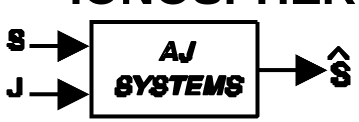
GPS SIGNAL STRUCTURE

GPS SIGNAL PARAMETERS

PARAMETER	C/A SIGNAL	P SIGNAL
CODE CLOCK RATE - R_C	1.023 MCHIPS/SEC	10.23 MCHIPS/SEC
CODE LENGTH	1023 CHIPS (1 ms)	» 6 TRILLION CHIPS (1 WEEK)
DATA RATE	50 BITS/SEC	50 BITS/SEC
TRANSMISSION FREQUENCY	L1 = 1575.42 MHz = 1540 R_C	L1 = 1575.42 MHz = 154 R_C L2 = 1227.6 MHz = 120 R_C

DATA INCLUDES

- TELEMETRY
- SYNCHRONIZATION INFORMATION (PREAMBLE, TIME)
- SATELLITE CLOCK AND EPHEMERIS PARAMETERS
- ALMANACS
- IONOSPHERIC DELAY AND UTC TIME MODELS



MATHEMATICAL SIGNAL REPRESENTATION

- $s_{L1}(t) = AP(t)D(t)\cos\left(2\pi f_1 t + \phi_{01}\right) + \sqrt{2}AC(t)D(t)\sin\left(2\pi f_1 t + \phi_{01}\right)$
- $s_{L2}(t) = \frac{A}{\sqrt{2}} P(t)D(t)\cos\left(2\pi f_2 t + \phi_{02}\right)$

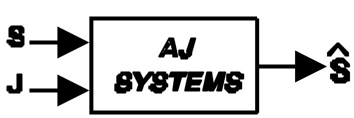
- A **= L1 P SIGNAL AMPLITUDE**

- $P(t)$ **AND** $C(t)$ **= ±1 P AND C/A CODE PRN SEQUENCES**

- $D(t)$ **= ±1 MESSAGE DATA BIT SEQUENCE**

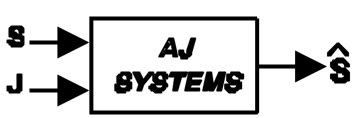
- f_1 **AND** f_2 **= L1 AND L2 CARRIER FREQUENCIES**

- ϕ_{01} **AND** ϕ_{02} **= AMBIGUOUS L1 AND L2 CARRIER PHASES**

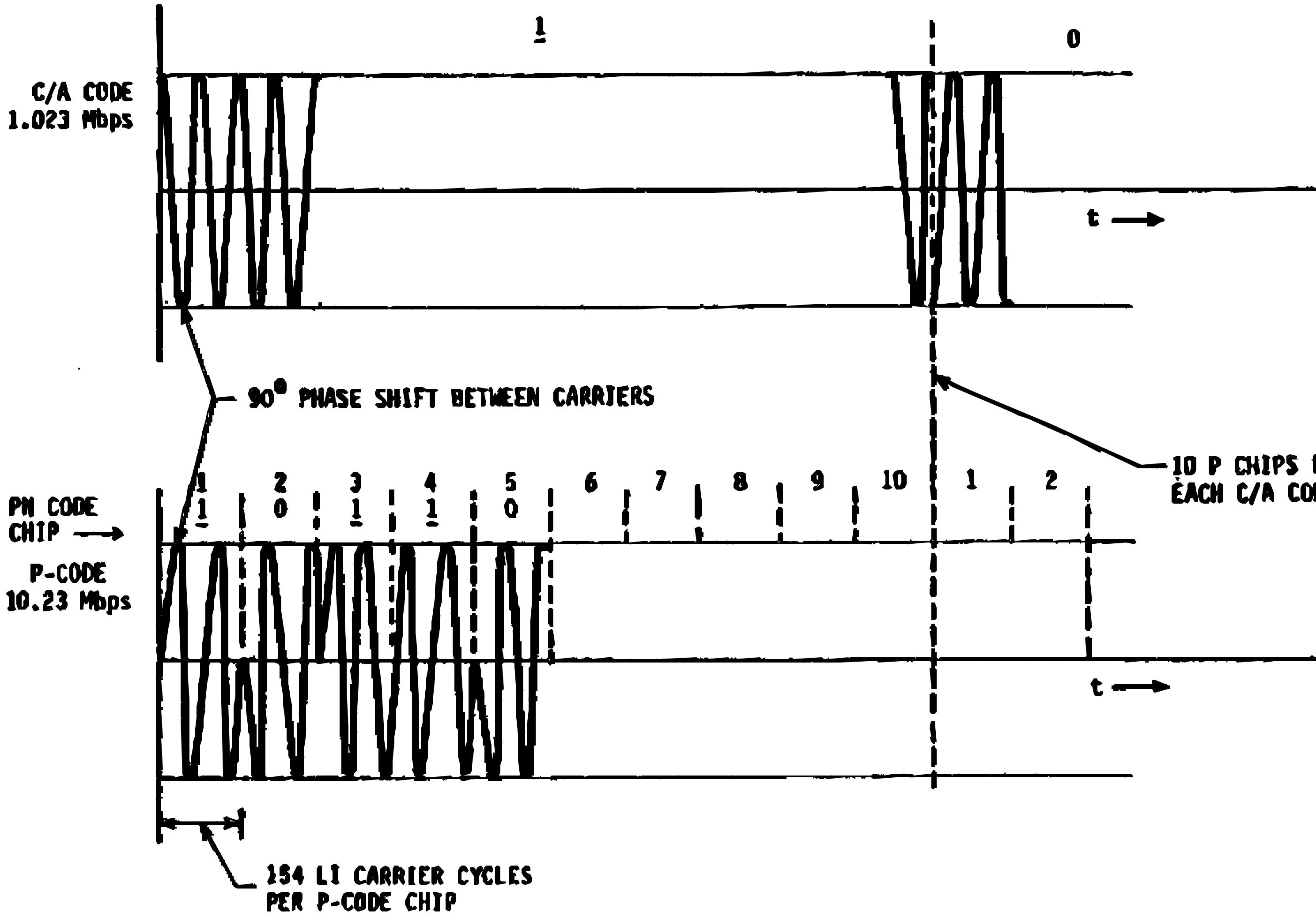


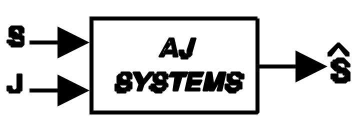
PRN CODES

- $C_i(t) = G1(t)G2(t + n_i T_c)$
- $P_i(t) = X1(t)X2[t + (i-1)T_p]$
  - FOR SATELLITE i
  - n_i = INTEGER [1 TO 1023] ASSIGNED TO SATELLITE i FOR C/A CODE
  - i TAKES ON INTEGER VALUES BETWEEN 1 AND 37 FOR P CODE
- **T_c = C/A CODE CHIP WIDTH = 1/1.023 $\times 10^6$ SECONDS**
- **T_p = P CODE CHIP WIDTH = 1/10.23 $\times 10^6$ SECONDS**



GPS SIGNAL WAVEFORM - L1 CHANNEL





GPS SIGNAL RECEIVED POWER

L1 FREQUENCY (1575.42 MHz)

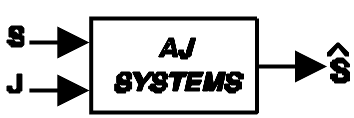
- **C/A CODE: -160 dBW (10^{-16} WATTS)***
- **P CODE: -163 dBW (5×10^{-17} WATTS)***

L2 FREQUENCY (1227.6 MHz)

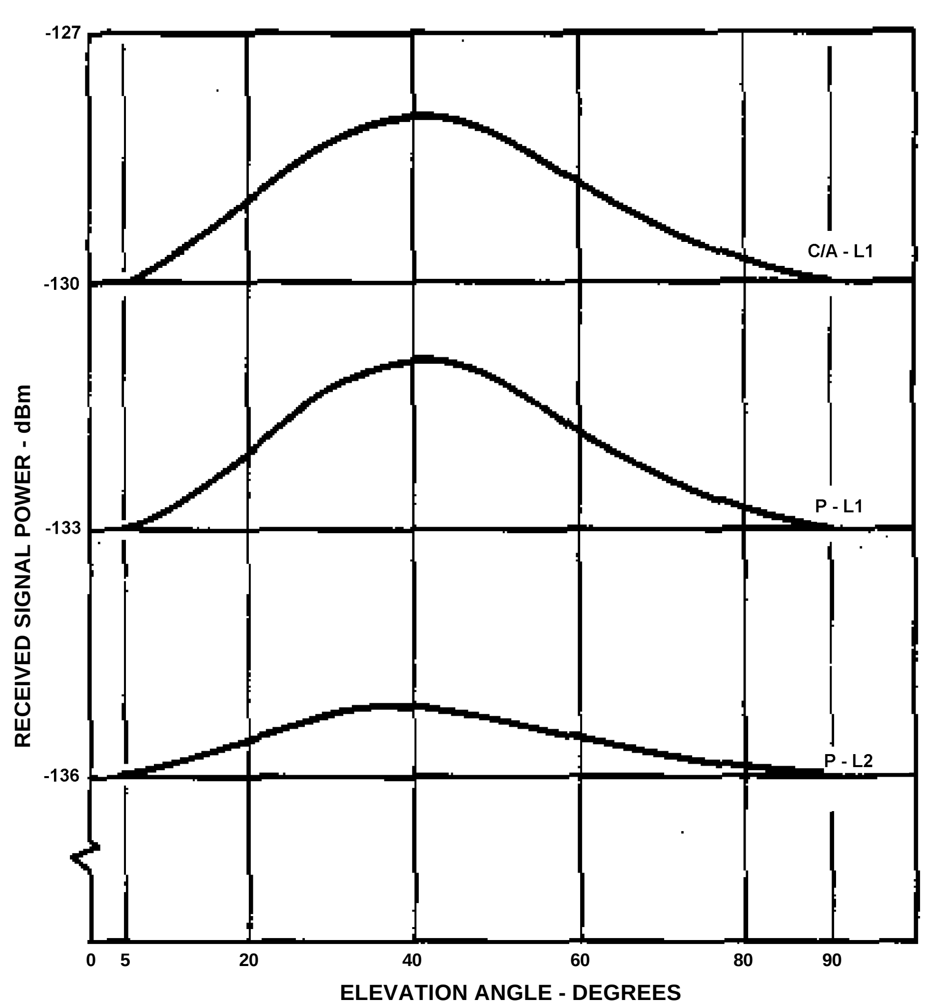
- **P CODE: -166 dBW (2.5×10^{-17} WATTS)***

ACTUAL LEVELS ARE 5-6 dB HIGHER

***INCLUDES 2 dB ATMOSPHERIC LOSS**



RECEIVED GPS SIGNAL POWER



PRN CODE SPECTRAL PROPERTIES

P CODE SPECTRAL DENSITY

- $S_{spi}(f) = P_{pi} T_c \dfrac{\sin^2(\pi f T_c)}{(\pi f T_c)^2}, -\infty < f < \infty$

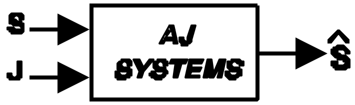
  - T_c = P CODE CHIP WIDTH

  - P_{pi} = P CODE CARRIER POWER

  - BANDLIMITED TO PROTECT RADIO ASTRONOMERS

    -- PREVENTS A RECEIVER FROM ACHIEVING FULL CORRELATION

    -- RESULTS IN CORRELATION LOSS DUE TO FILTERING



PRN CODE SPECTRAL PROPERTIES (CONTINUED)

C/A CODE SPECTAL DENSITY

- **SHORT 1 MILLISECOND REPEATING CODE**

- **LINE SPECTRUM WITH COMPONENTS** c_{ji}, $j = -\infty$ **to** $+\infty$ **1 kHz APART**

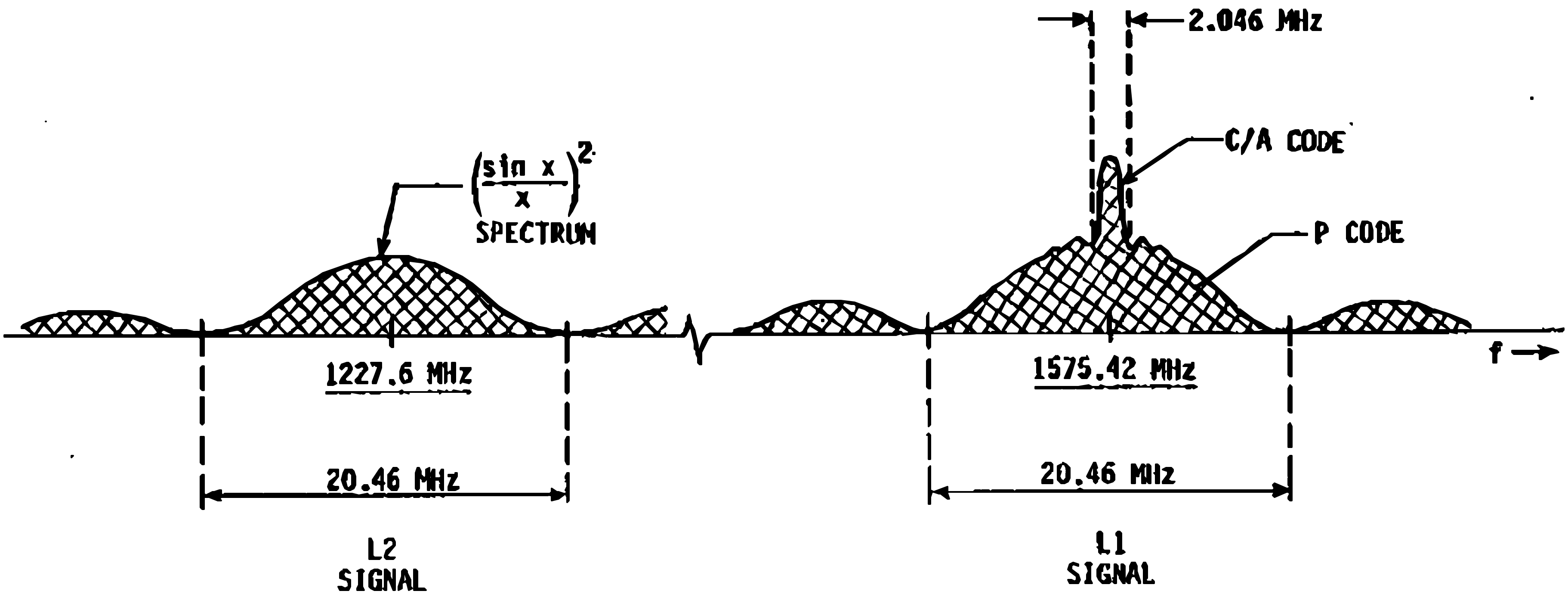
- $\sum_{j=-\infty}^{j=+\infty} c_{ji} = P_{ci}$

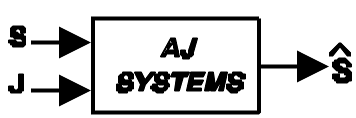
  - P_{ci} **= C/A CODE CARRIER POWER**

- **ENVELOPE OF LINE SPECTRUM**

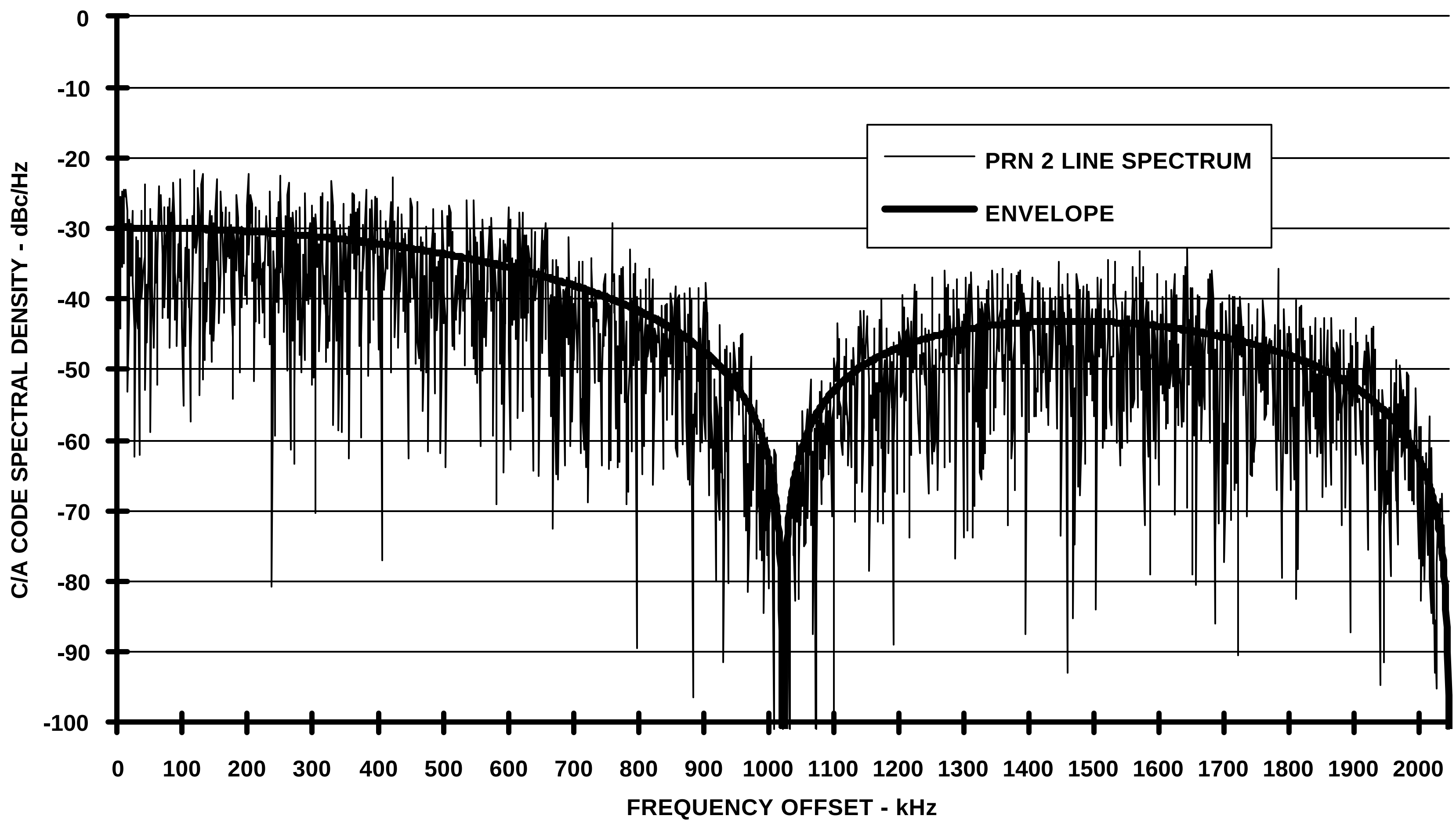
  - $S_{ci}(f) = 1000\, P_{ci}\, T_c \dfrac{\sin^2(\pi f T_c)}{(\pi f T_c)^2}$

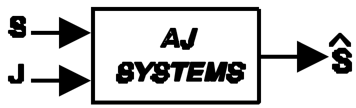
GPS SIGNAL POWER SPECTRAL DENSITY



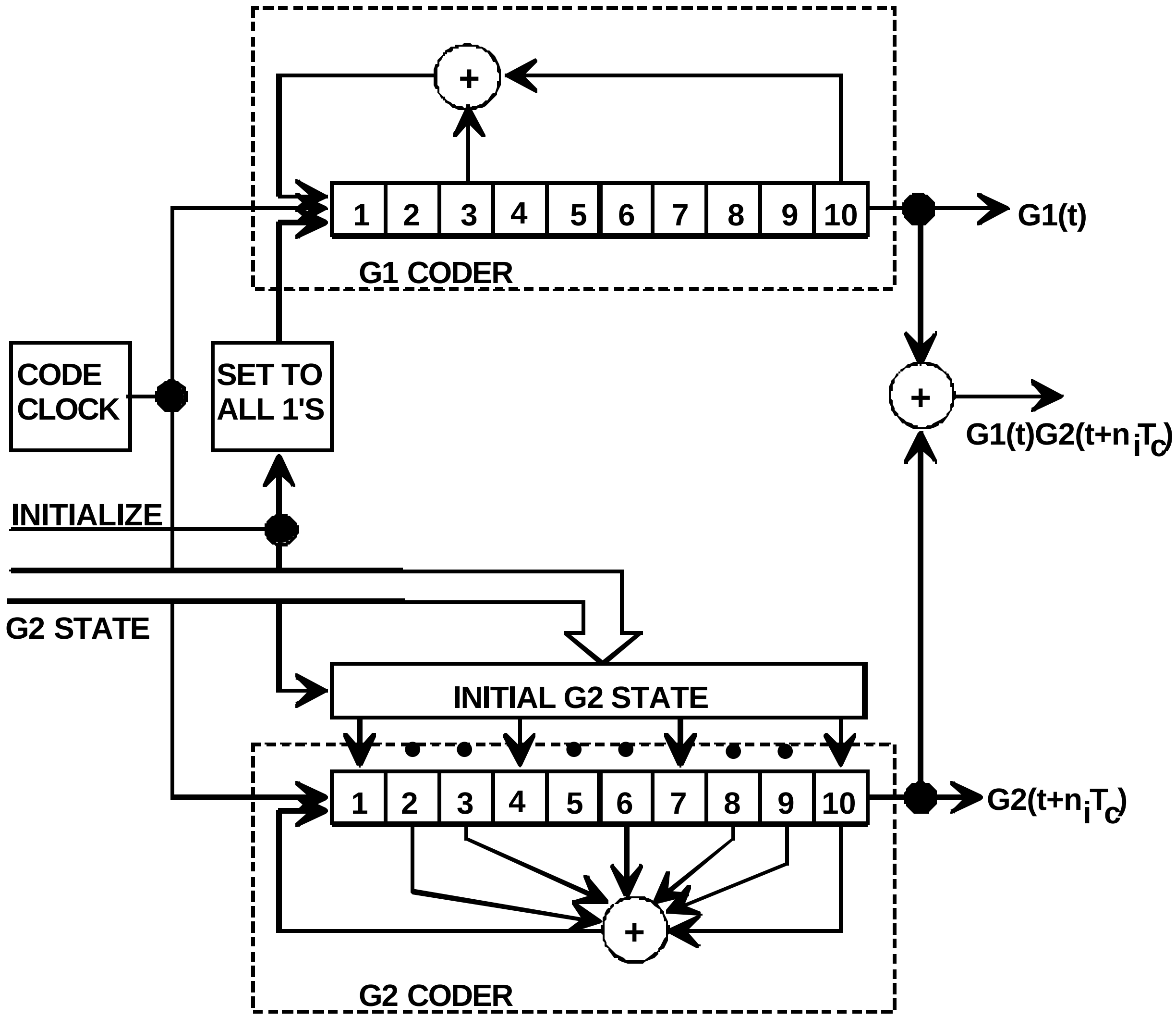


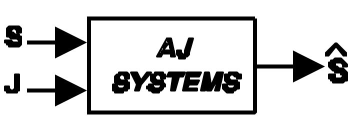
PRN 2 C/A CODE SPECTRAL DENSITY





C/A CODER WITH INITIAL G2 STATE





TYPICAL P CODER IMPLEMENTATION