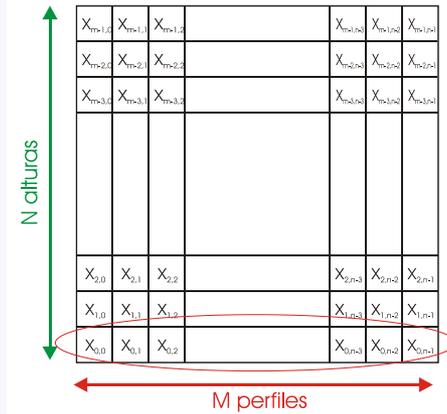
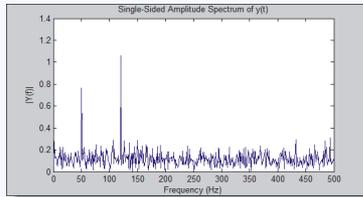
Integración Coherente



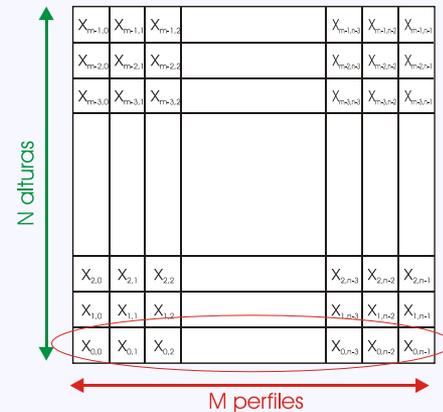
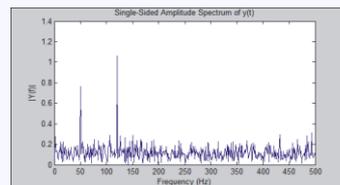
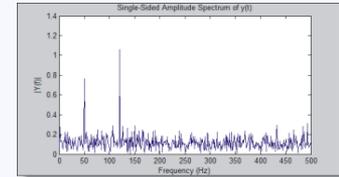
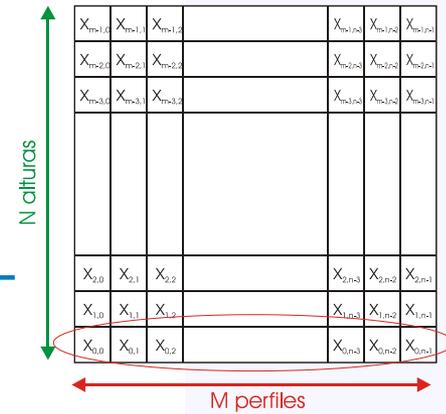
INTEGRACION COHERENTE = 2

Integración Incoherente

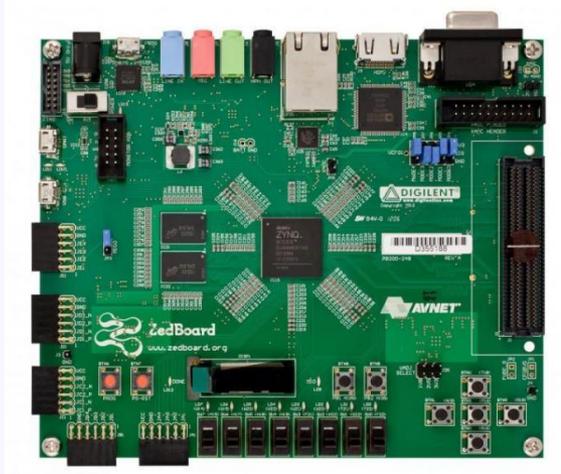
INTEGRACION INCOHERENTE = 2



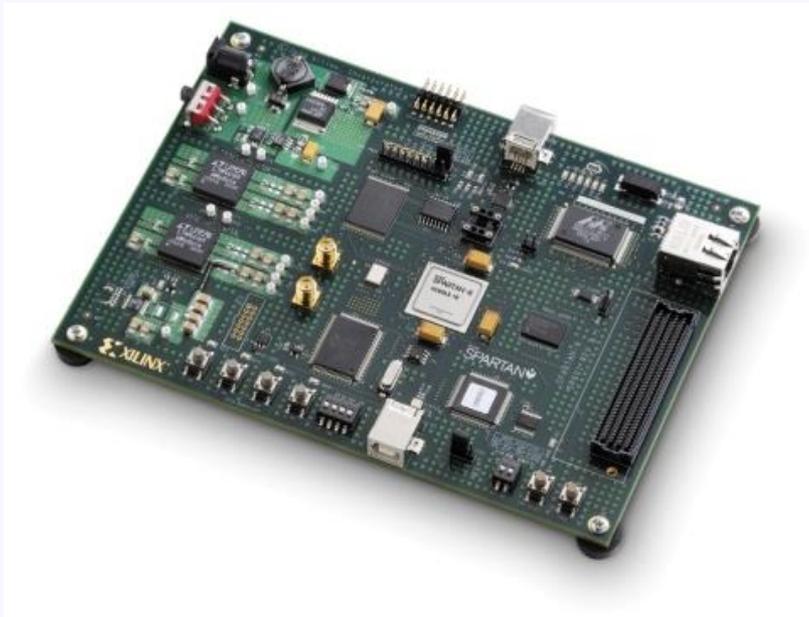
+



Proyectos a desarrollar



- Sistemas de adquisición en sistemas embebidos
- Procesamiento de señales en FPGA
- Desarrollador de simuladores de Radar
- Configuración de sistemas de Radar a través de la Web
- Transferencia de datos a través de InfiniBand
- Programación en paralelo para Procesamiento y Clusters



Python

Prácticas 2014

- Dirigido a Jóvenes de ciclo 7º, 8º y 9º de las Escuelas Electrónica, Sistemas, Computación, Matemática y Física.
- Desarrollar proyectos en Ingeniería y Ciencias en el ROJ
- Duración: 2 meses y medio: Enero - Marzo 2014
- Inicio de Convocatoria: Noviembre 2013
- Entrevistas: Diciembre 2013
- Contacto:

programa@jro.igp.gob.pe

