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ルビジュームクロック

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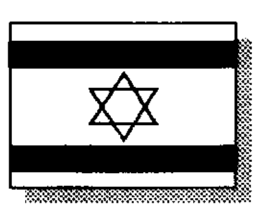

クロニクス株式会社
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AccuBeat Ltd **Accurate frequency and time**

Products and Applications

Heartbeat of the Global village!

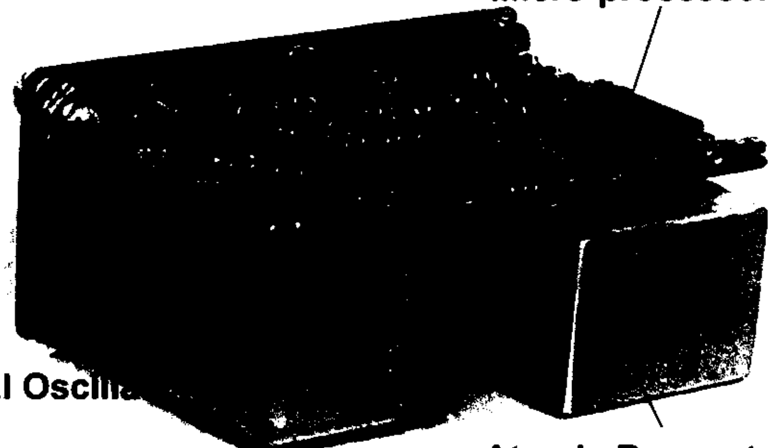
AccuBeat

AccuBeat's Competitive Edge

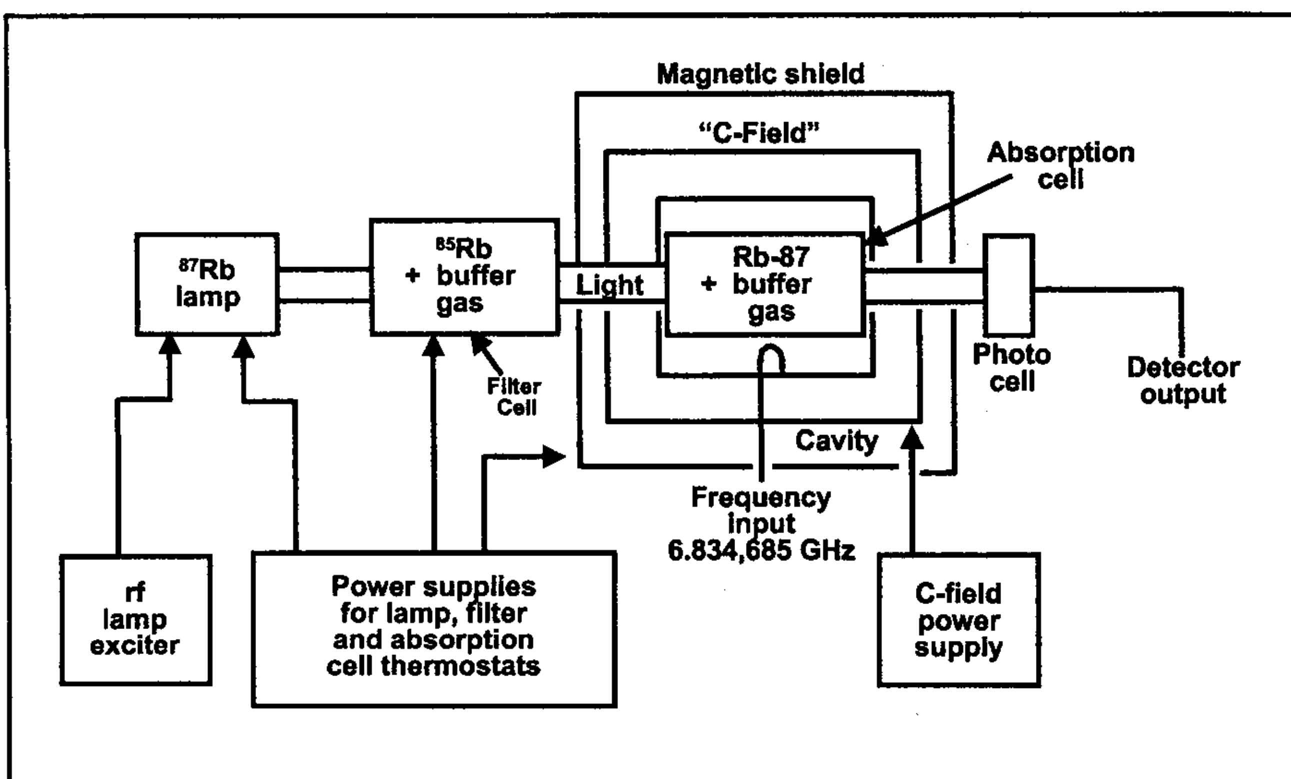
- ☆ **Miniature Design**
- ☆ **High Performance**
- ☆ **High operating temperature**
- ☆ **Design for low cost production**

AccuBeat's Rubidium Clocks

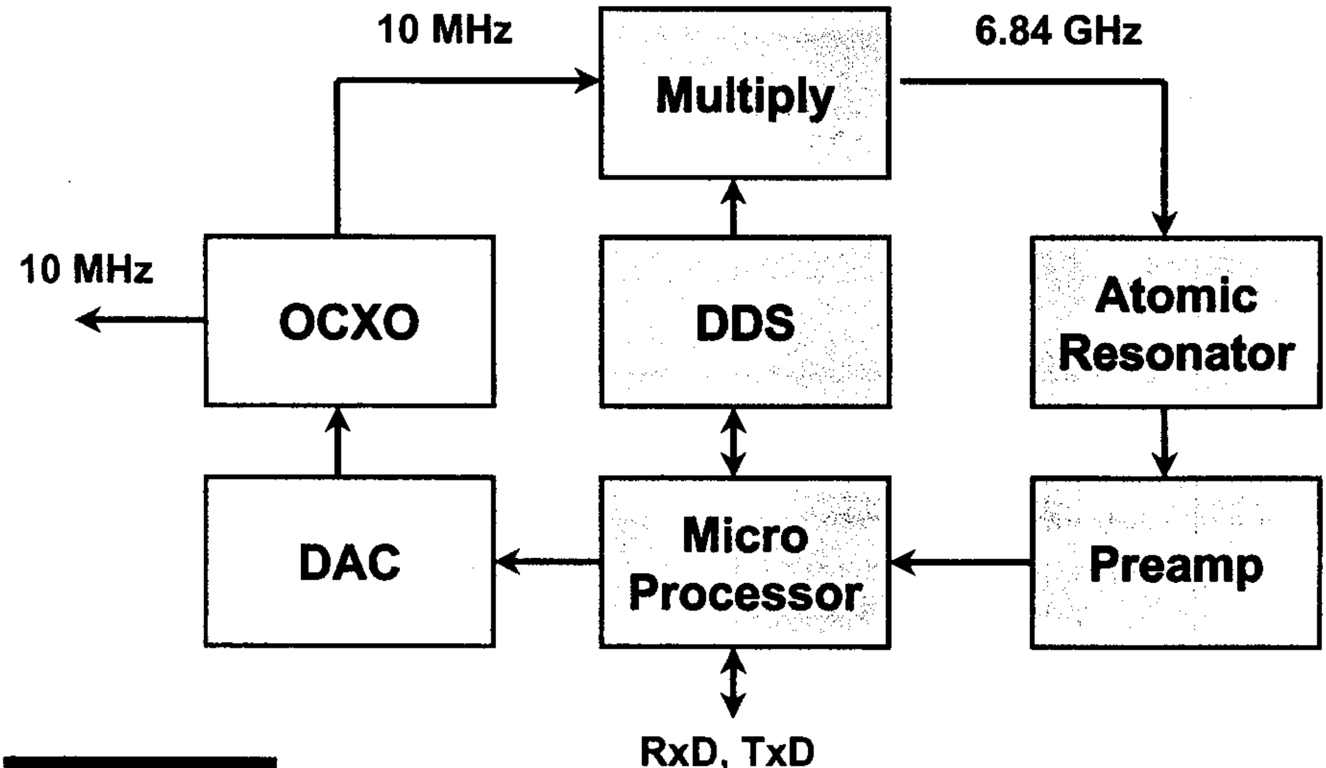
- Leading edge technology
- Innovative design (patented)
- Smart clocks



Vapour Cell Atomic Clock

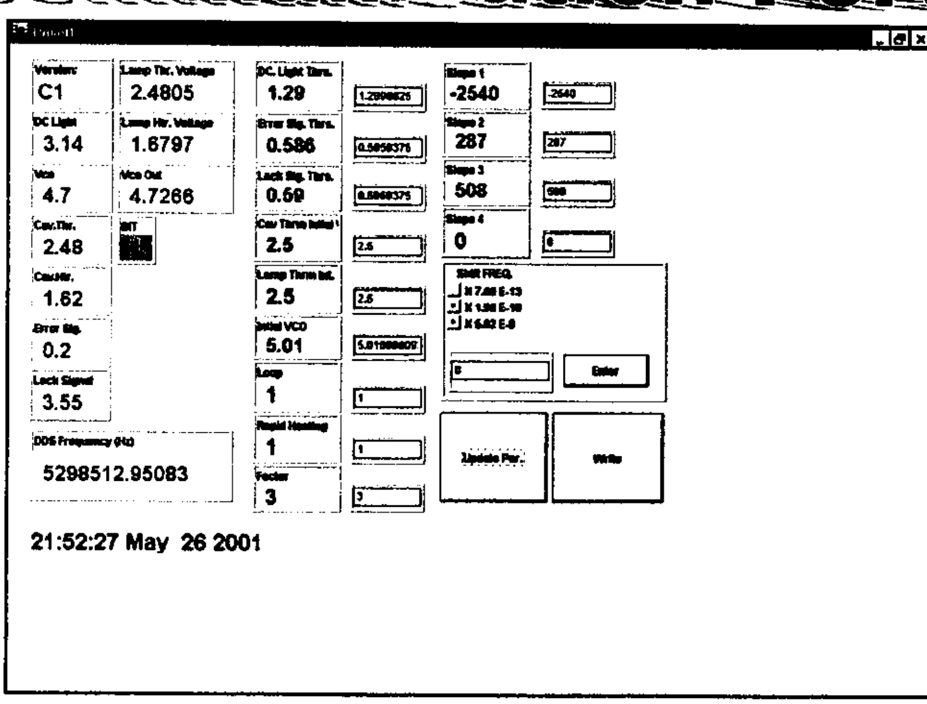


AccuBeat' Digital Loop



AR-40A 0A/100A

Communi ation Ports

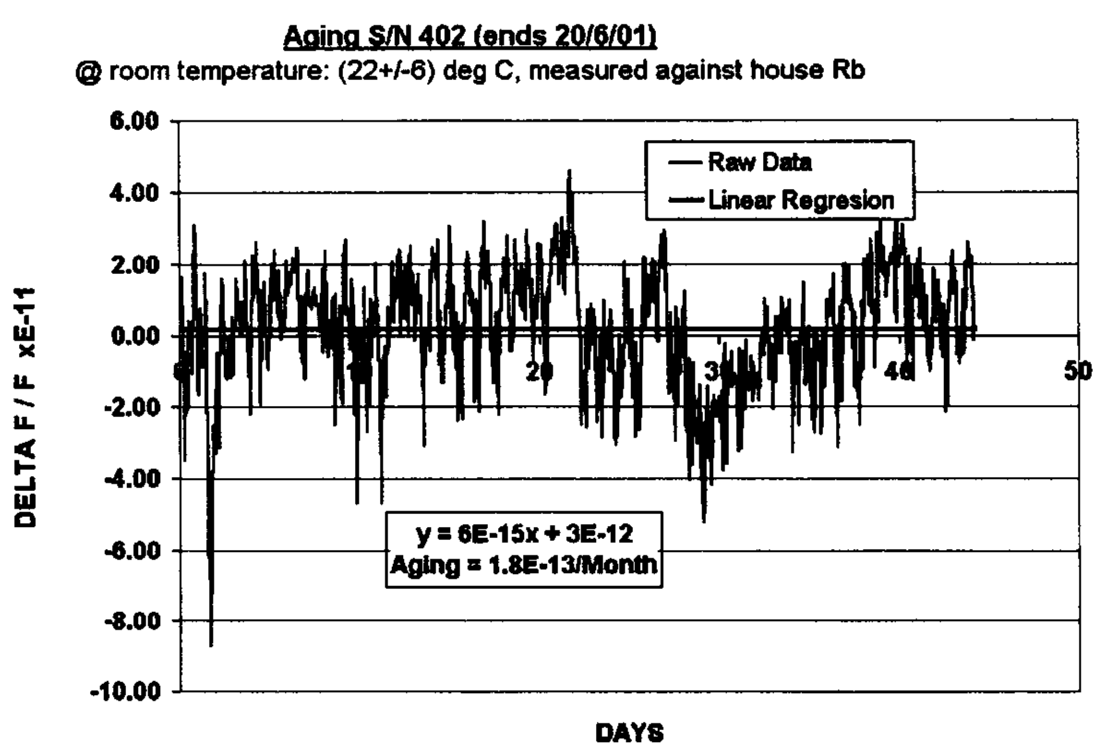


For Automated Production and Control

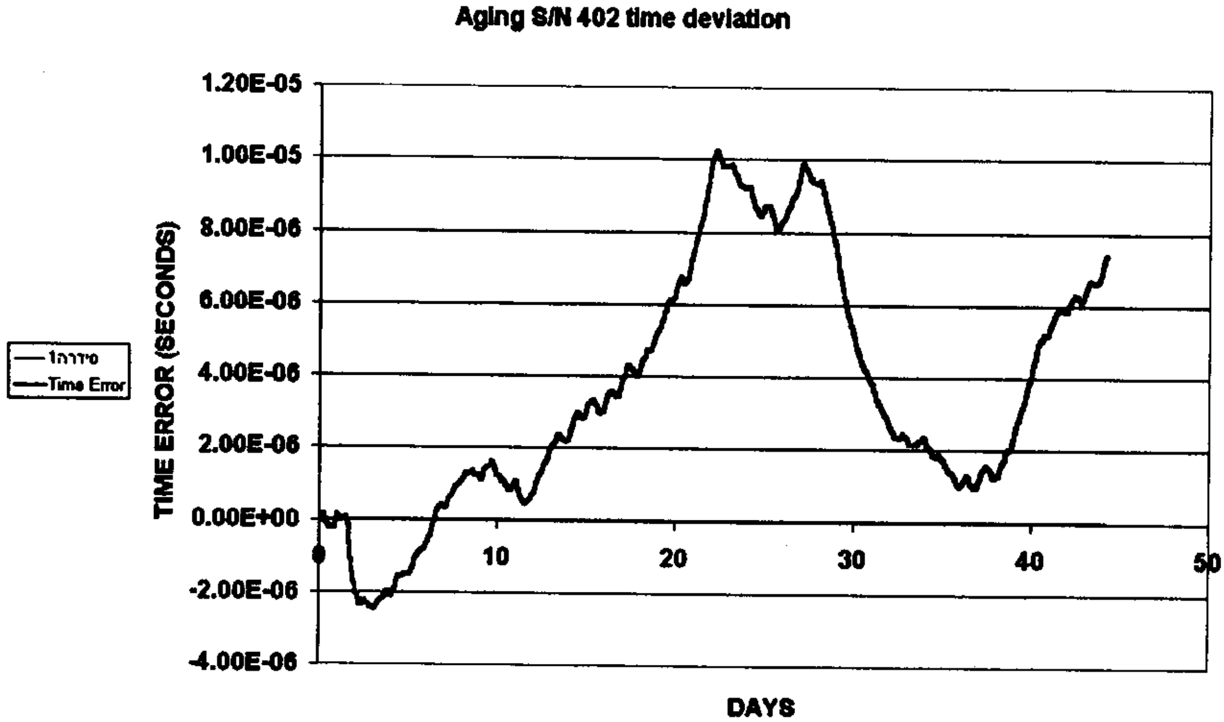
Performance Summary

Miniature Oscillators:	**0.71x3.5x3.0 inch**
Low Aging:	**2×10^{-10} / Year**
Wide Temp. Range:	**-40°C to +78°C (+85°C)**
Temp. Stability:	**5×10^{-11} / 0 to 50°C**
Low Phase Noise	**150dBc/Hz (floor)**
Digital Freq. Cntrl:	**7×10^{-13} steps**
Smart Clocks:	**Hold-Over, Noise Reduction**
High Reliability:	**>261,000 Hrs at 25°C**

Frequency Drift Example



Time Drift Example



Rubidium vs. OCXO Retrace

Rubidium:

5E-10 within 5 minutes
2E-11 within 1 hour after 1 week turn off

OCXO:

5E-8 within 30 minutes

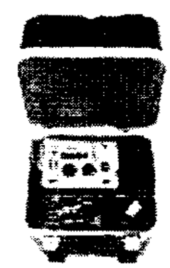
AccuBeat Ltd Accurate frequency and time

AccuBeat announces a breakthrough that enables operation of Rubidium Frequency Standard up to 85°C!

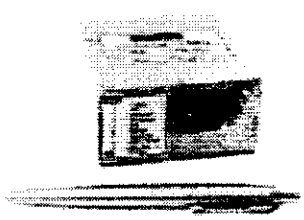
AccuBeat's Products

AR-40A
Commercial Miniature Rubidium Oscillator

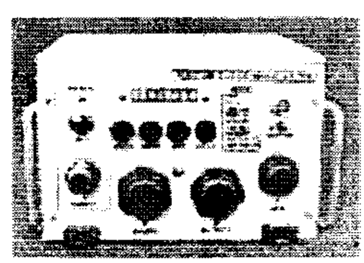
AR-50A
Portable Rubidium Clock for T&F dissemination



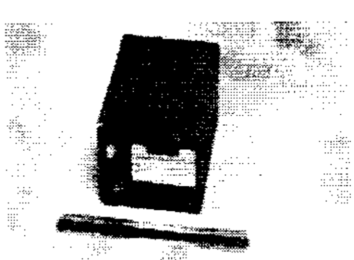
AR-60A
Industrial Small Rubidium Oscillator



AR-51A
Military Calibrated Rubidium Clock



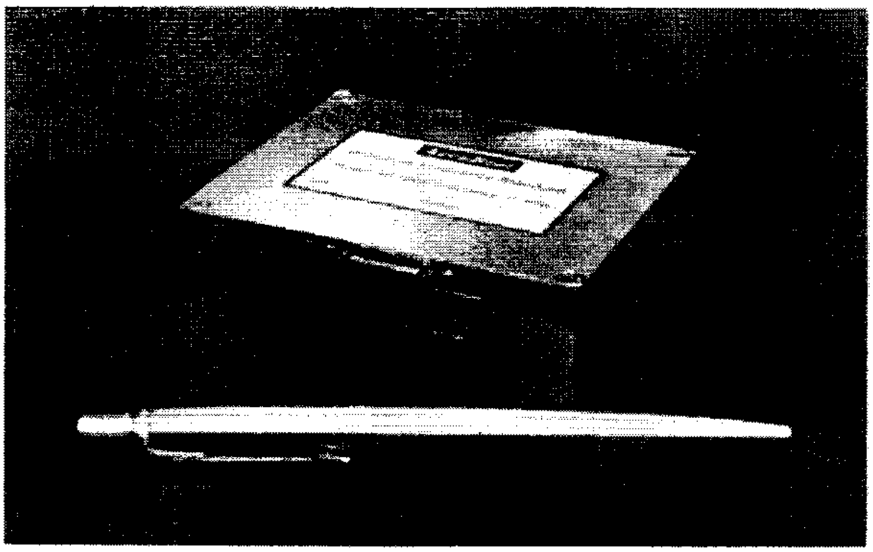
AR-61A
Military Compact Rubidium Oscillator



AR-80A
Bench mount Rubidium Clock

New Products

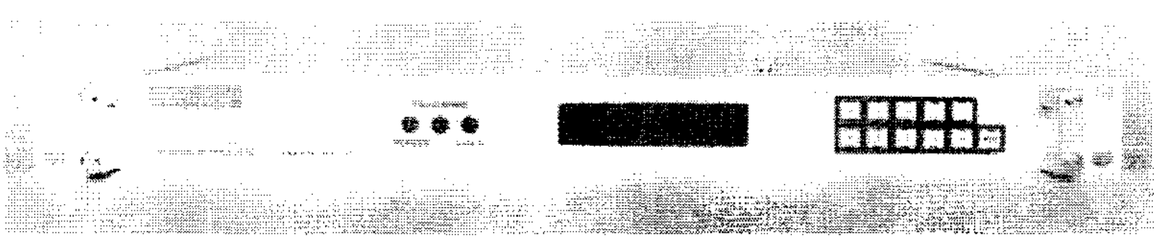
Model AR-100A
Miniature Low-Profile Rubidium



Designed for wireless applications

New Products

Model AR-73A
Rubidium-GPS Clock



Combines the long term stability of the GPS with the short/medium term stability of the Rubidium

Commercial Applications:

Present and new generation (3G) requires the Cellular Base Stations to have the same time (7 usec).

This is accomplished by Rubidium – GPS Clocks

Commercial Applications:

- Cellular Base Stations (CDMA, TDMA, GSM, W-CDMA, 3G)
- Wire line Communication
- Test Equipment
- Geo Location – 911 service
- Calibration and Scientific Labs

Commercial Applications:

- LAN: Local area networks
- WAN: Wide area networks
- Internet: Voice over IP
- TV: Cable TV, HDTV
- DBS: Direct Broadcast System
- DAR: Digital Audio Radio

Military and Space Applications

- Communication Systems, Radio & Wire
- Secure Communication
- Guidance and Control
- RADAR, IFF, EW.
- Navigation Systems
- Telemetry
- Satellites (GPS, Galileo, Glonnass)

Impacts of Oscillator Noise

- Limits the ability to determine the current state and the predictability of oscillators
- Limits syntonization and synchronization accuracy
- Limits receivers' useful dynamic range, channel spacing, and selectivity; can limit jamming resistance
- Limits radar performance (especially Doppler radar's)
- Causes timing errors [~$\tau\sigma_y(\tau)$]
- Causes bit errors in digital communication systems
- Limits number of communication system users, as noise from transmitters interfere with receivers in nearby channels
- Limits navigation accuracy
- Limits ability to lock to narrow-linewidth resonances
- Can cause loss of lock; can limit acquisition/reacquisition capability in phase-locked-loop systems

Digital Netwo Syncronization

Synchronization plays a critical role in digital telecommunication systems. It ensures that information transfer is performed with minimal buffer overflow or underflow events, i.e., with an acceptable level of "slips." Slips cause problems, e.g., missing lines in FAX transmission, clicks in voice transmission, loss of encryption key in secure voice transmission, and data retransmission.

In AT&T's network, for example, timing is distributed down a hierarchy of nodes. A timing source-receiver relationship is established between pairs of nodes containing clocks. The clocks are of four types, in four "stratum levels."

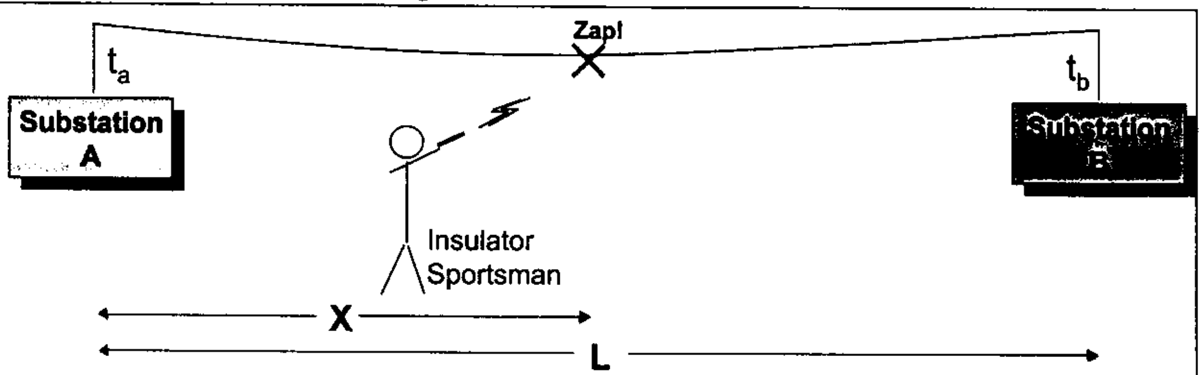
Stratum	Accuracy (Free Running) Long Term	Accuracy (Free Running) Per 1st Day	Clock Type	Number Used
1	1×10^{-11}	N.A.	GPS W/Two Rb	16
2	1.6×10^{-8}	1×10^{-10}	Rb Or OCXO	~200
3	4.6×10^{-6}	3.7×10^{-7}	OCXO Or TCXO	1000's
4	3.2×10^{-5}	N.A.	XO	~1 million

Phase Noise in PLL and PSK Systems

The phase noise of oscillators can lead to erroneous detection of phase transitions, i.e., to bit errors, when phase shift keyed (PSK) digital modulation is used. In digital communications, for example, where 8-phase PSK is used, the maximum phase tolerance is ±22.5°, of which ±7.5° is the typical allowable carrier noise contribution. Due to the statistical nature of phase deviations, if the RMS phase deviation is 1.5°, for example, the probability of exceeding the ±7.5° phase deviation is 6×10^{-7}, which can result in a bit error rate that is significant in some applications.

Shock and vibration can produce large phase deviations even in "low noise" oscillators. Moreover, when the frequency of an oscillator is multiplied by N, the phase deviations are also multiplied by N. For example, a phase deviation of 10^{-3} radian at 10 MHz becomes 1 radian at 10 GHz. Such large phase excursions can be catastrophic to the performance of systems, e.g., of those which rely on phase locked loops (PLL) or phase shift keying (PSK). Low noise, acceleration insensitive oscillators are essential in such applications.

Utility Fault Location



When a fault occurs, e.g., when a "sportsman" shoots out an insulator, a disturbance propagates down the line. The location of the fault can be determined from the differences in the times of arrival at the nearest substations:

$$x = 1/2[L - c(t_b - t_a)] = 1/2[L - c\Delta t]$$

where x = distance of the fault from substation A, L = A to B line length, c = speed of light, and t_a and t_b = time of arrival of disturbance at A and B, respectively.

Fault locator error = $x_{error} = 1/2(c\Delta t_{error})$; therefore, if $\Delta t_{error} \leq 1$ microsecond, then $x_{error} \leq 150$ meters $\leq 1/2$ of high voltage tower spacings, so, the utility company can send a repair crew directly to the tower that is nearest to the fault.

Military Requirements

Military needs are a prime driver of frequency control technology. Modern military systems require oscillators/clocks that are:

- Stable over a wide range of parameters (time, temperature, acceleration, radiation, etc.)
- Low noise
- Low power
- Small size
- Fast warmup
- Low life-cycle cost

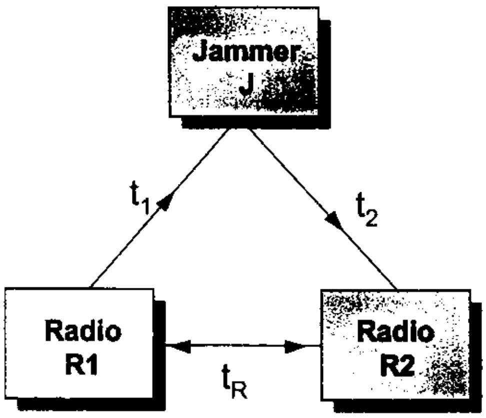
From Dr John Vig Tutorial

Spread Spectrum Systems

- In a spread spectrum system, the transmitted signal is spread over a bandwidth that is much wider than the bandwidth required to transmit the information being sent (e.g., a voice channel of a few kHz bandwidth is spread over many MHz). This is accomplished by modulating a carrier signal with the information being sent, using a wideband pseudonoise (PN) encoding signal. A spread spectrum receiver with the appropriate PN code can demodulate and extract the information being sent. Those without the PN code may completely miss the signal, or if they detect the signal, it appears to them as noise.
- Two of the spread spectrum modulation types are: 1. direct sequence, in which the carrier is modulated by a digital code sequence, and 2. frequency hopping, in which the carrier frequency jumps from frequency to frequency, within some predetermined set, the order of frequencies being determined by a code sequence.
- Transmitter and receiver contain ***clocks*** which must be synchronized; e.g., in a frequency hopping system, the transmitter and receiver must hop to the same frequency at the same time. The faster the hopping rate, the higher the jamming resistance, and the more accurate the clocks must be (see the next page for an example).
- Advantages of spread spectrum systems include the following capabilities: 1. rejection of intentional and unintentional jamming, 2. low probability of intercept (LPI), 3. selective addressing, 4. multiple access, and 5. high accuracy navigation and ranging.

From Dr John Vig Tutorial

Clock for Very Fast Frequency Hopping Radio



To defeat a "perfect" follower jammer, one needs a hop-rate given by:

$$t_m < (t_1 + t_2) - t_R$$

where $t_m \approx$ message duration/hop
$\approx$ 1/hop-rate

Example

Let R1 to R2 = 1 km, R1 to J =5 km, and J to R2 = 5 km. Then, since propagation delay =3.3 μs/km,
$t_1 = t_2 = 16.5\ \mu s$,
$t_R = 3.3\ \mu s$, and $t_m < 30\ \mu s$.
Allowed clock error $\approx 0.2\ t_m$
$\approx 6\ \mu s$.

For a 4 hour resynch interval, clock accuracy requirement is:
4×10^{-10}

Clocks and Frequency Hopping C^3 Systems

Slow hopping ‹-------------------------------›Good clock

Fast hopping ‹-------------------------------› Better clock

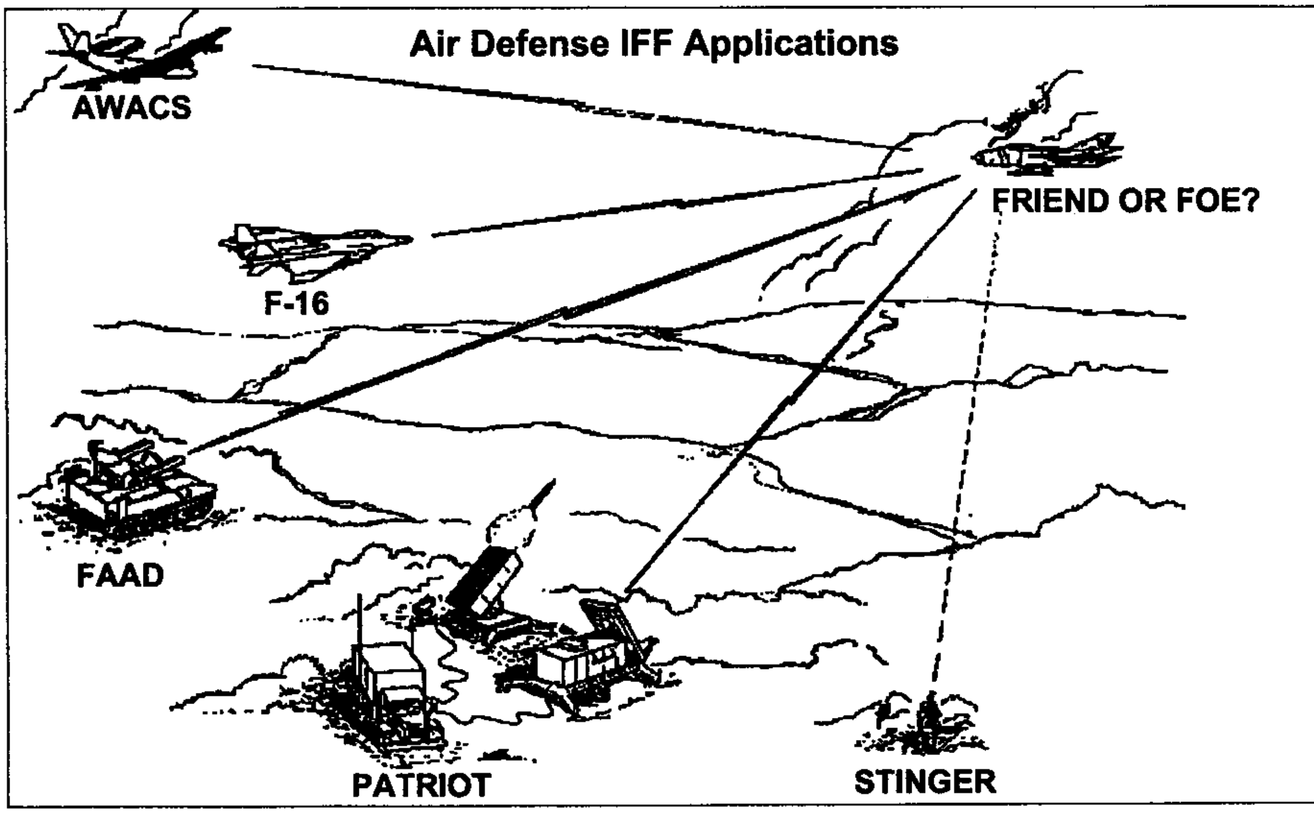
Extended radio silence ‹-----------------› Better clock

Extended calibration interval ‹----------› Better clock

Othogonality ‹-------------------------------› Better clock

Interoperability ‹----------------------------› Better clock

Identification-Friend-Or-Foe (IFF)



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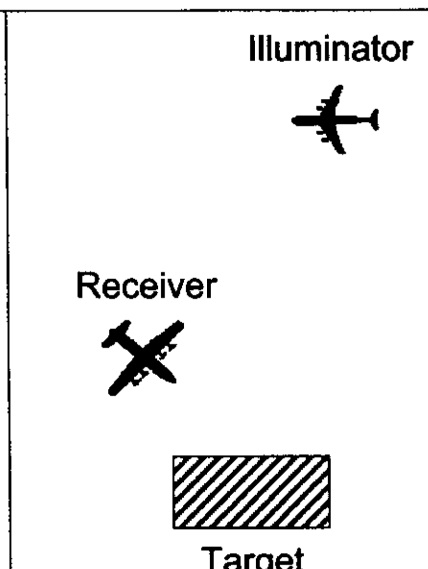
Bistatic Radar

Conventional (i.e., "monostatic") radar, in which the illuminator and receiver are on the same platform, is vulnerable to a variety of countermeasures. Bistatic radar, in which the illuminator and receiver are widely separated, can greatly reduce the vulnerability to countermeasures such as jamming and antiradiation weapons, and can increase slow moving target detection and identification capability via "clutter tuning" (receiver maneuvers so that its motion compensates for the motion of the illuminator; creates zero Doppler shift for the area being searched). The transmitter can remain far from the battle area, in a "sanctuary." The receiver can remain "quiet."

The timing and phase coherence problems can be orders of magnitude more severe in bistatic than in monostatic radar, especially when the platforms are moving. The reference oscillators must remain synchronized and syntonized during a mission so that the receiver knows when the transmitter emits each pulse, and the phase variations will be small enough to allow a satisfactory image to be formed. Low noise crystal oscillators are required for short term stability; atomic frequency standards are often required for long term stability.



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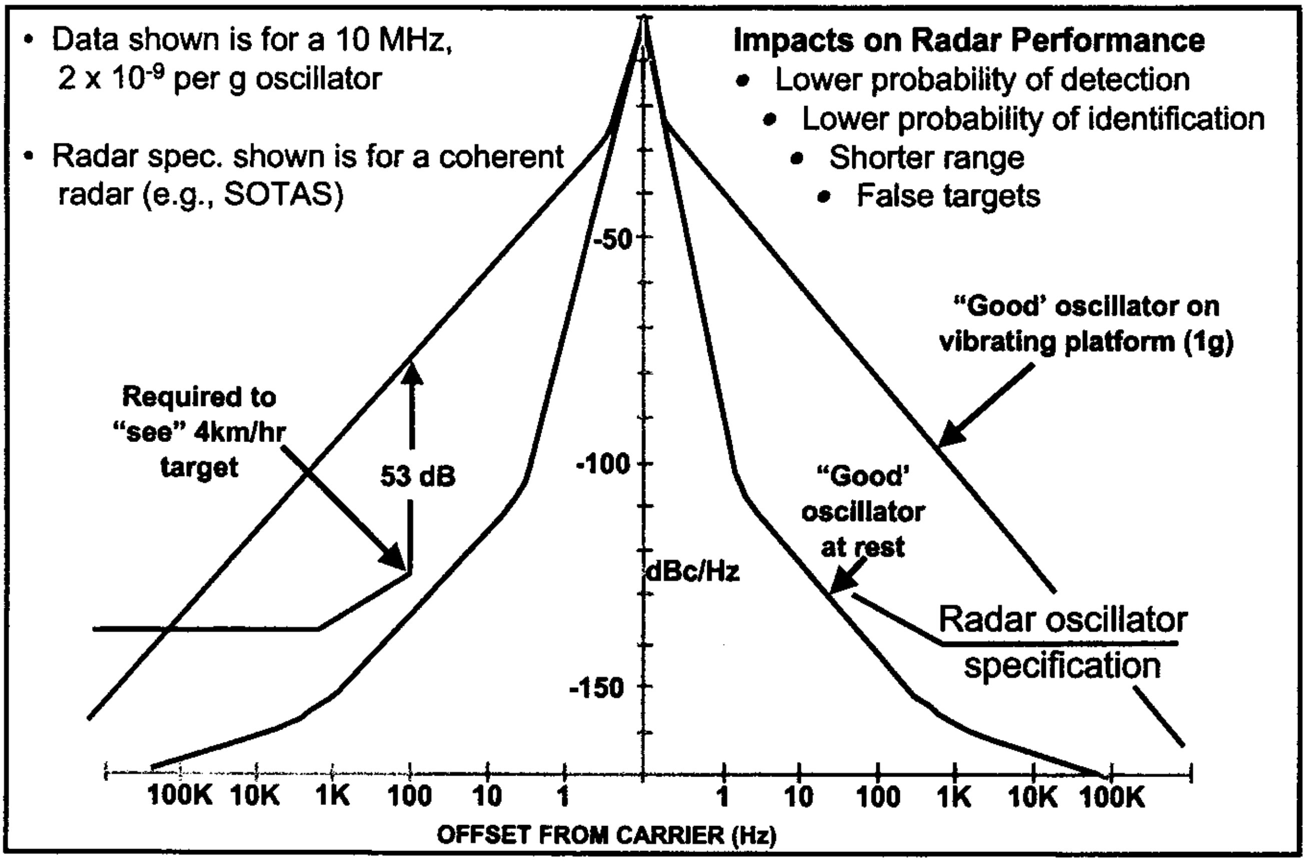
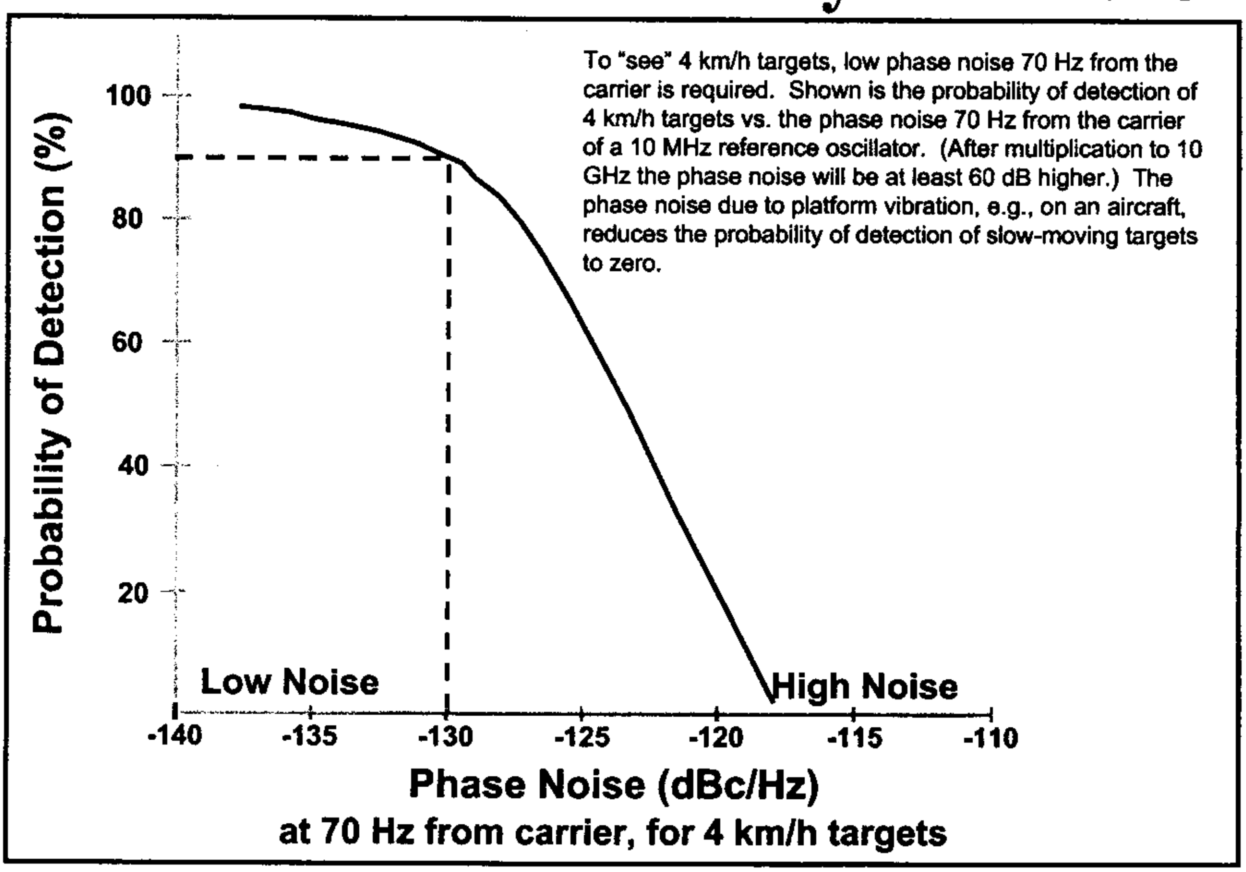
Impact of Phase Noise on Radar



Coherent Radar Probability of Detection



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