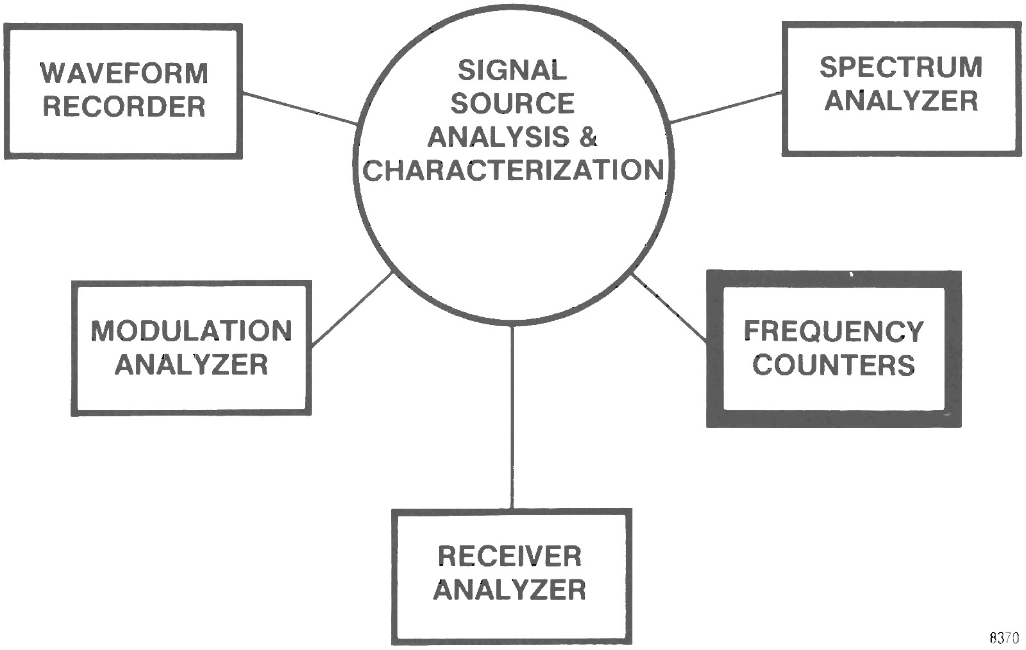
SIGNAL SOURCE CHARACTERIZATION USING LOW COST FREQUENCY AND TIME COUNTERS

Dick Schneider
Lyle Hornback

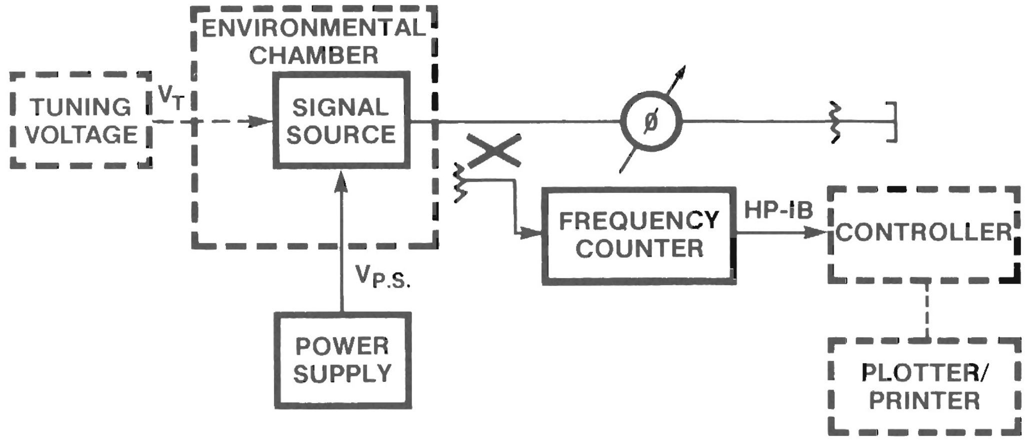


AGENDA

- Frequency drift, modulation sensitivity, pushing and pulling figure
- Center frequency for FDM signals
- Agile signals
- M-ARY FSK and frequency hop
- Tuning transients — post tuning drift and settling time
- Timing measurements — aeronautical navigation
- Communication modulation — MPSK, QPSK, BPSK
- Communication modulation transients
- Radar parameters — chirp, frequency and phase coded
- Group delay

8371

FREQUENCY DRIFT, MODULATION SENSITIVITY, AND PUSHING AND PULLING FIGURES

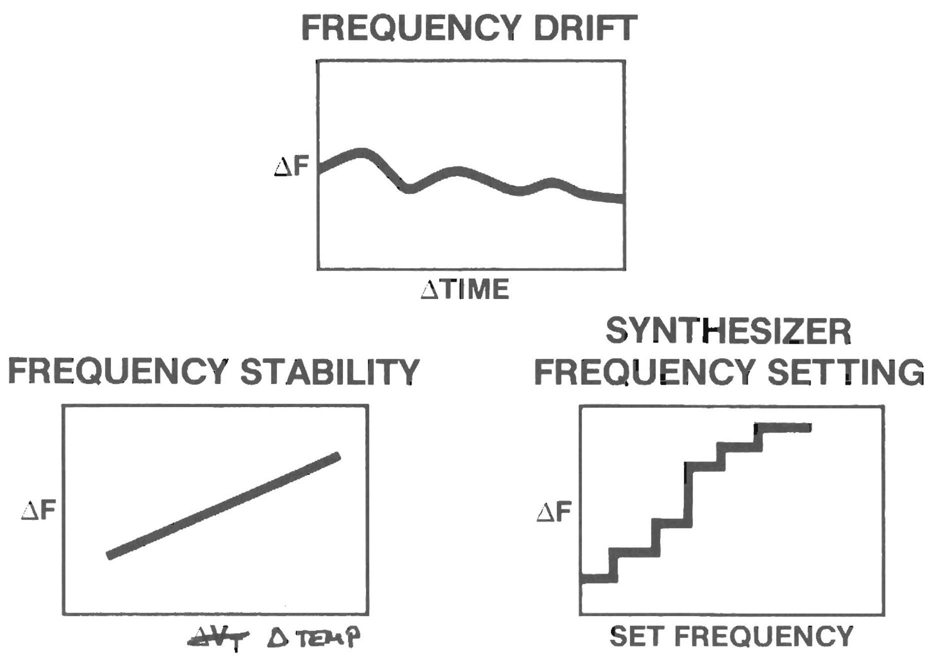


8372

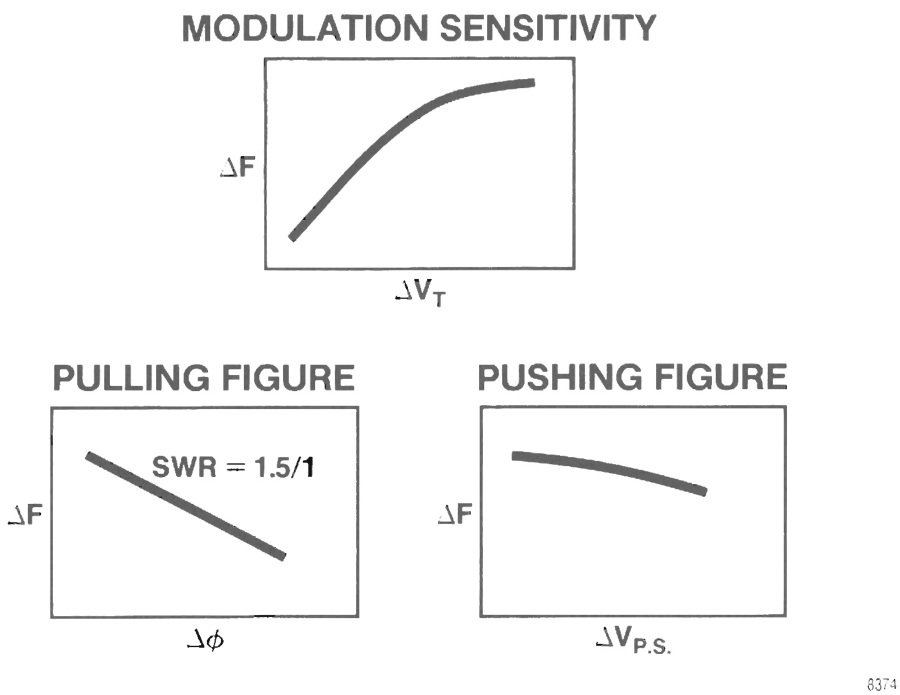
The frequency drift, stability, modulation sensitivity, pulling and pushing figures, and synthesizer frequency setting may be easily measured with a low cost frequency counter.

Modern microwave counters include a delta frequency reading where the difference between a stored reference frequency and current measurements are calculated and displayed.

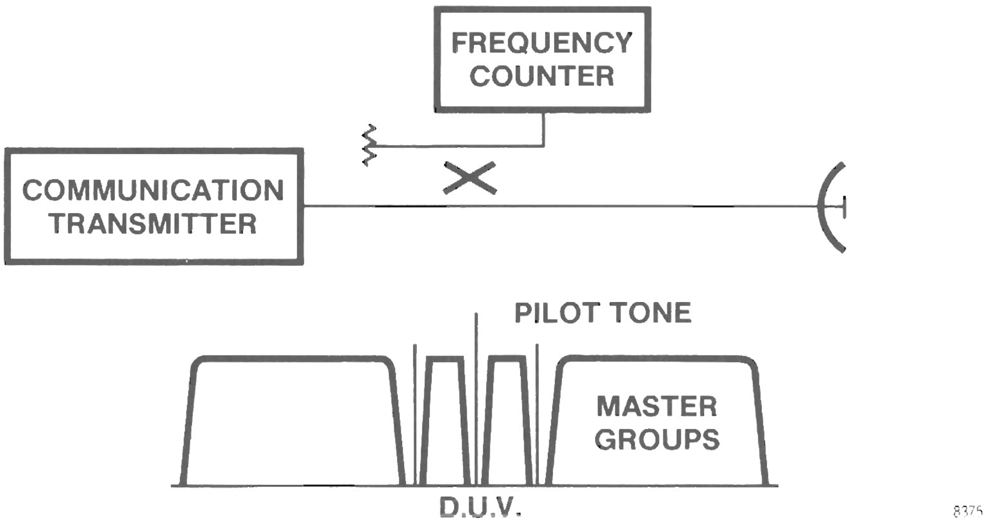
Of course data can be collected by a controller on the HP-IB for plotting or print out.



8373



CENTER FREQUENCY OF FDM COMMUNICATIONS SYSTEMS

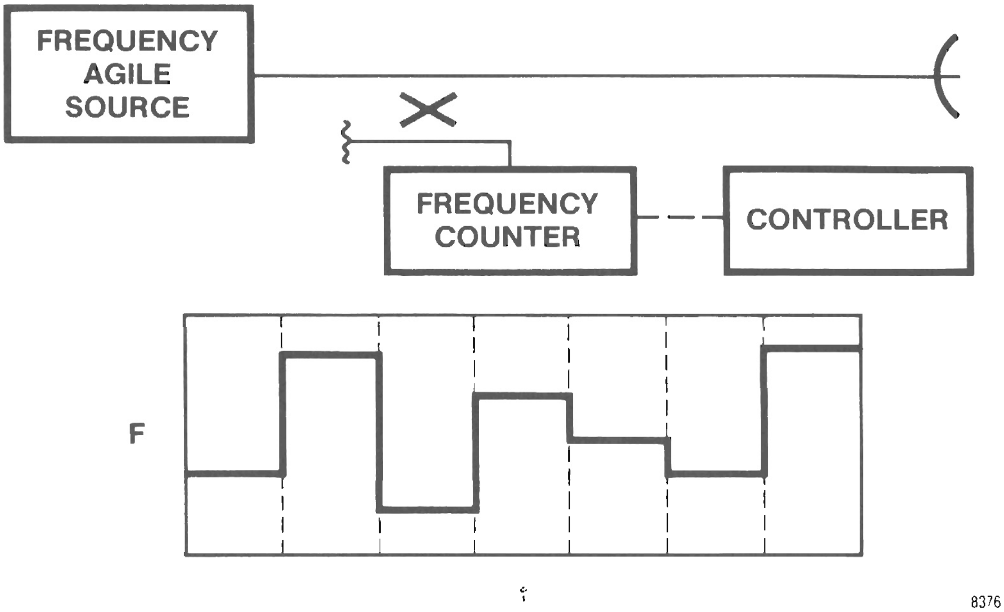


The center frequency of a microwave communications link that uses Frequency Division Multiplex (FDM) may be easily measured with a low cost frequency counter.

For example a voice channel system of three master groups (1800 channels with 3.4 kHz/channel plus bandwidth for multiplexing) requires approximately 8 MHz bandwidth. Pilot tones and Data Under Voice (DUV) may also be present in the low frequency baseband modulation.

Absolute or center frequency deviations would be monitored with the frequency counter.

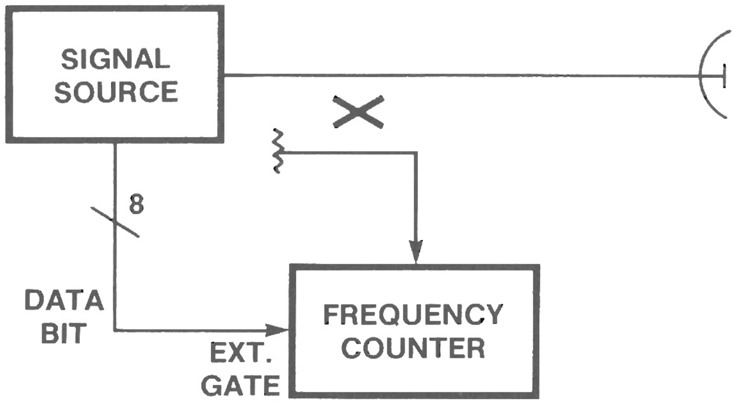
AGILE SIGNALS



Many modern transmitters (and therefore LO's and spot jammers) use frequency agility. The frequency counter's wide instantaneous bandwidth allows for up to 1200 MHz at baseband and 250 MHz deviation to 50 GHz (heterodyned).

For signal sources exceeding 250 MHz deviation the frequency counters LO can be programmed to reposition the 250 MHz window by the HP-IB in less than 100 msec.

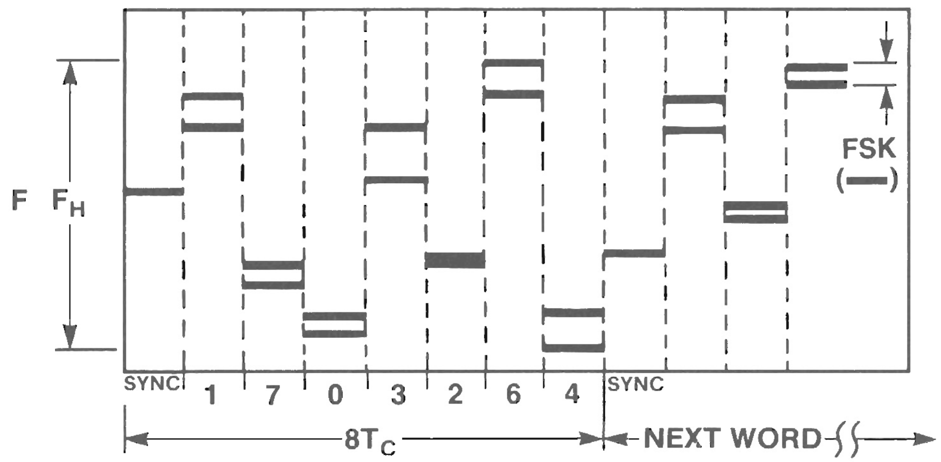
M-ARY FREQUENCY SHIFT KEYING AND FREQUENCY HOPPING



"ONE" OF 8 AND "ONE" OF HOP

8377

M-ARY FREQUENCY SHIFT KEYING AND FREQUENCY HOPPING

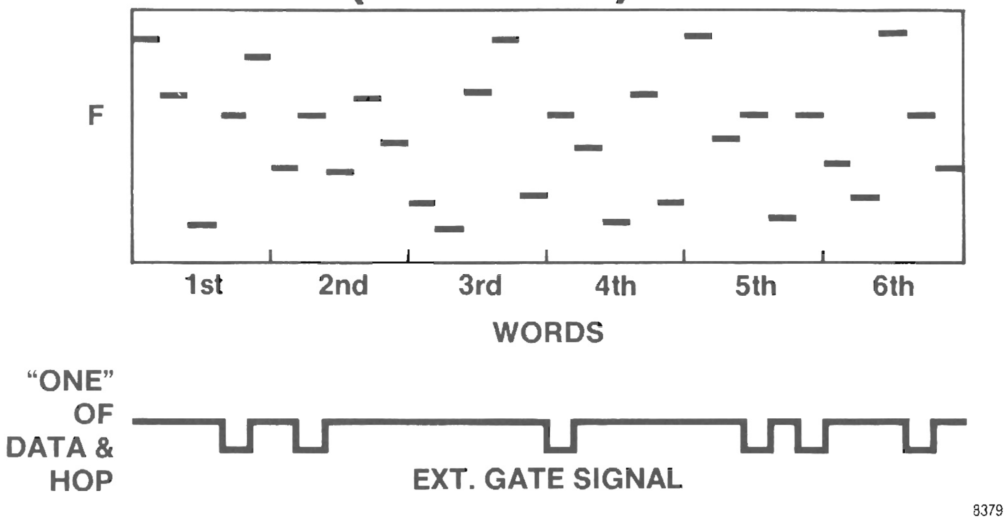


8378

M-ARY Frequency Shift Keying (MFSK) message modulation and frequency hopping diversity communication systems require the measurement of frequency during the data bit period T_C to determine proper frequency transmission according to shift keying and hopping deviations.

One shot or repetitive (to increase resolution) measurements can be made by providing the data bit to the external gate of the frequency counter. (Assuming a "one" of data and hop gate signal.)

M-ARY FREQUENCY SHIFT KEYING AND FREQUENCY HOPPING (AVERAGE)



The resolution of the measurement may be increased by averaging the counts for each "one" of data and hop events. Measurement resolution improves by $\sqrt{N}$, where N is the number of events.

For example:

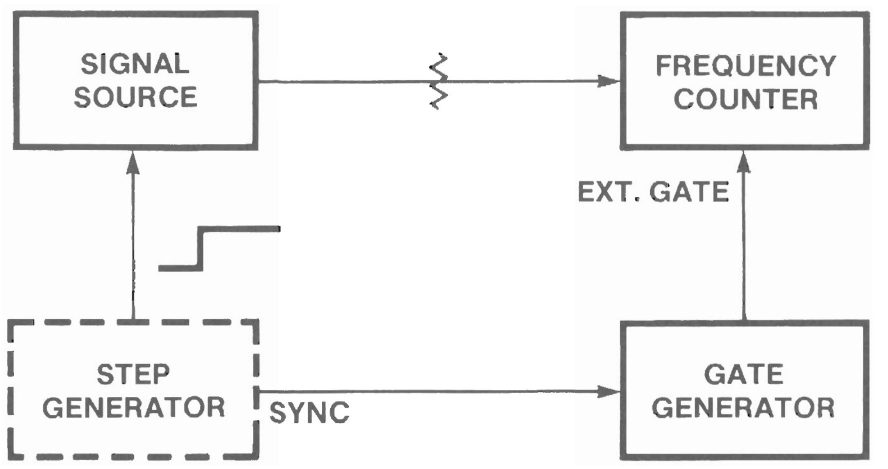
Bit width = 100 μsec
Single shot resolution = ~~100~~ 10 kHz
Counter gate time = 100 msec

$$N = \frac{100 \times 10^{-3}}{100 \times 10^{-6}} = 1000$$

Averaged Resolution = $\frac{100\ \text{kHz}}{\sqrt{1000}}$ = ~~3.16~~ 316 ~~k~~Hz

TUNING TRANSIENTS

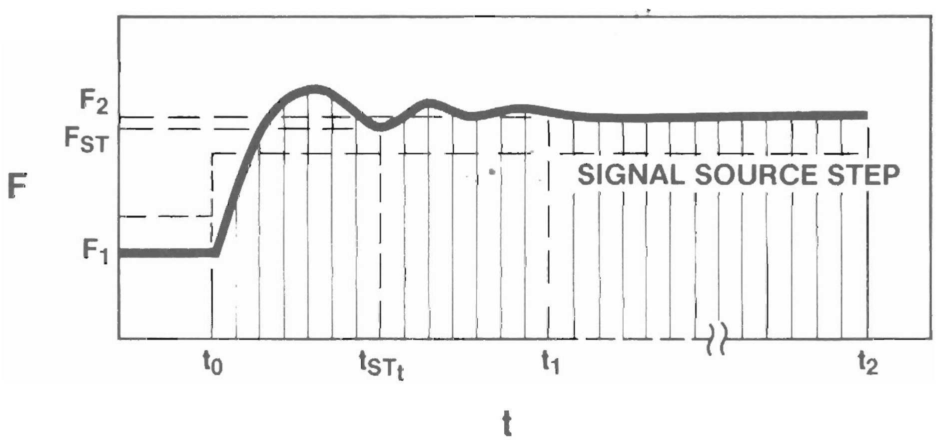
POST-TUNING DRIFT AND SETTLING TIME



8380

TUNING TRANSIENTS

POST-TUNING DRIFT AND SETTLING TIME

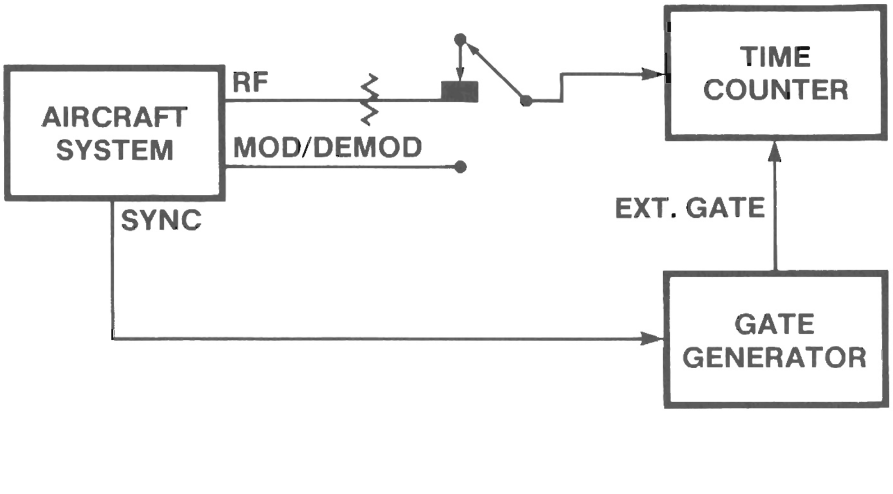


8381

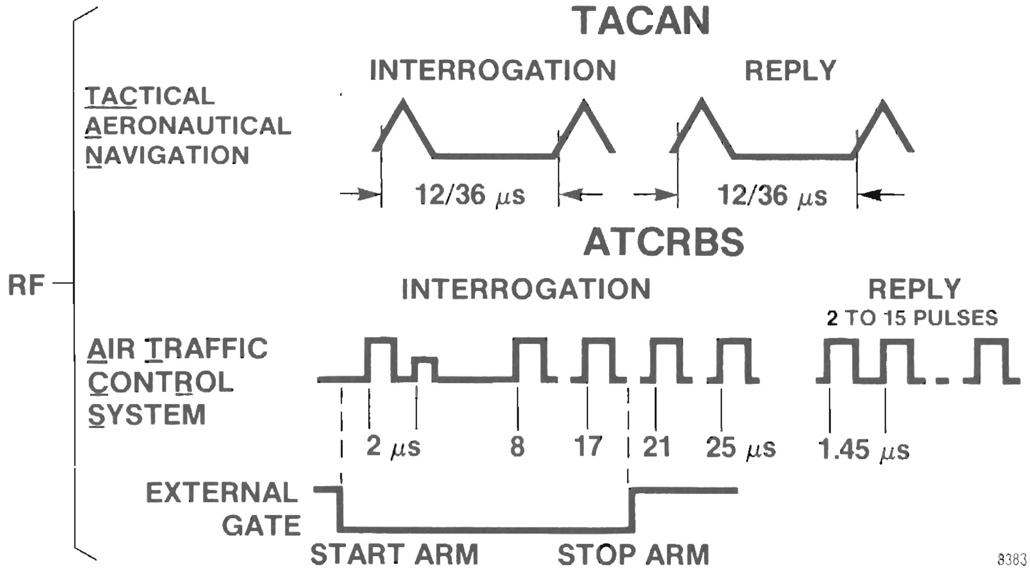
Transient measurements needed to evaluate a signal source are settling time and post-tuning drift. Post-tuning drift is the change in frequency during the time interval t_1 to t_2, where t_1 is a specified time after t_ϕ, the start of the step. Normally this measurement can be made the same as frequency drift.

A profile of the frequency transient can be made by externally gating the counter from a gate generator synchronized to the step input.

TACAN, TCAS, ATCRBS, AND DABS TIMING

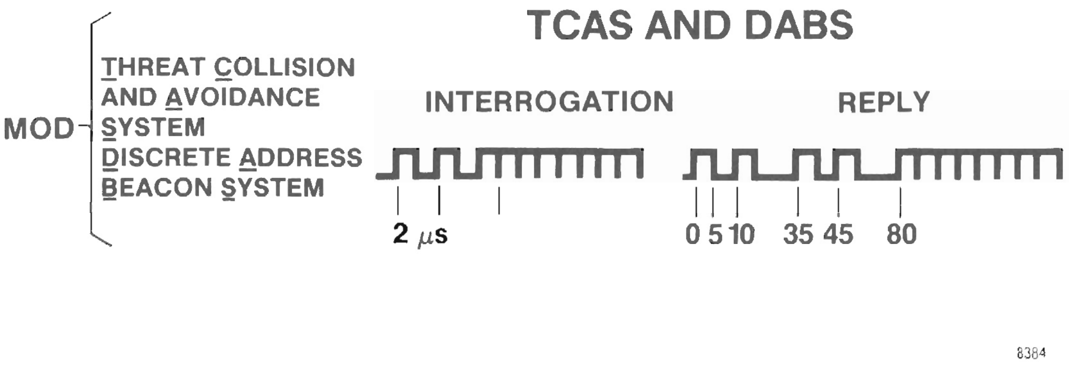


TACAN, TCAS, ATCRBS, AND DABS TIMING

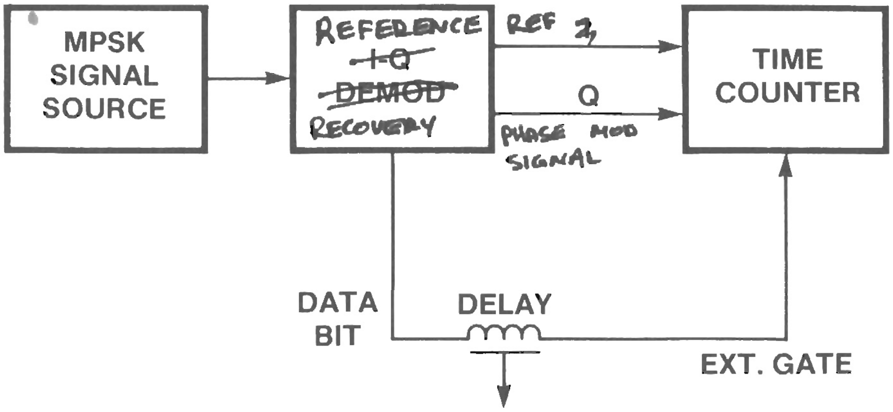


Precision time measurements may be made of complex pulse timing by externally gating the time counter. For example, the 21 µsec delay of the ATCRBS interrogation signal can be measured if the external gate signal is applied as shown.

TACAN, TCAS, ATCRBS, AND DABS TIMING

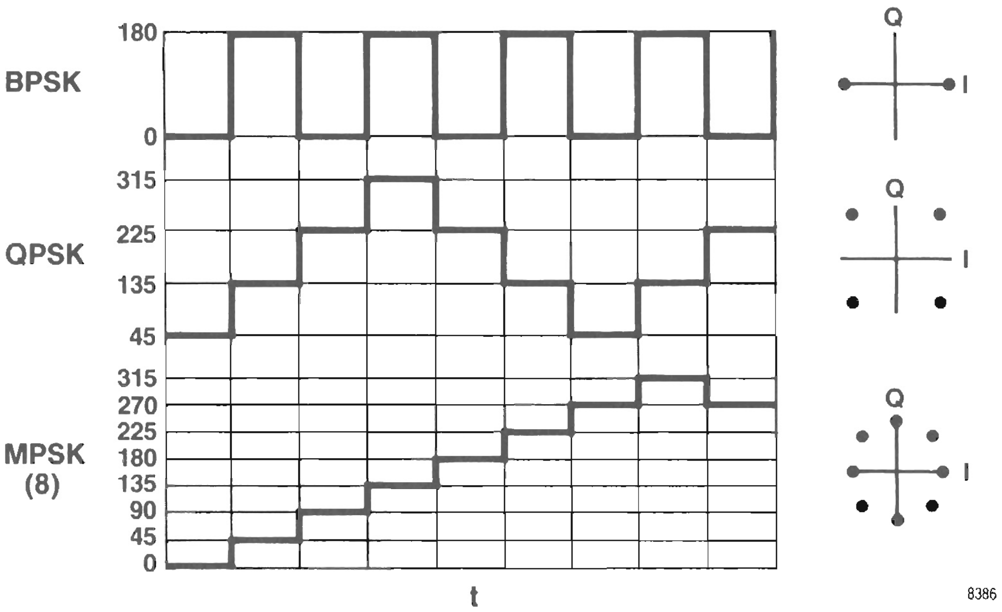


MPSK DIGITAL PHASE MODULATION



8385

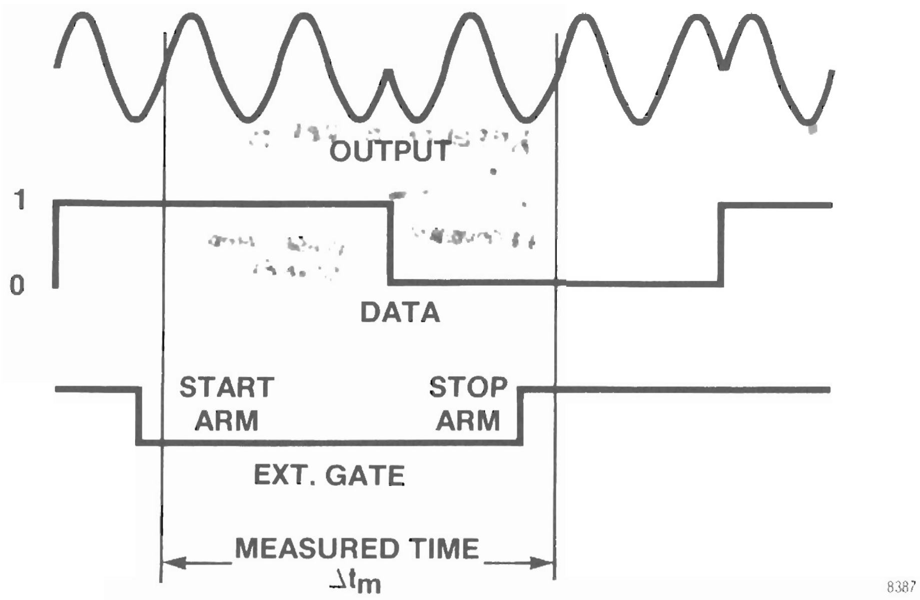
DIGITAL PHASE MODULATION



8386

Since $\frac{\Delta\theta}{\theta} = \frac{\Delta t}{T}$ time interval measurements can be made of the I-Q signals to determine the phase modulation of the source. I-Q demodulation techniques are described in another symposium paper or these signals may be available from the digital radio under test.

BPSK EXAMPLE



$$\Delta t_m = \frac{180}{360} \times T + NT$$

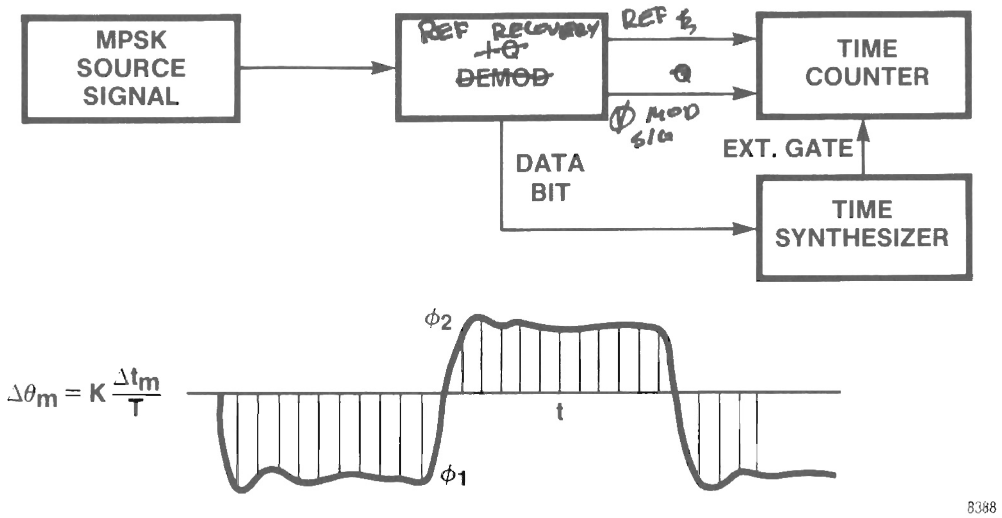
where T = period of the IF signal and N is the integer number of periods between start and stop arm.

For example:

IF = 20 MHz, T = 50 nsec
N = 3, 2 cycles data bit 1, 1 cycle data bit 0

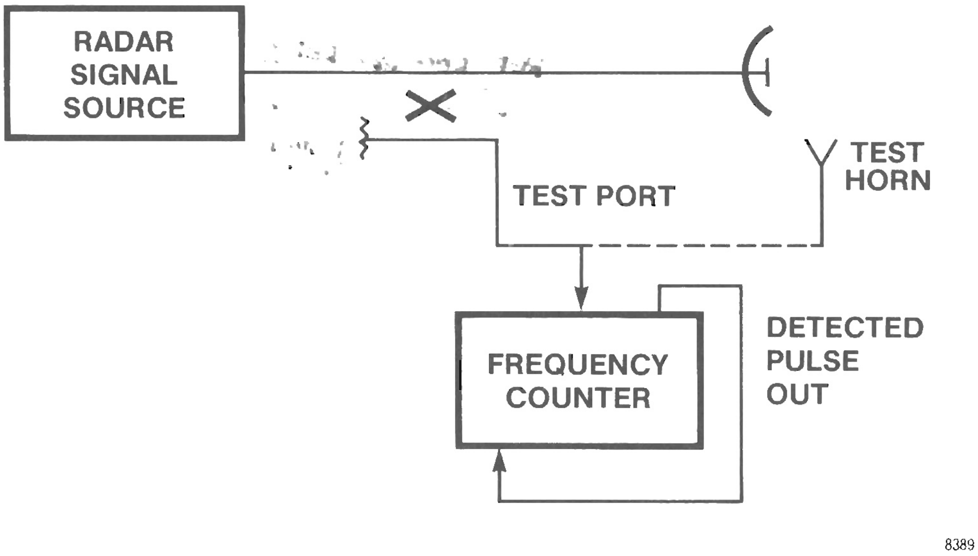
$1 \rightarrow 0 \ \Delta t_m = 1/2 \times 50 + 3 \times 50 = 175$ nsec

MPSK DIGITAL PHASE MODULATION TRANSIENTS

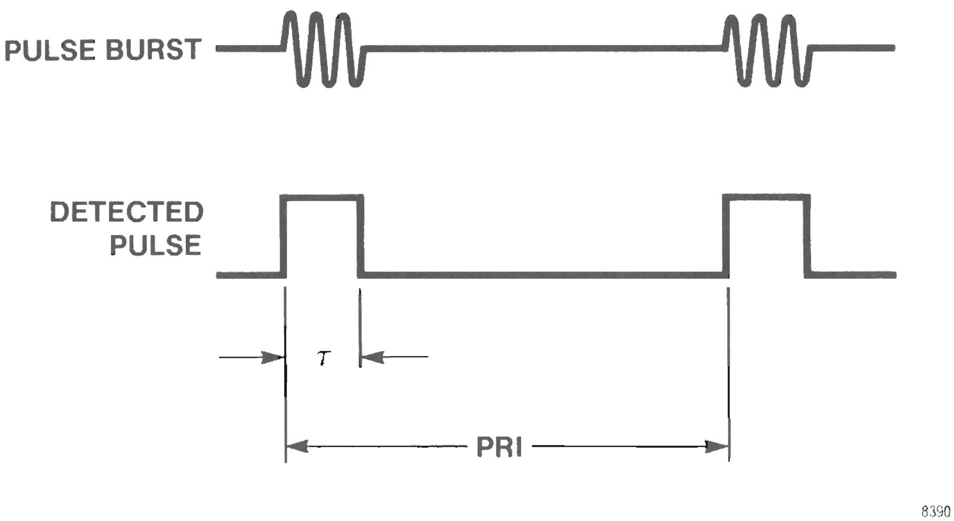


By gating the time counter with successive gate widths the time interval transient can be profiled in the same manner the step tuning transient or chirp pulse was measured.

RADAR PARAMETERS

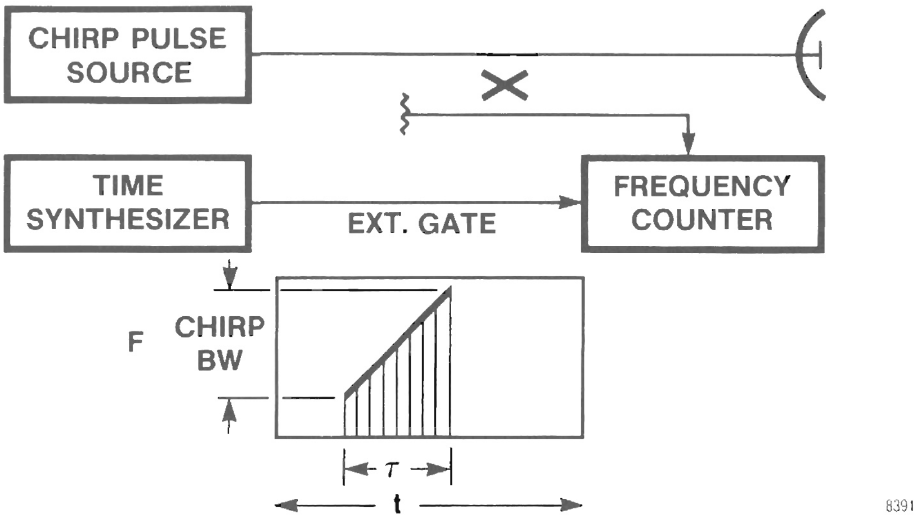


RADAR PARAMETERS



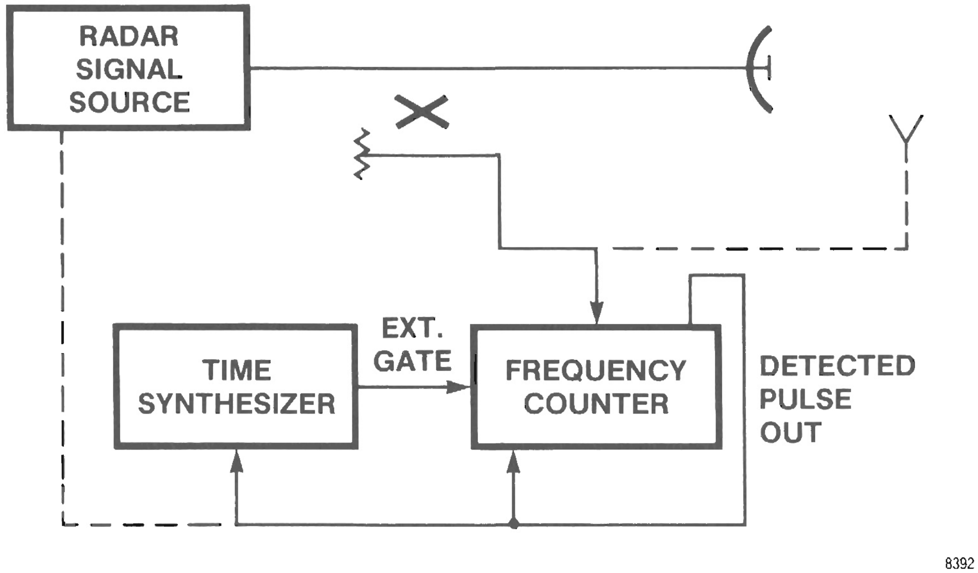
Modern microwave frequency and time counters measure the pulse burst frequency, the pulse width, and PRI or PRF of radar signals.

CHIRP PULSE FREQUENCY PROFILING

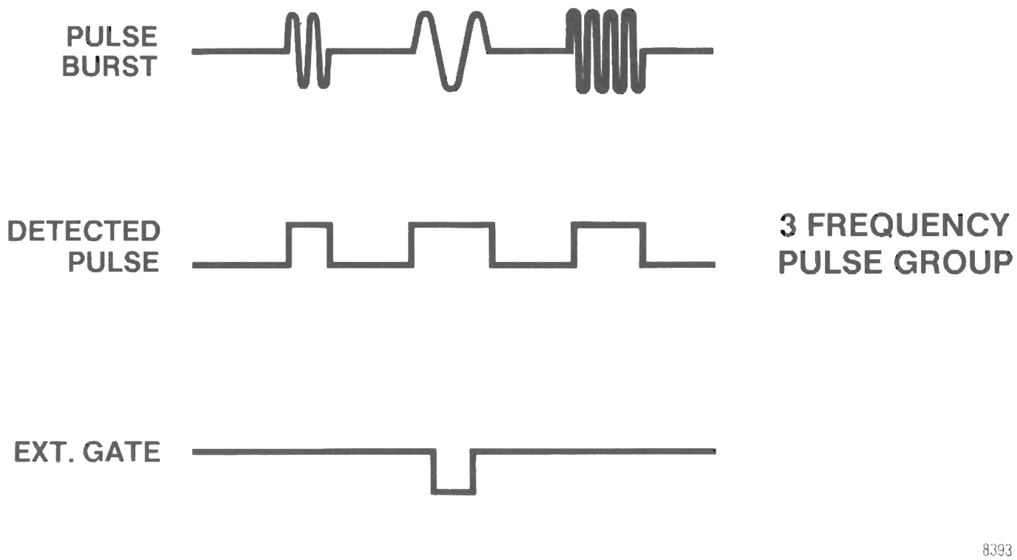


A radar chirp pulse frequency measurement is made by moving an external gating signal successively across the chirp pulse width. For chirp radar applications the modulation accuracy is paramount, while doppler radars require minimal FM on the burst.

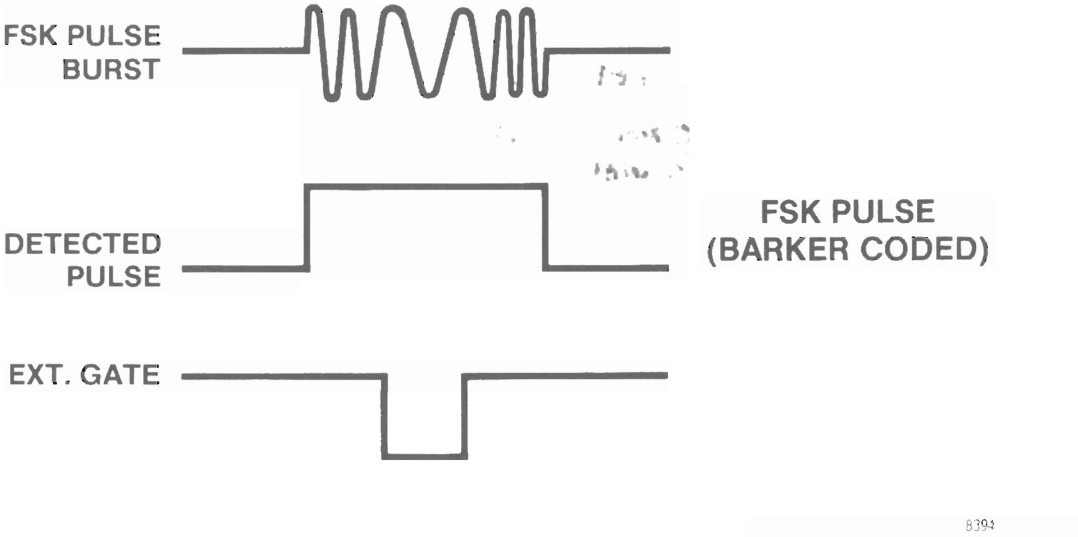
FREQUENCY CODED RADAR



FREQUENCY CODED RADAR

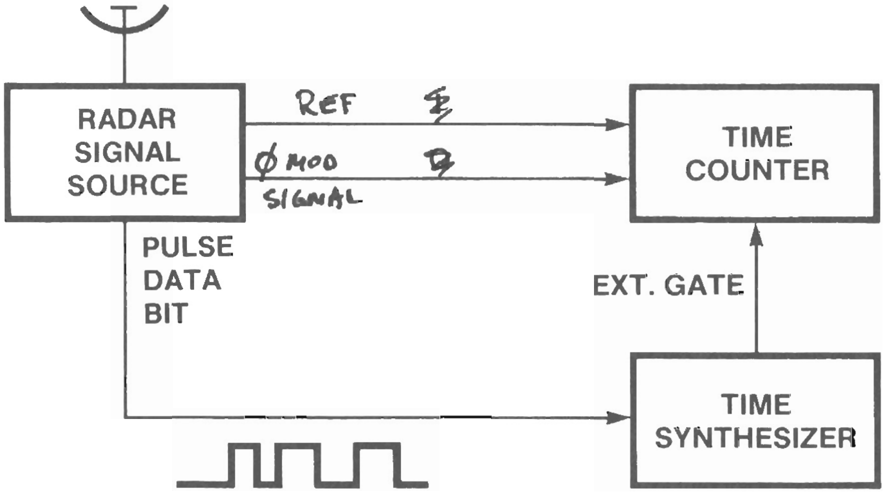


FREQUENCY CODED RADAR



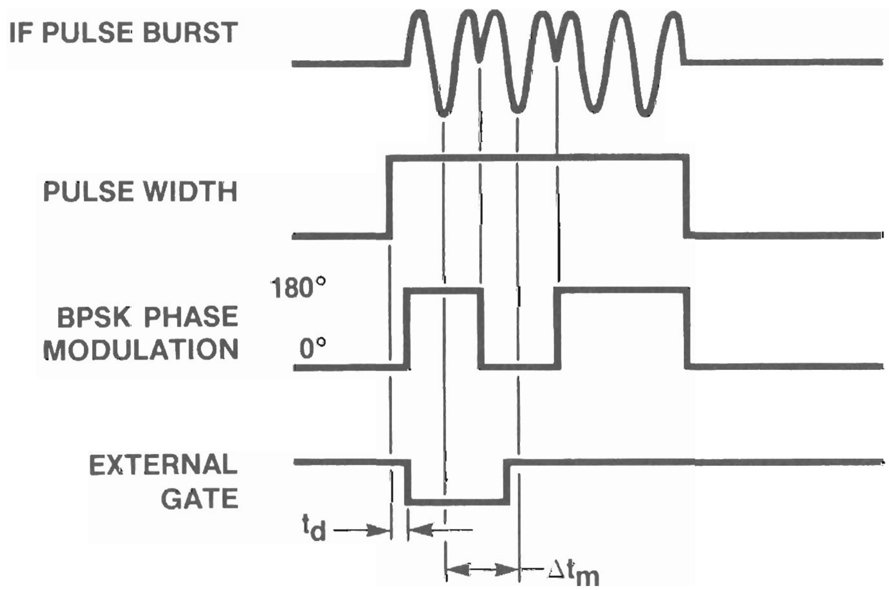
By positioning an external gate to the region of interest, the pulse frequency from the group, or the FSK pulse frequency modulation can be measured.

PHASE CODED RADAR



8395

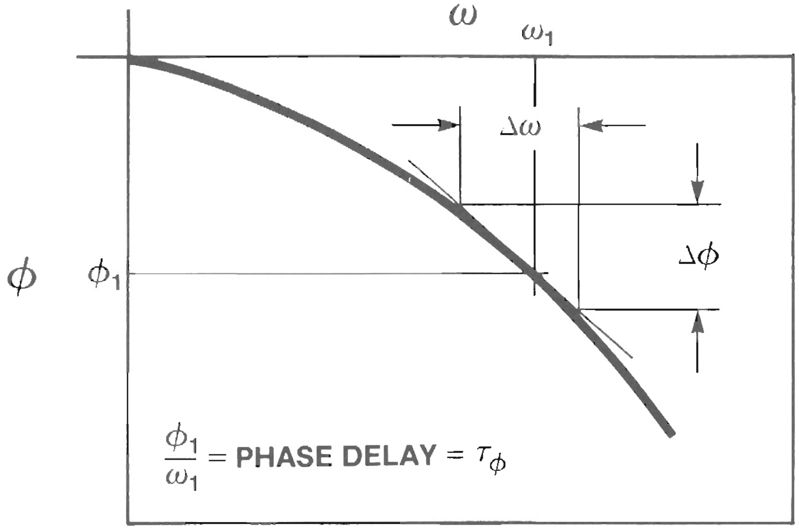
PHASE CODED RADAR



8396

By arming the time interval measurement of the counter, in the same manner as for MPSK signals, the phase coded modulation can be measured. Varying the time delay from the start of the pulse and external gate width would enable demodulation analysis of the phase coded radar

GROUP DELAY



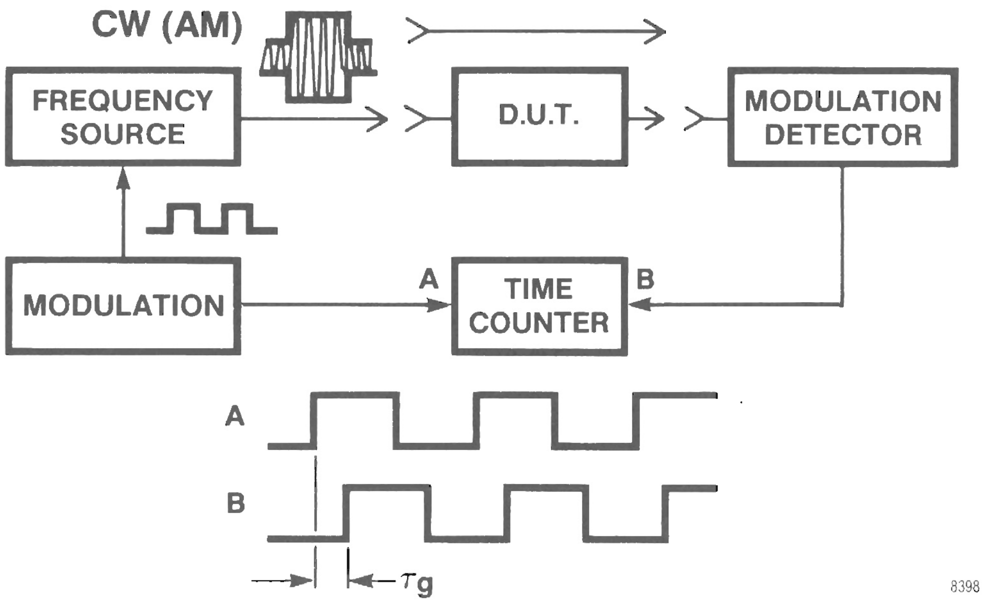
GROUP DELAY = $\tau_g = \frac{-d\phi}{d\omega} \cong \frac{-\Delta\phi}{\Delta\omega}$

8397

Group delay τ_g is proportional to the rate of change of phase shift with frequency fω

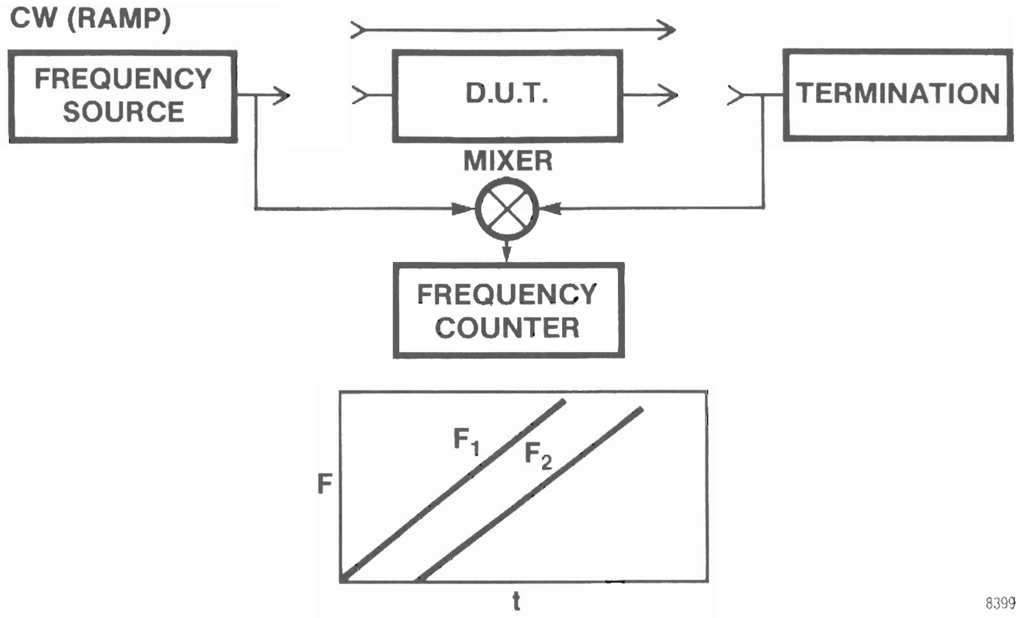
$$\tau_g = \frac{-\,d\phi}{d\omega} \cong \frac{-\,\Delta\phi}{\Delta\omega}$$

GROUP DELAY



8398

GROUP DELAY



8399

$F_1 = kt$

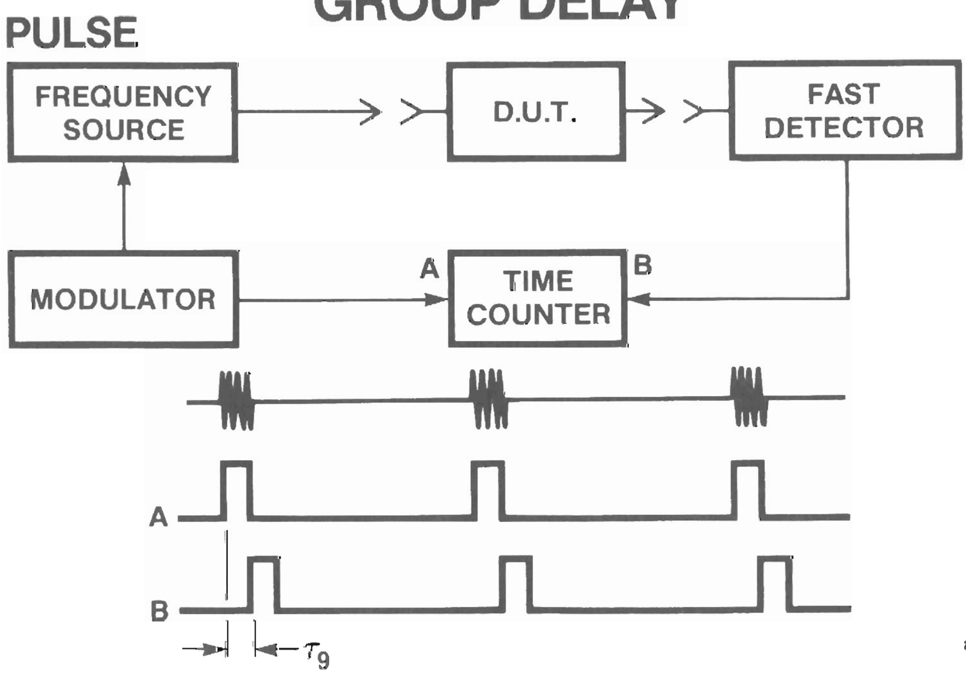
$F_2 = k(t + \tau_\phi)$

$F_1\text{-}F_2 = k\,\tau_\phi = k\,\dfrac{\phi_1}{\omega_1}$

$\tau_g \cong \dfrac{\Delta\phi}{\Delta\omega} \cong \dfrac{\Delta\,(F_1\text{-}F_2)}{k}$ for short gate times

---

GROUP DELAY



8400

HEWLETT PACKARD

DATA SUBJECT TO CHANGE

PRINTED IN U.S.A.