SECTION-C

Generation & Analysis of waveforms

Frequency and Time Measurement

Asynchronous Counter

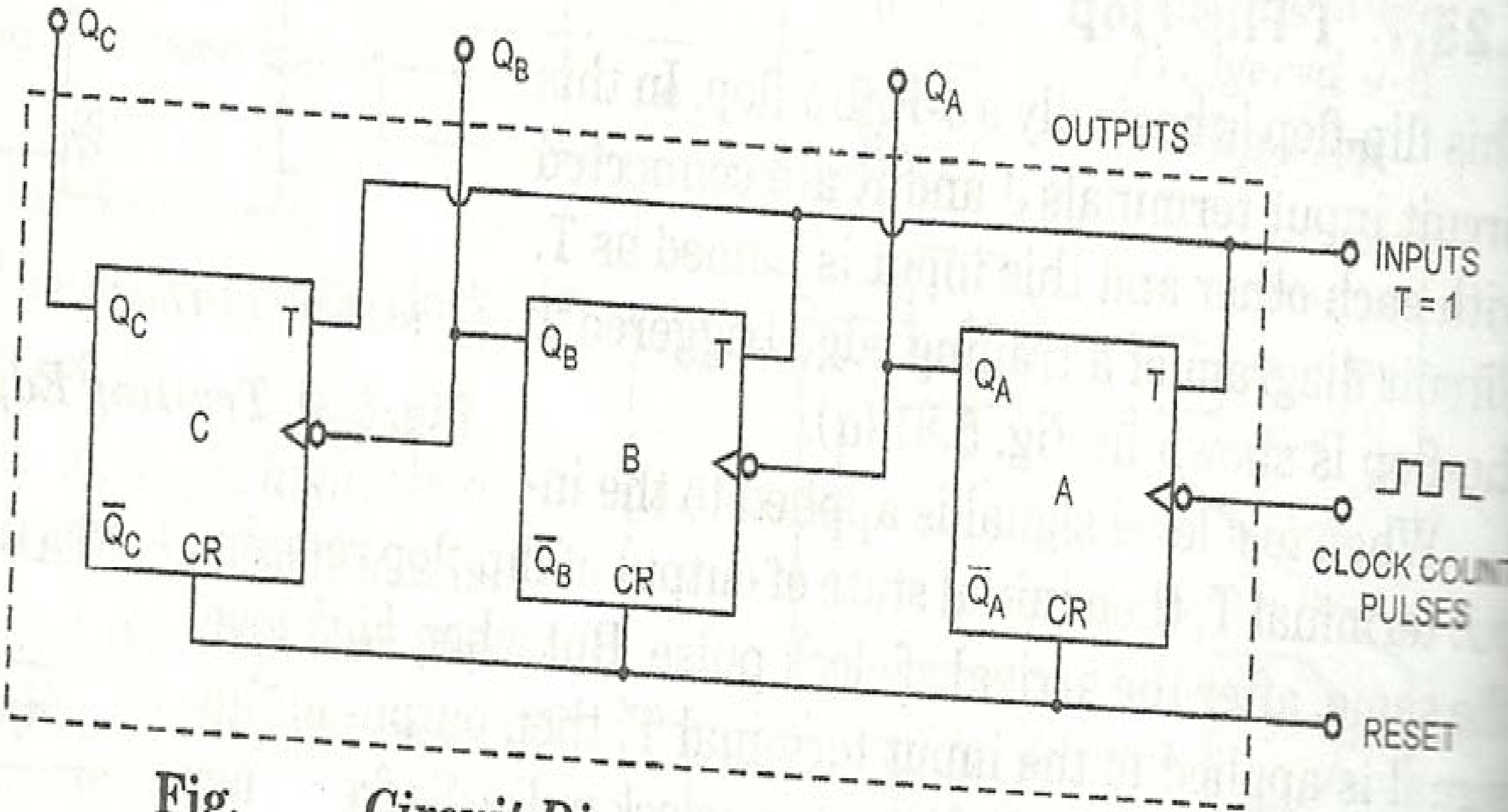
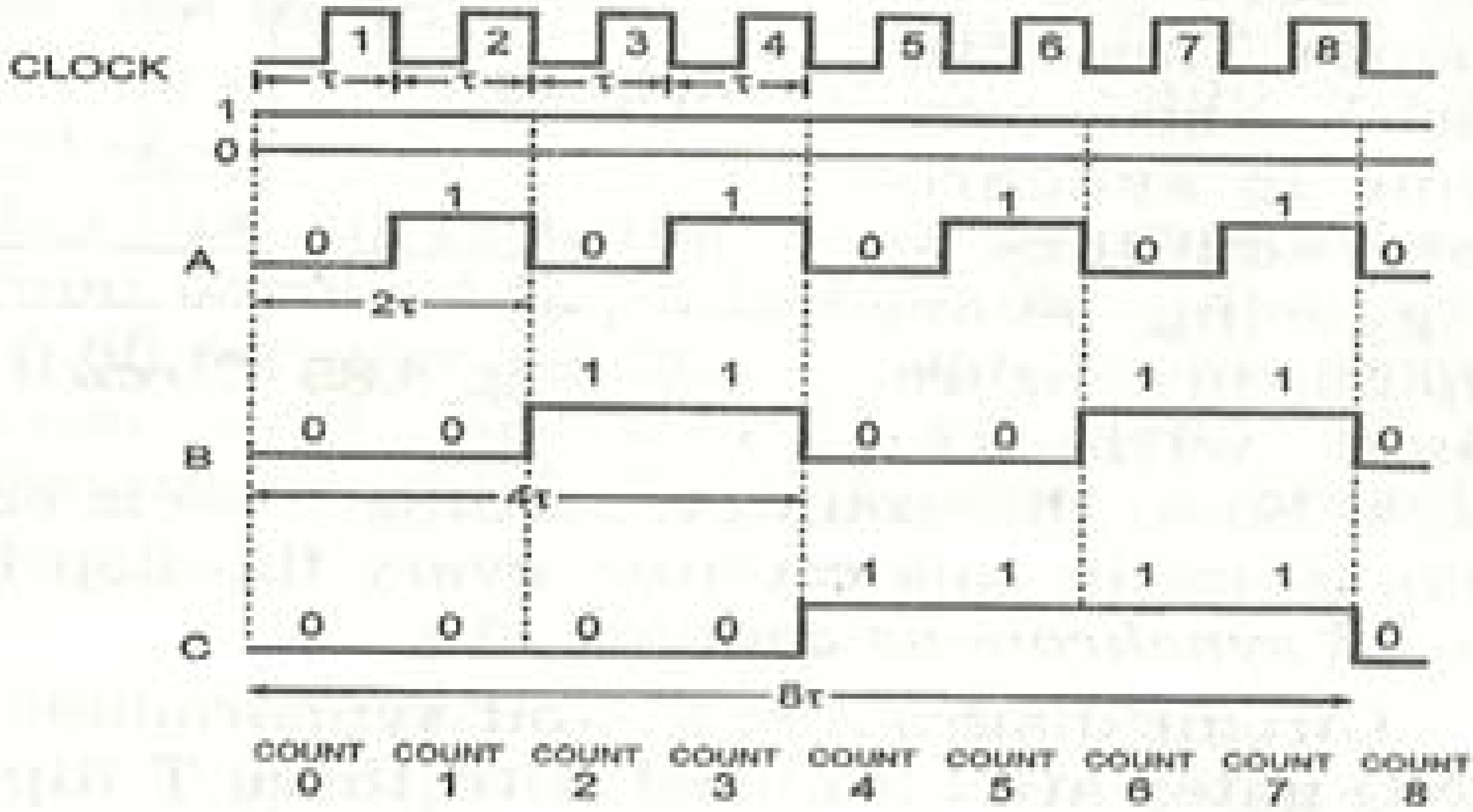


Fig. *Circuit Diagram of a 3-bit Ripple Counter*

Asynchronous Counter

Q_C	Q_B	Q_A	Clock Count Pulse
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7
0	0	0	8 (recycles)

Asynchronous Counter



Synchronous Counter

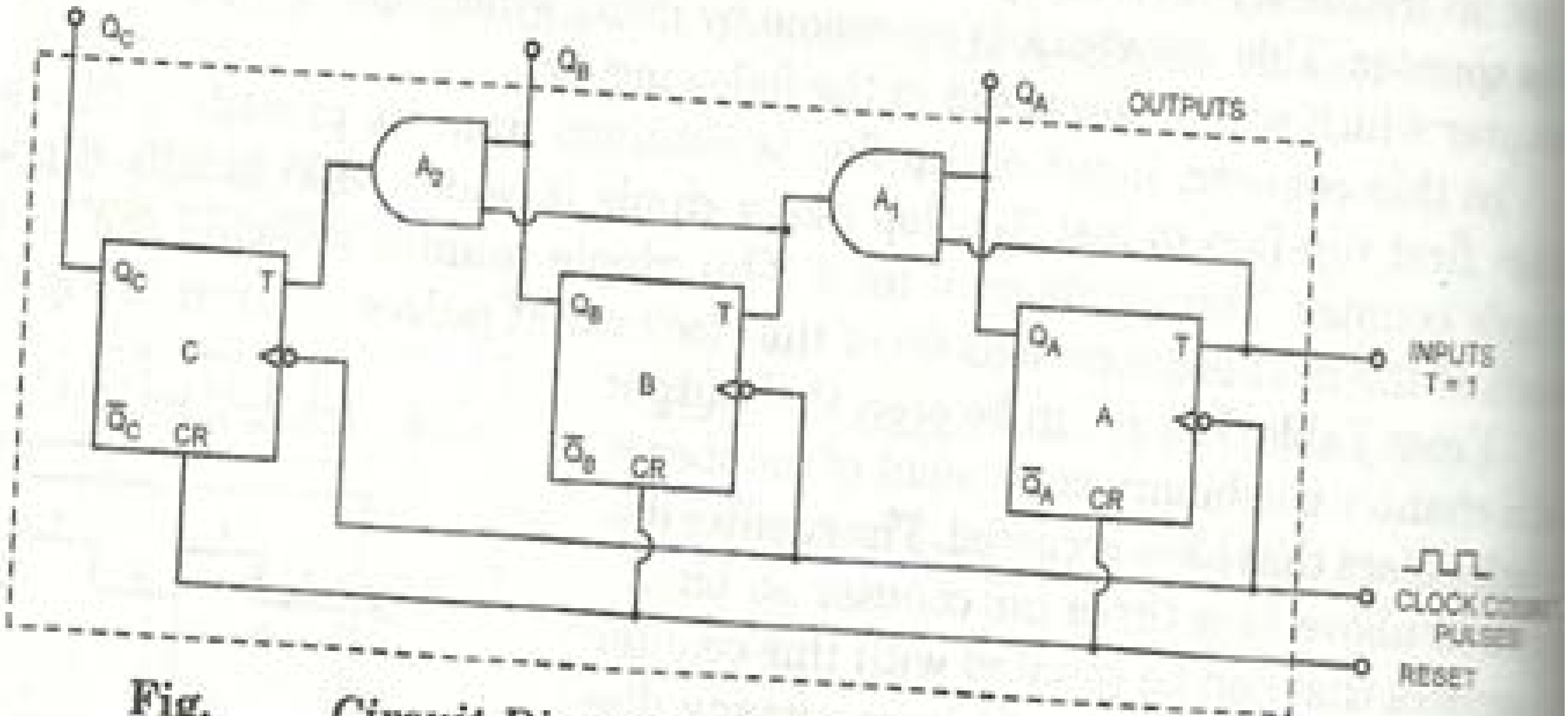


Fig. *Circuit Diagram of a 3-bit Synchronous Counter*

Ring Counter

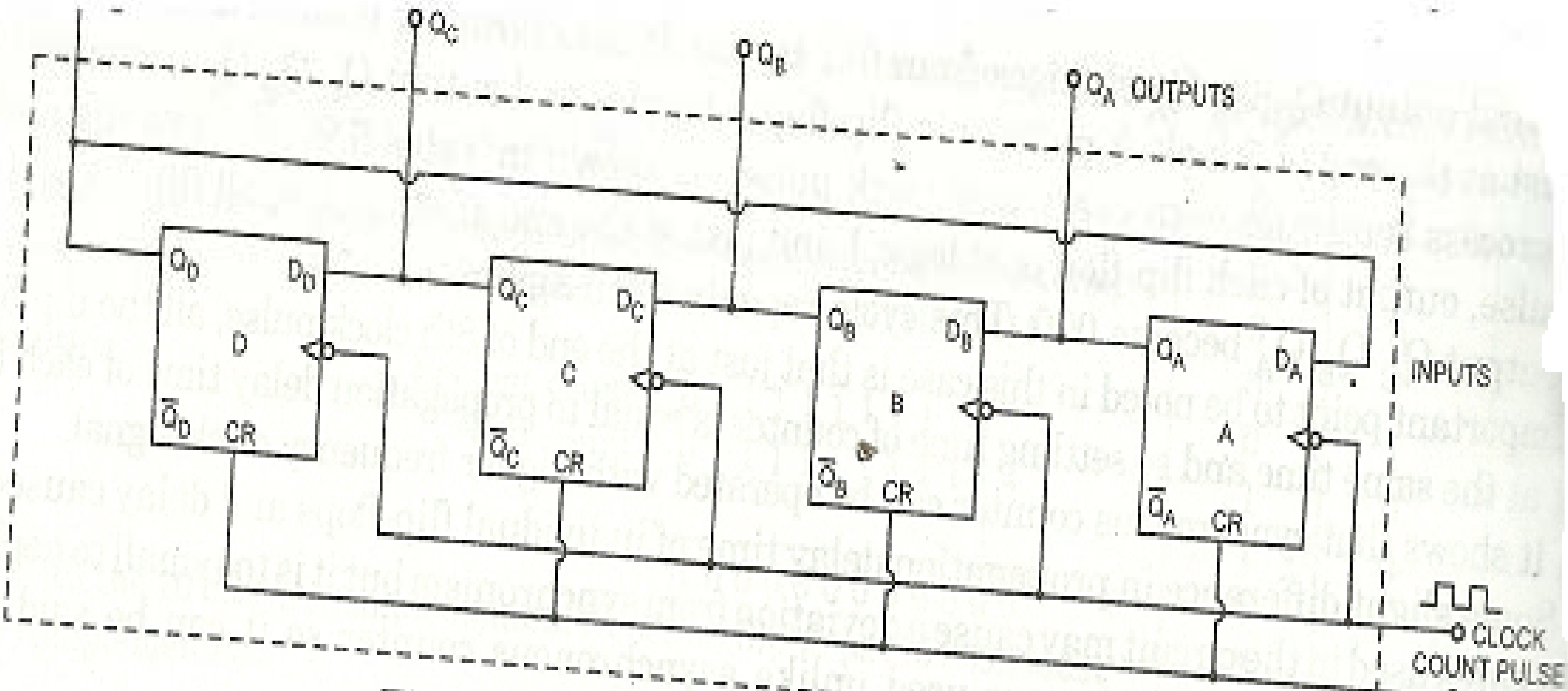
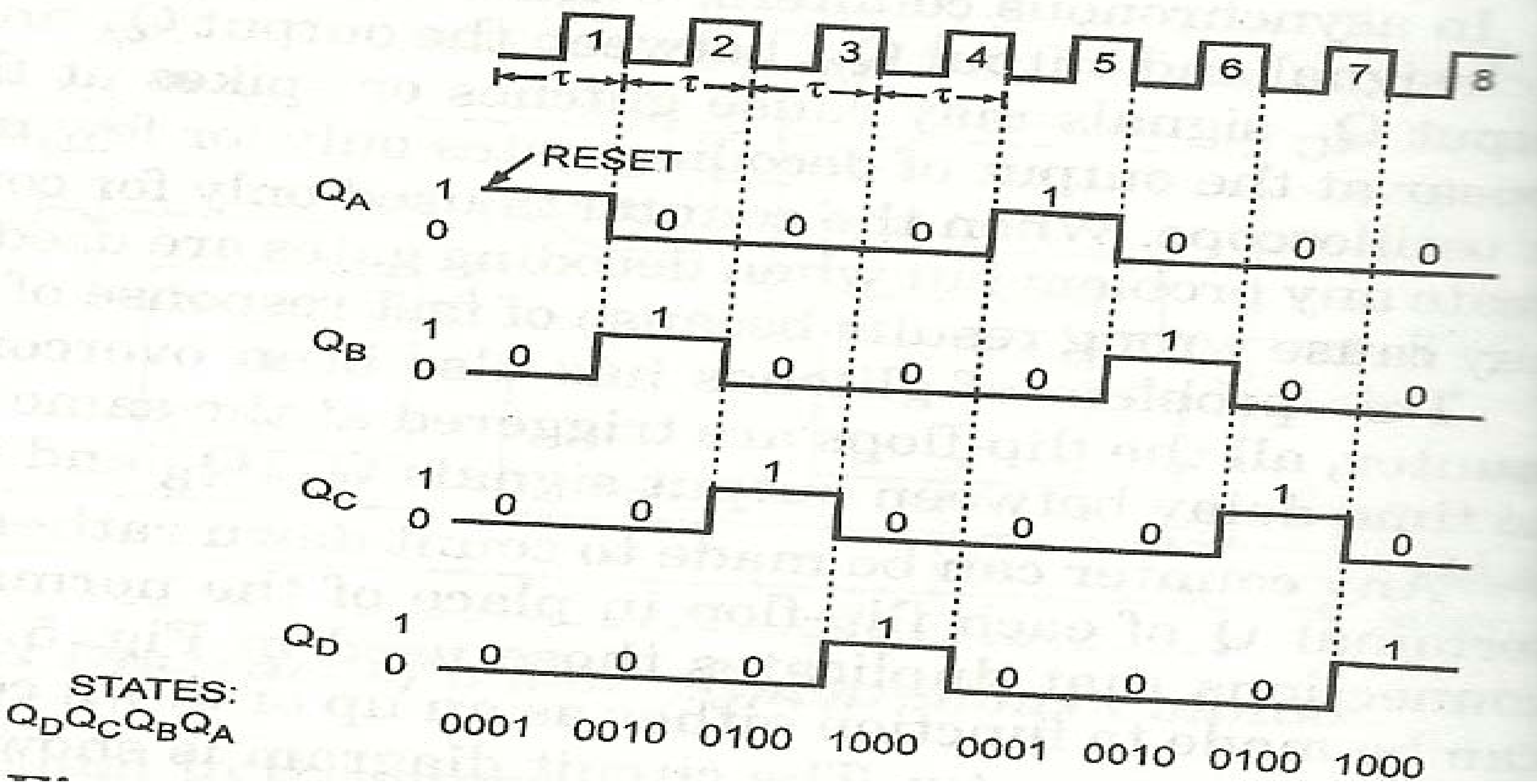


Fig. ***Circuit Diagram of Ring Counter***

Ring Counter

Q_D	Q_C	Q_B	Q_A	Clock Count Pulse
0	0	0	1	0
0	0	1	0	1
0	1	0	0	2
1	0	0	0	3
0	0	0	1	Next Cycle 4
0	0	1	0	5
0	1	0	0	6
1	0	0	0	7
0	0	0	1	Next Cycle 8

Ring Counter



Binary Counter

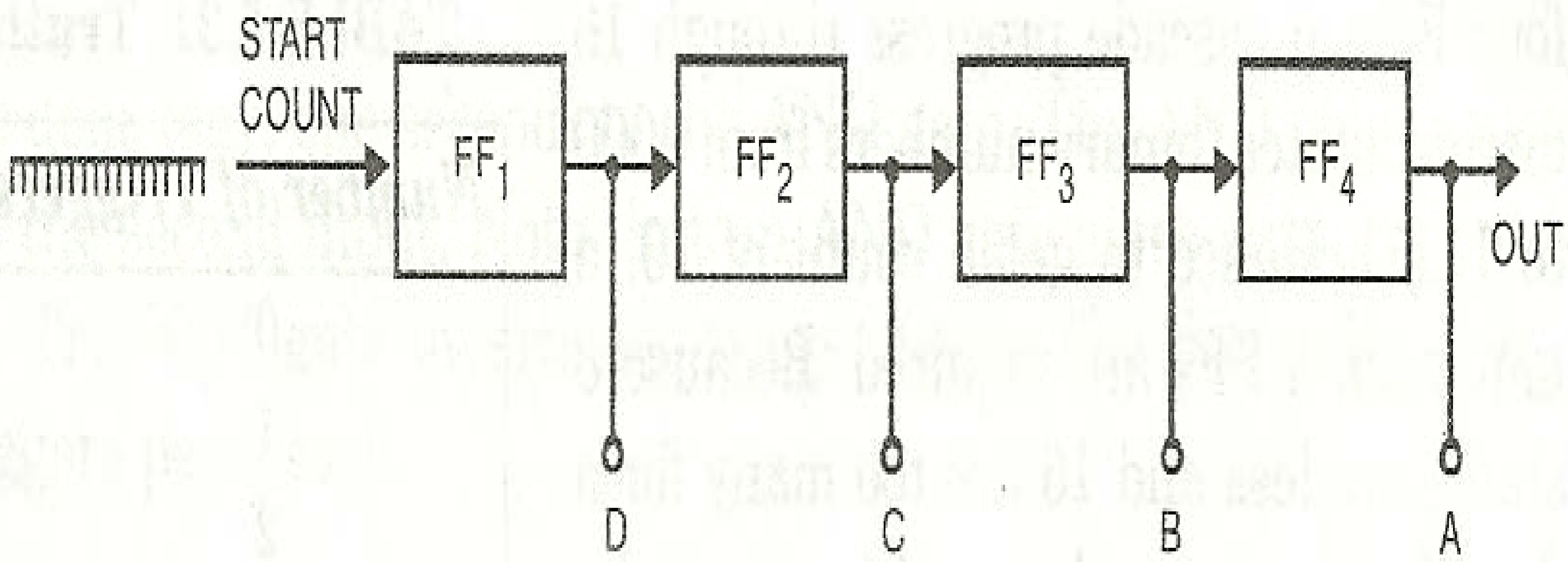


Fig. *Block Diagram of Binary Counter*

Binary Counter

TABLE .. Truth Table for Binary Counter

Number of Triggers	*A*	*B*	*C*	*D*
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1
16	0	0	0	0

Decimal or Decade Counter

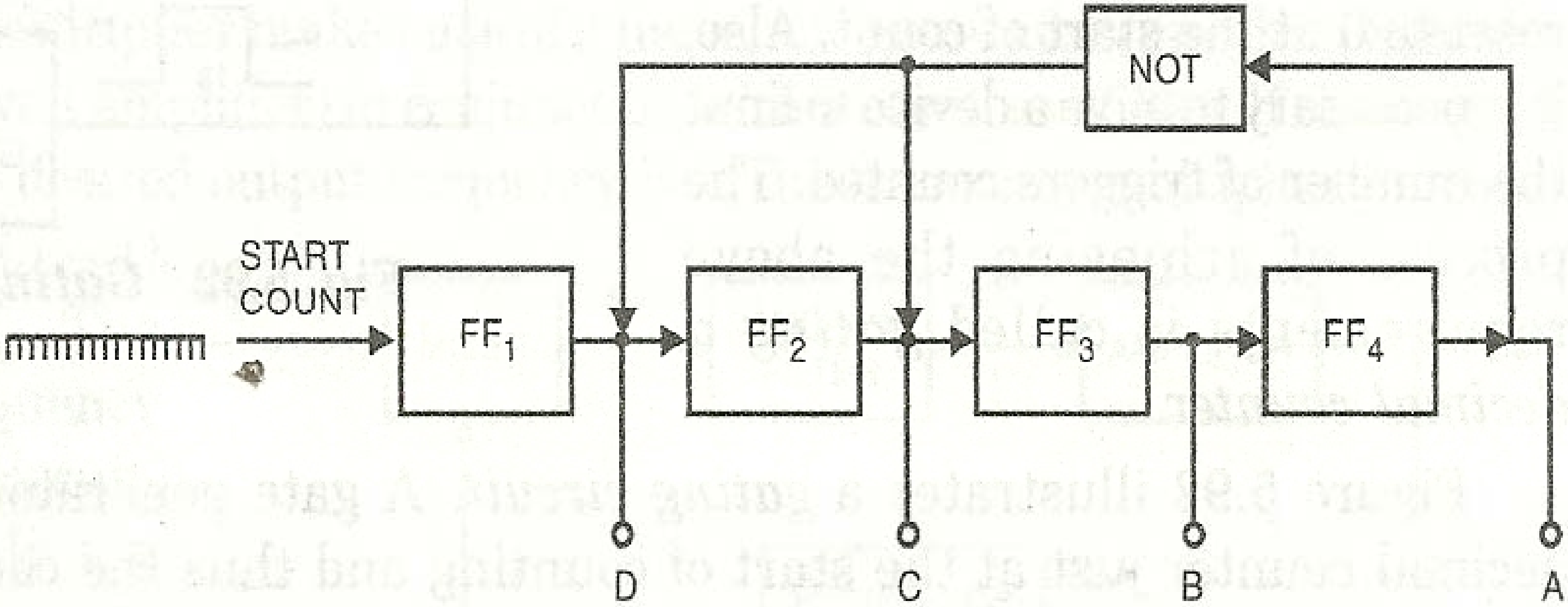


Fig. *Block Diagram of a Decimal Counter*

Decimal or Decade Counter

TABLE **Truth Table for Decade Counter**

Number of Triggers	*A*	*B*	*C*	*D*
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	1	1	0
9	1	1	1	1
10	0	0	0	0

Gating a Decimal Counter

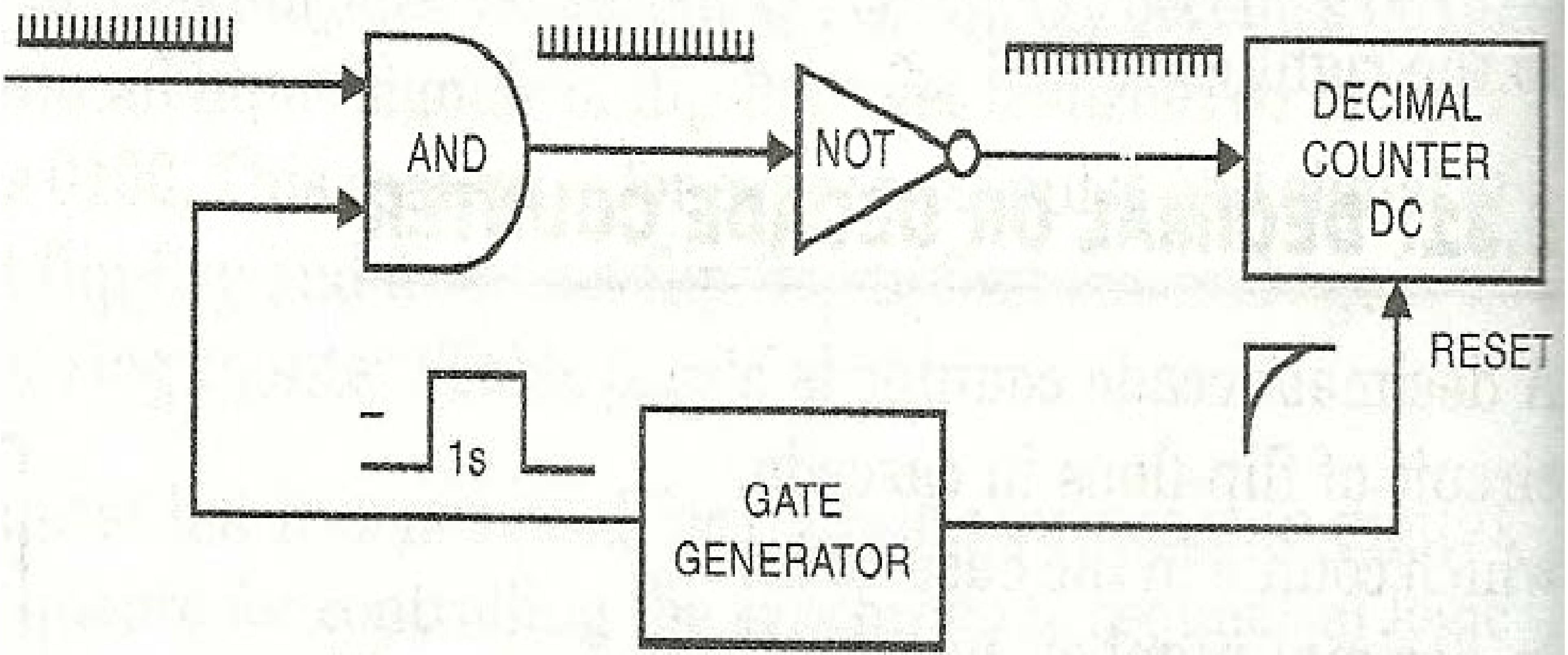


Fig. ***Gating a Decimal Counter***

Universal Counter

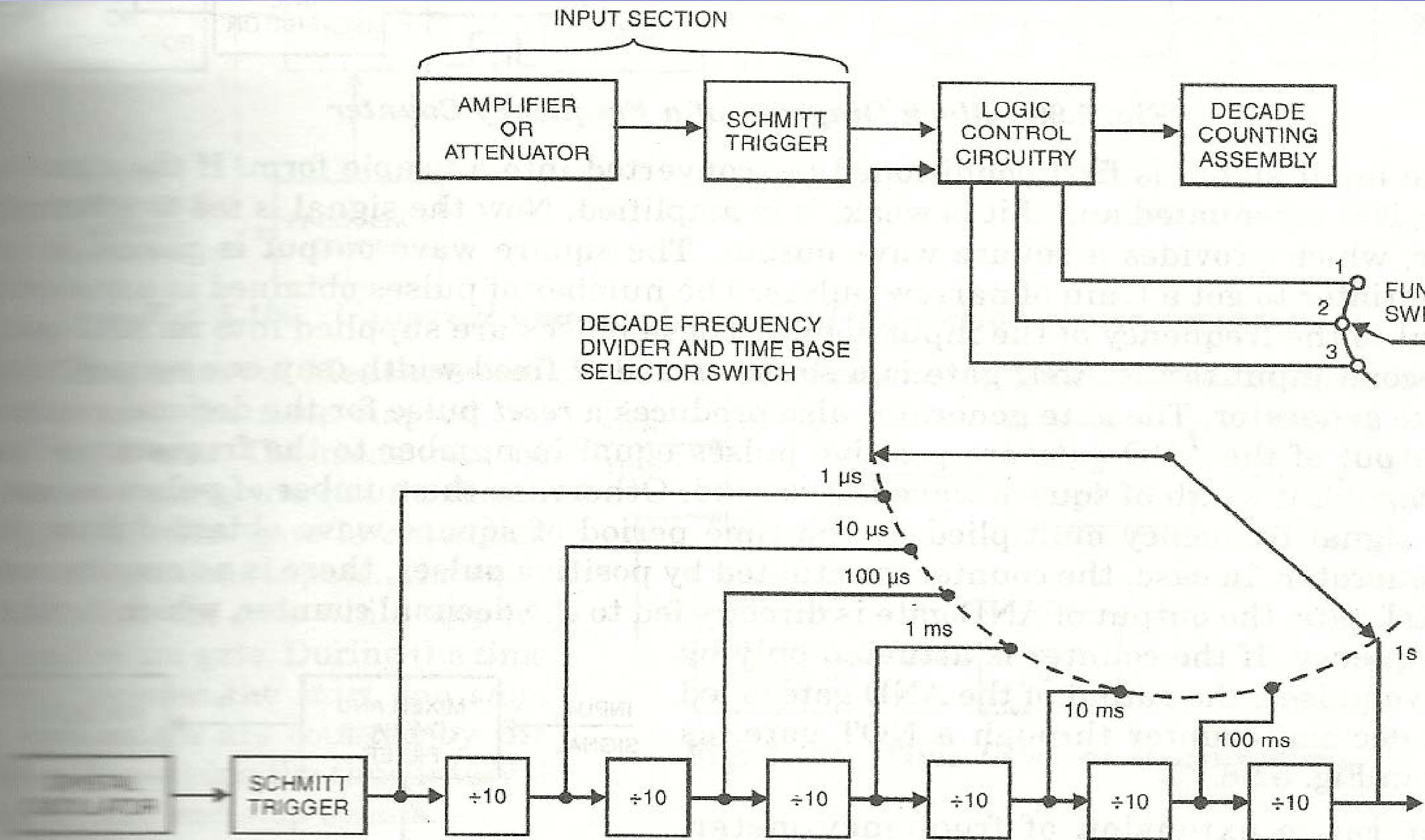


Fig. *Universal Counter*

Universal Counter

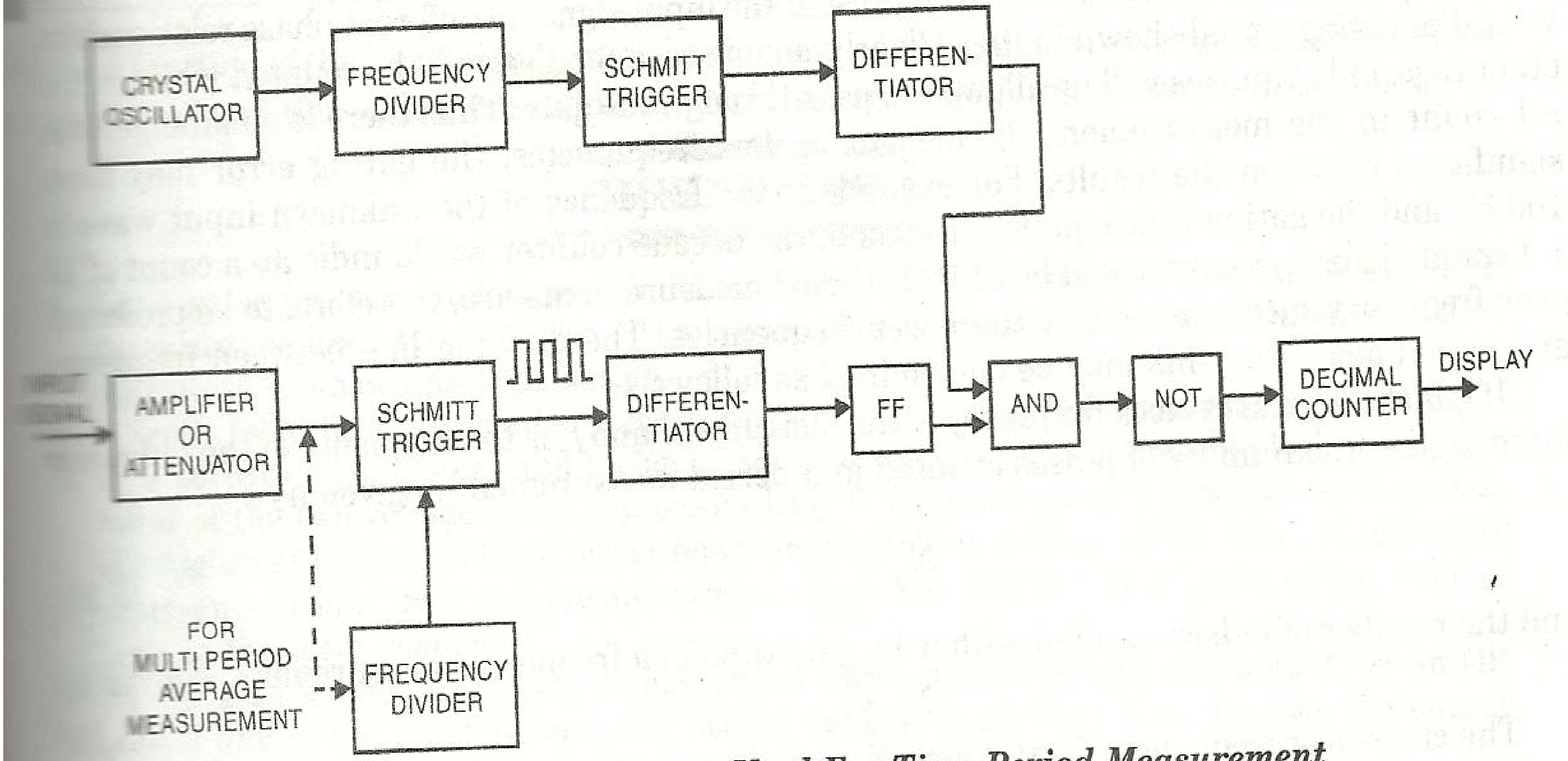


Fig. *Universal Counter Used For Time Period Measurement*

Universal Counter

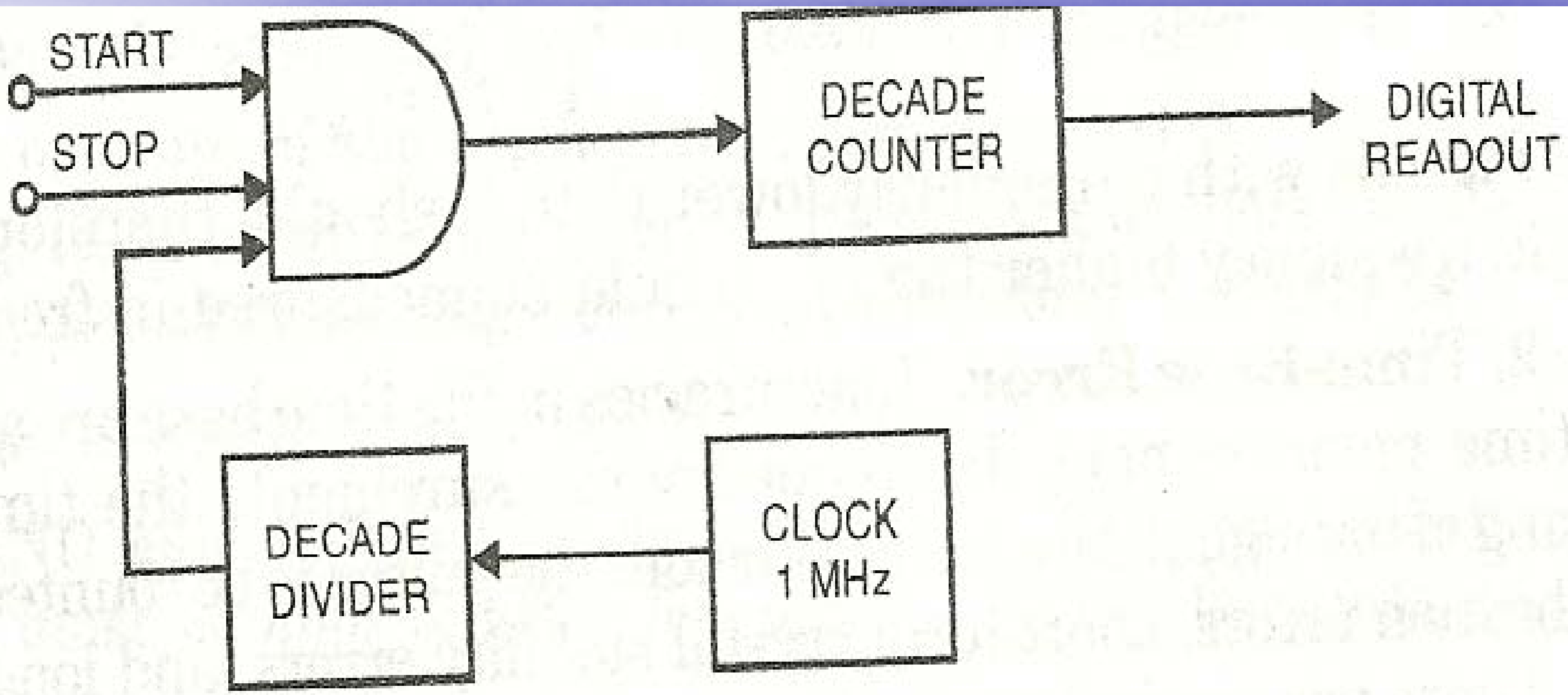


Fig. *Time Interval Measurement*

Universal Counter

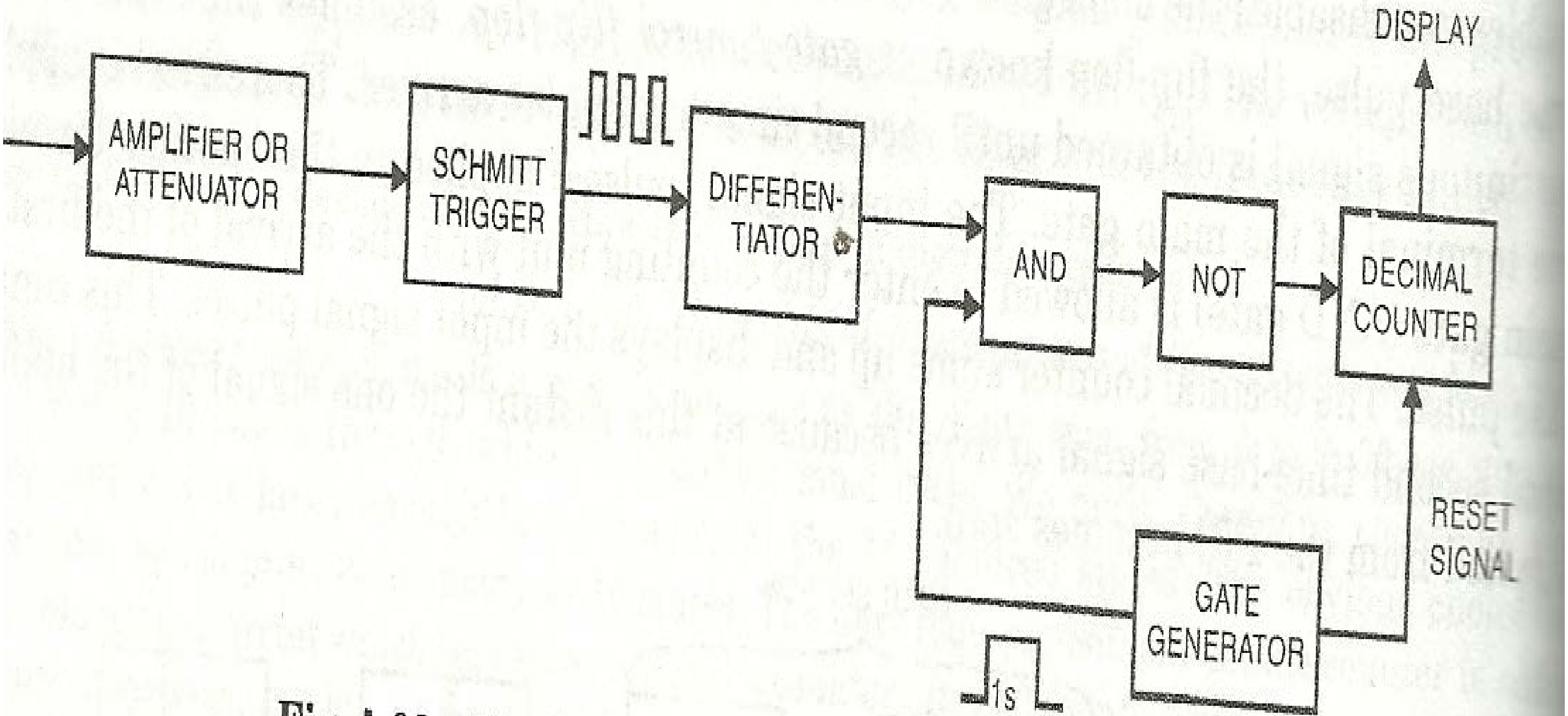


Fig. 5.3 *Block Diagram of a Frequency Counter*

e input signal is first ...

Signals

- Signal
  - Any **physical quantity** variable in time (or any other independent variable) containing information
    - Continuous
    - Discrete (Amplitude and time)
- Electrical signal (voltage or current loop)
  - Analog - continuous
  - Digital - quantized

Measurements Fundaments

- Fundamental Units
  - L, T, M, I, Temp, Light
- Derived Units
  - Coulomb, Q =1A*s
  - 1A==Current between 2 conductors apart 1m generating a 2E-7N net force.
  - Elementary charge counting

Units

- Fundamental
- Derived
  - Linear
    - $1V=1W/1A$ (L^2M/T^3I)
  - Non-linear
    - $1dB=10^{1/10}$

Quantity	Units
L	M
M	Kg
T	S
I	A
θ	ºK
Luminosidade	cd

Some dBs references

Referência	Unidade
1 kW	dBk
1mW (sobre 600R, sin 1kHz)	dBm
1 V	DbV
1 W	dBw
Ganho Tensão	dBvg
10^{-16} Potência acustica	dBrap
1 mW (sobre 600R, voz)	VU

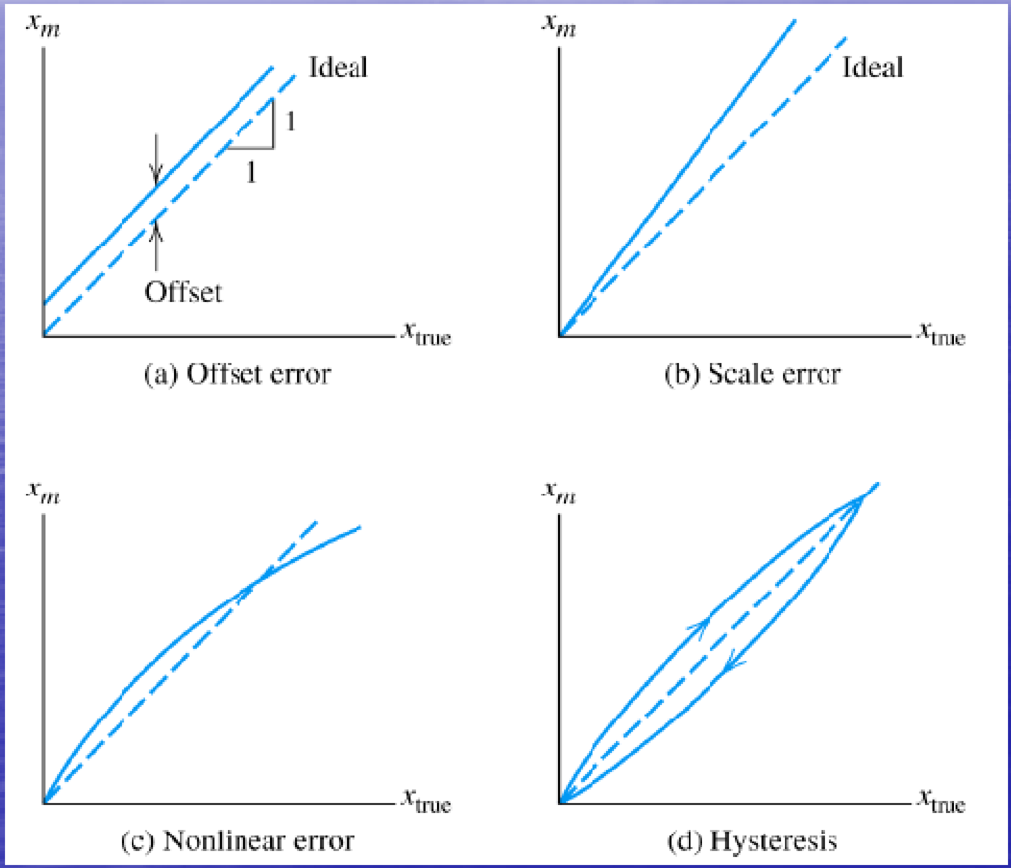
Concepts

- Precision=1-$|(x_i-x_{med})/x_i|$
  - The ability of the instrument to repeat the measurement of a constant value. More precise measurements have less random error.
- Accuracy (Tolerance) - The maximum expected difference in magnitude between measured and true values (often expressed as a percentage of the full-scale value); the true value is unknown!
  - Accuracy -> Precision
- Consistency (Histogram)

Concepts

- Sensibility: The relation between the instrument output according to the input changes
- Resolution: Δ Minimum
  - The smallest possible increment discernible between measured values. As the term is used, higher resolution means smaller increments. Thus, an instrument with a five digit display (say, 0.0000 to 9.9999) is said to have higher resolution than an otherwise identical instrument with a three-digit display (say, 0.00 to 9.99). The least identifiable change in the input regarding the instrument output
- Error= $|X_{expected} - X_{measured}|=d$;
  - Absolute and relative
  - Random and systematic
- Scale: range and spam

Typical errors



Statistics

- Value distribution:
  - Average deviation (data dispersion): $\sigma = \frac{\sum |d_i|}{n}$
  - Standard deviation: $s = \sqrt{\frac{\sum d_i^2}{n}}$
    - n->(n-1) if n<20
  - Correlation of data:
    - Linear regression: $Y = mX + b$

$$m = \frac{n\sum(XY) - \sum X \sum Y}{n\sum(X^2) - (\sum X)^2}$$

$$b = \frac{\sum Y(\sum X^2) - \sum X \sum(XY)}{n\sum(X^2) - (\sum X)^2} = \frac{\sum Y - m\sum X}{n}$$

Correlation

- Correlation coefficient (Pearson):

$$r = \frac{n\sum(XY) - \sum X \sum Y}{\sqrt{\left(n\sum X^2 - \left(\sum X\right)^2\right)\left(n\sum(Y^2) - \left(\sum Y\right)^2\right)}}$$

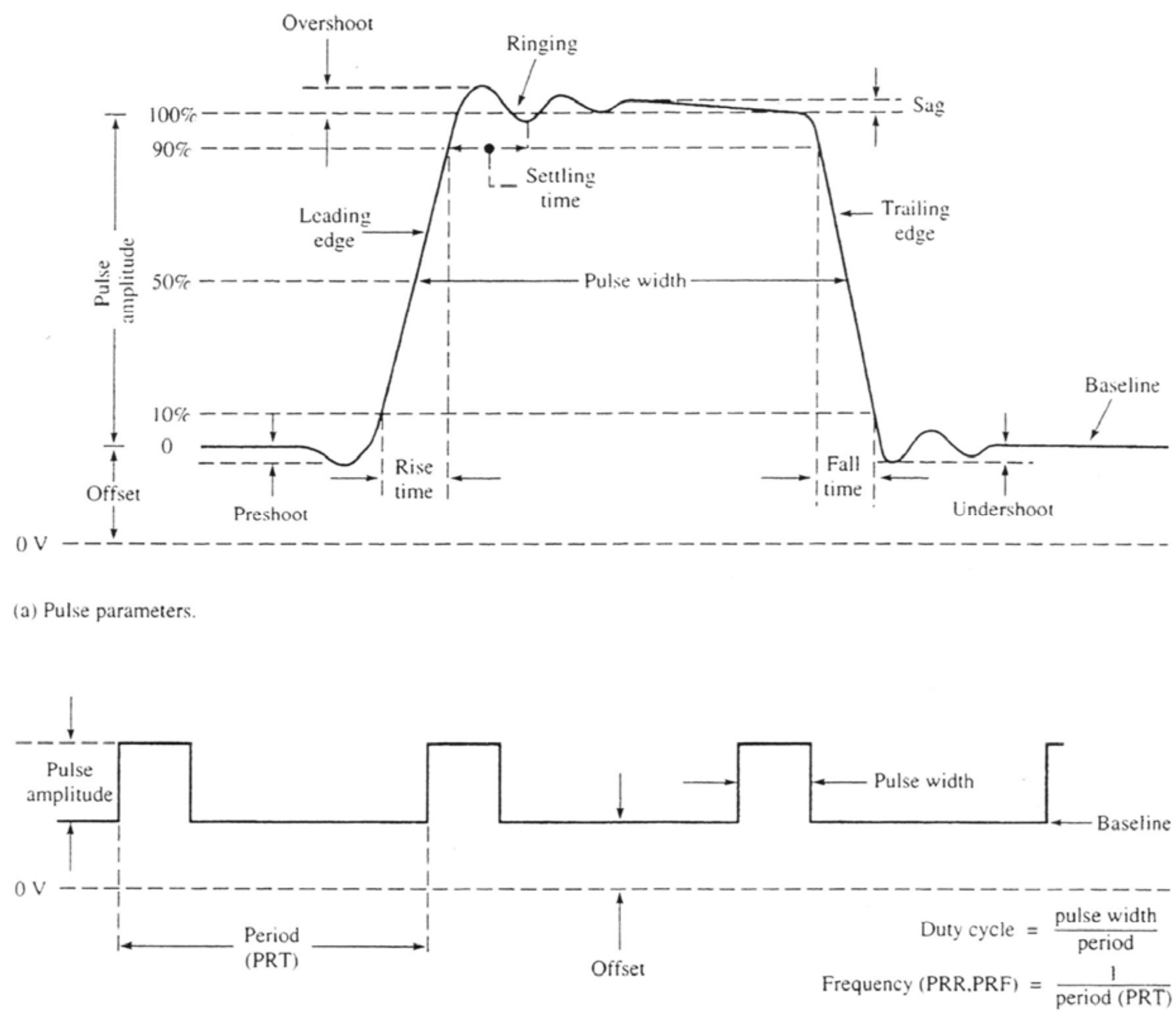
- Coefficient of determination (variance):

$$v = r^2$$

- Standard deviation – same units as original values

Signal characteristics

- – Preshoot
- – Rise-time/Fall-time (10%-90%)
  - – $t_r=0.35/BW$
- – Leading/trailing edge
- – Overshoot
- – Ringing
- – Pulse with
- – Pulse amplitude
- – Off-set/Baseline
- – Duty-cycle

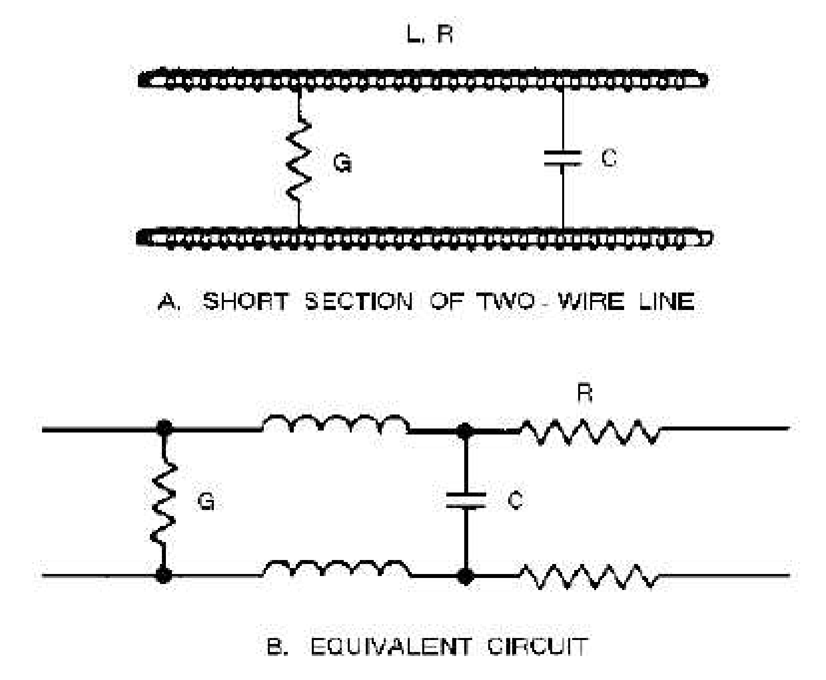


(a) Pulse parameters.

(b) Parameters for periodic pulses.

Signal transmission

- Electrical lines (up 1MHz)
  - Distributed parameters
  - Atenuation per unit lenght
  - RLC
  - Coaxiais/twisted-pair
  - Termination (Wavelenght)
    - Compensation (Z) – Probes
- Optical lines
  - Analog signals – PWM
  - Digital signals
  - Modulated/ON-OFF



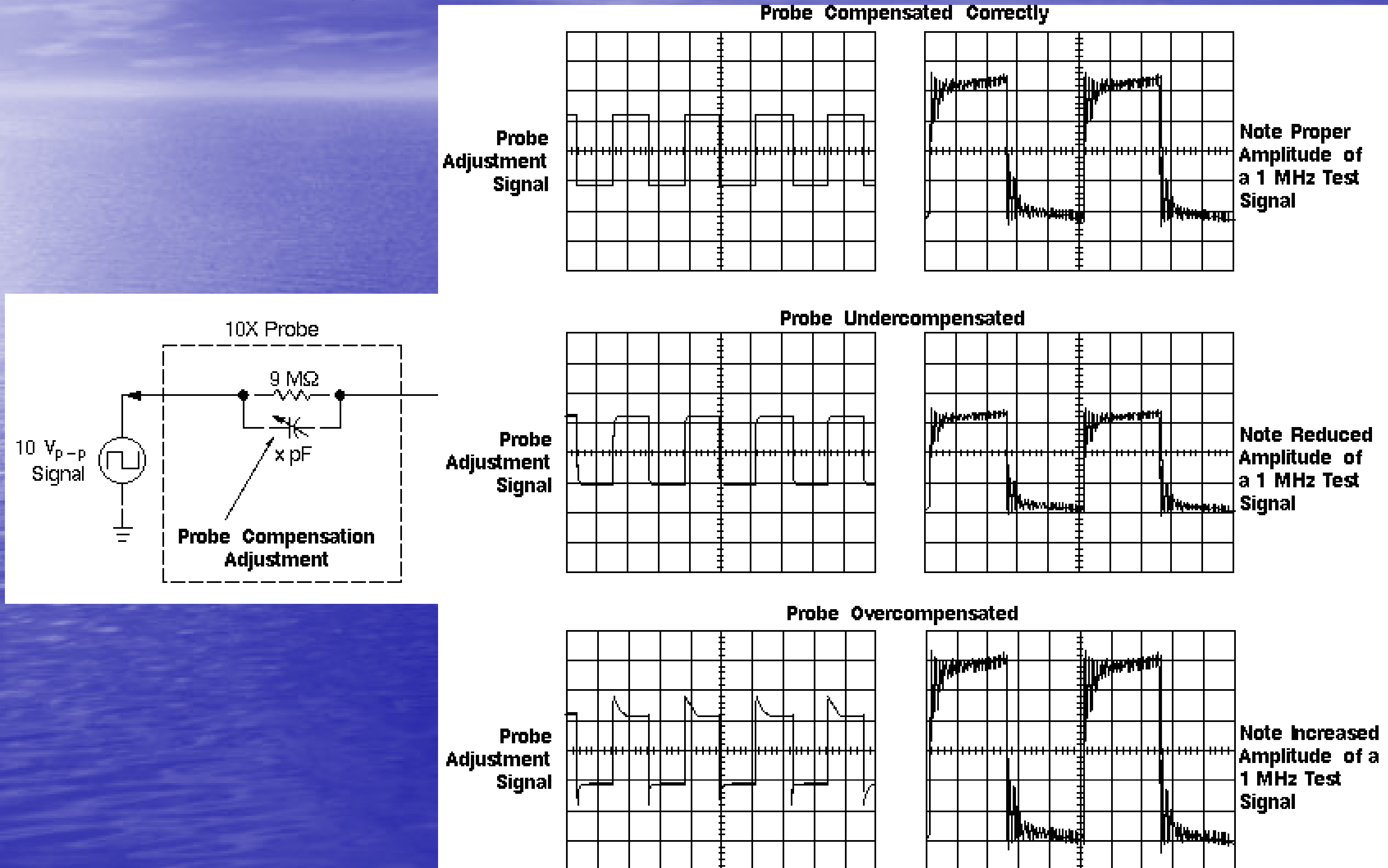
Signal transmission

- Above 1MHz
  - Characteristic impedance
  - Propagation delay time
  - Standing waves
    - PCI Bus
  - Crosstalk

$$Z_0 = \sqrt{\frac{L}{C}}$$

$$T_D = \sqrt{LC}$$

Line compensation



ElectroMagnetic Interference EMI

- Near field - inductive ($1/r^2$)
- Far field – plane wave ($1/r$)
  - Wavelength – some consideration
  - RF (GSM – switched packet)
  - Impulsive signals – motors
  - Oscillators (Micro-waves, Carrier)
- Shielding and Filtering (Power supplies)
  - L’s, C’s, cages, Coaxial cables

Ground and earth connections

- Ground == 0V (signal reference)
- earth == Local potential (1-10m, $1/r^2$, $1/r$)
  - Connection to a low impedance earth point.
  - Copper wire under the ground (>1m, 18mm)
- 50Hz AC
  - Brown/Black – "live"
  - Blue – "neutral": Earth on the originate connector PT (5% allowed, 1% nominal) – Power ground
  - Yellow.Green – earth (section immediately above)

Earth

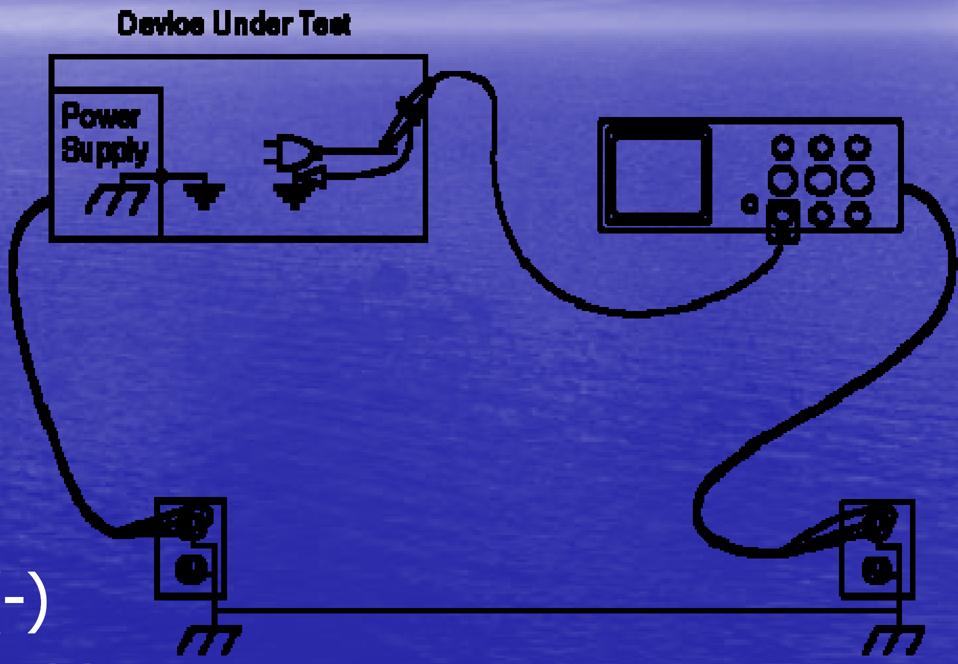
- Leaks
  - Current returning from protective ground instead of the power ground
  - Ground-fault interrupter
    - Differential flux return path
    - “Cheater adapter”
    - Physiological effects on humans
      - Current sensibility : 100mA (DC) up to 1A (1MHz)

Ground

- Power ground
  - Return current path
- Signal ground
  - Reference to circuit design
  - Return path to signals
  - Analog and Digital (ground planes)
- Chassis and shielding
  - EMI protection
  - Inductive and capacitive coupling

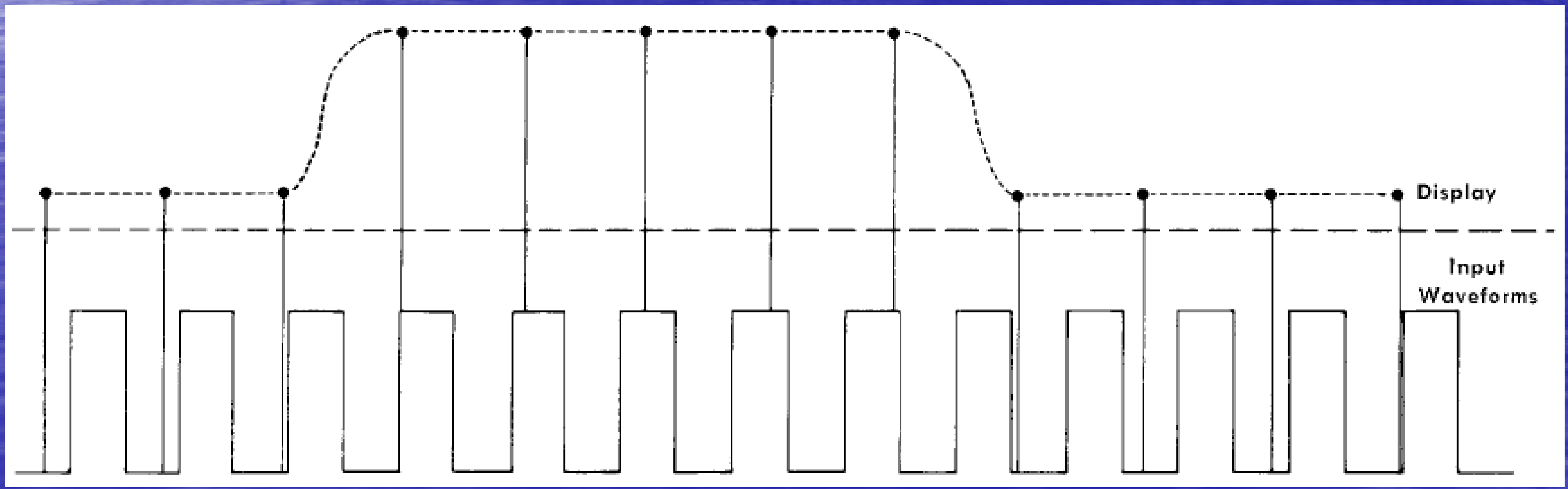
Ground loops

- Sources
  - Ground planes
  - Current loops
    - dB/dt (+)
    - Spurious noise (+)
    - Capacitive coupling (-)
    - Common-mode noise (-)

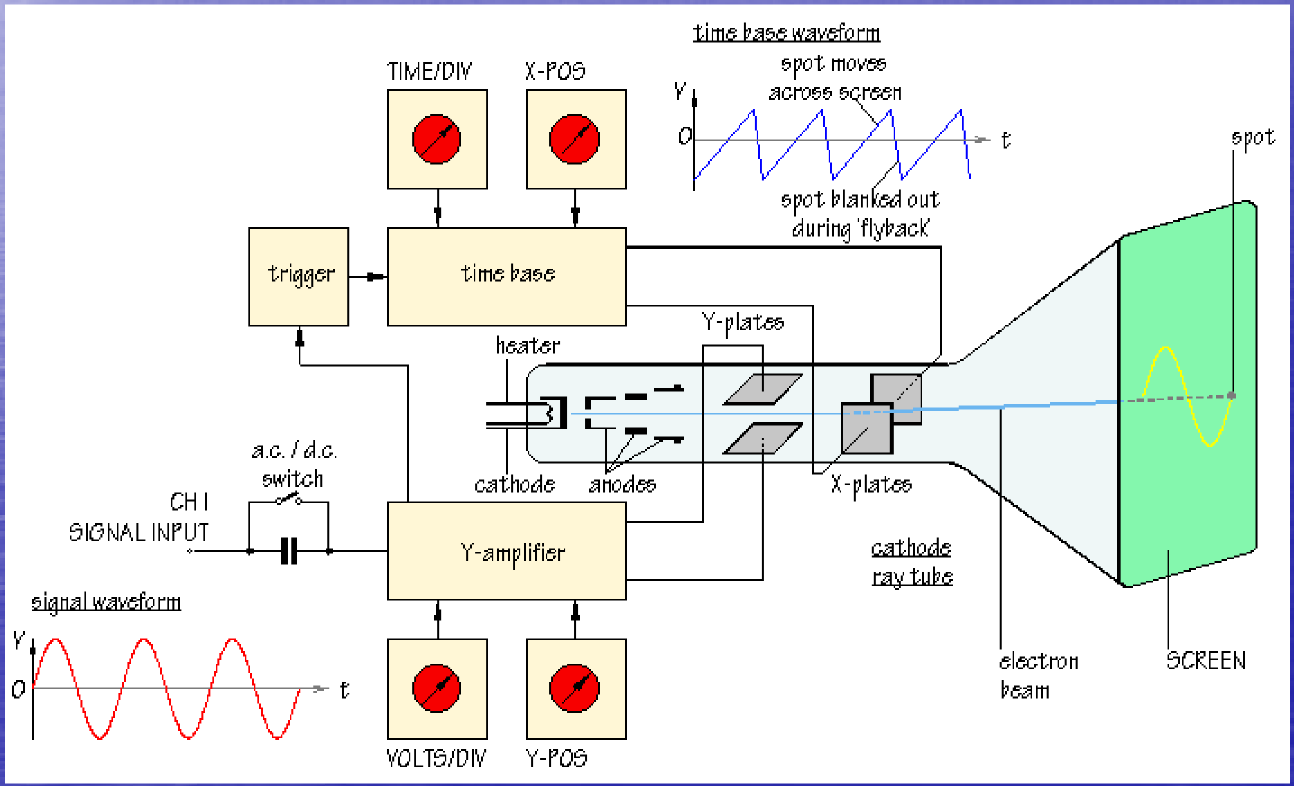


Equipments

- Oscilloscopes
  - Digital vs analog
    - Sampling oscilloscopes
    - Bandwidth vs Sampling frequency



Oscilloscope

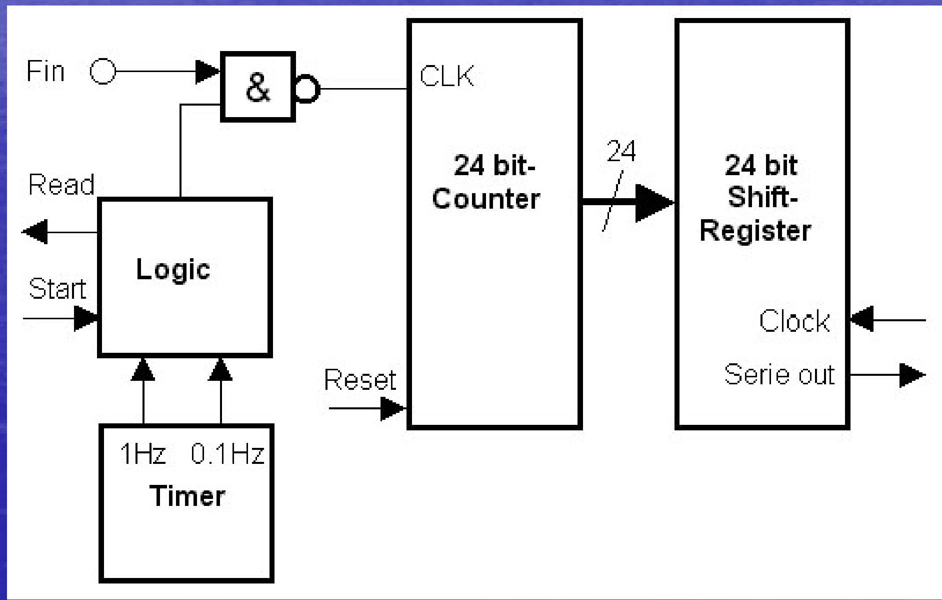


Signal generators
Arbitrary waveforms

- Oscillators (sinusoidal waveforms)
- Signal generators (RF)
- Function generators
- Arbitrary waveforms generators
  - Analog
  - Digital (DAC based)
- Synthesizers (base frequencies)

Frequency counters

- Frequency
- Period
- Event counter
- Frequency rates
- Time intervals

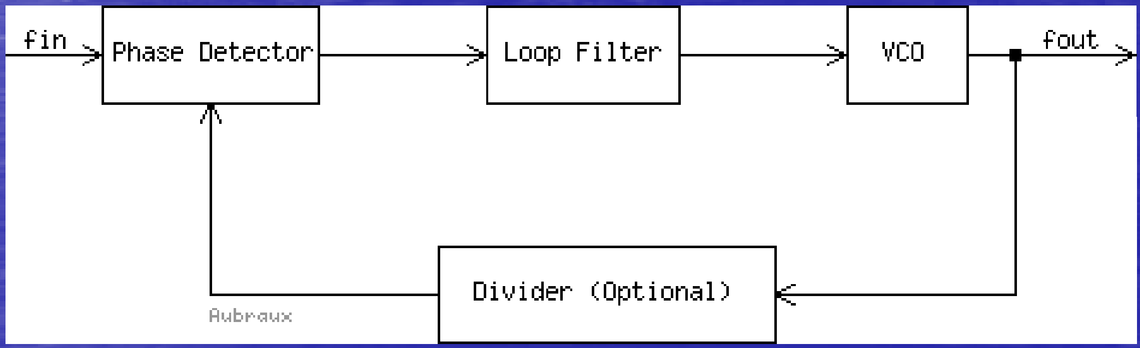


Frequency counters

- Very high frequency
  - Prescaler
  - Transfer oscillator (VFO based)
    - Two harmonics with zero beat
      - Ex: 2 471 429 e 2 544 118
      - $N=f_1/|f_1-f_2|$, $f_x=N*f_1$
  - Harmonic heterodyne converter
    - Transfer oscillator w/local heterodyne converter

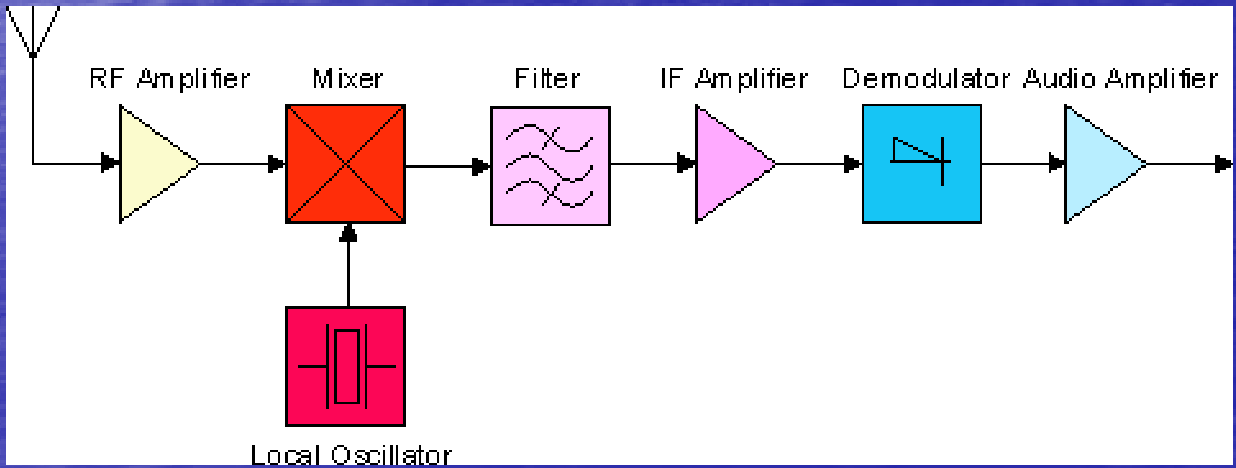
PLL

- Phase looked loops
  - Free-running/capture mode
  - Phase-locked
  - Lock range



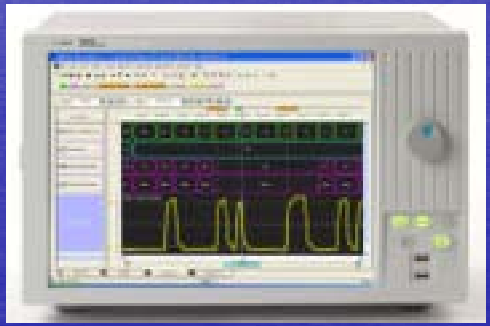
Spectrum analyzers

- Superheterodinic radio
  - Frequency resolution
  - Reference levels



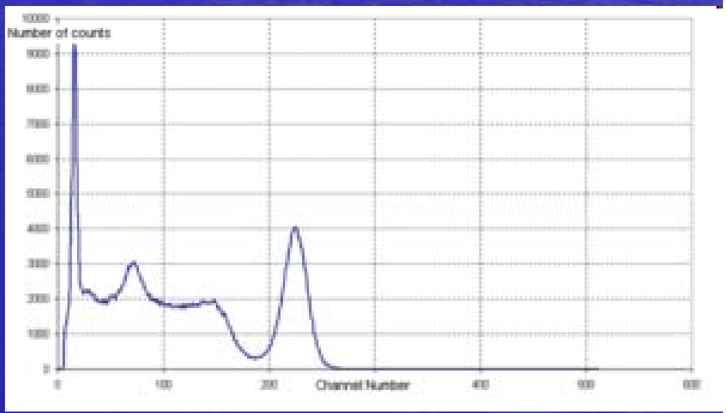
Logic analyzer

- Modes
  - Time
  - State
- Clock source
- Trigger condition



Multichannel analyzer

- Gaussian pulse shaping
- Fast ADC vs Bin's windows
  - Channel counters (9bits – 512 bins)
- Many events are needed to become statistical relevant
  - Low resolution time windows
  - Scintillator and photomultiplier efficiency



TDC

- Time to digital converter
  - Inter-pulse measurements
    - Time of flight applications
      - Neutron energy measurements
      - Ion beam energy
      - Particles decay time
    - Precise timing (capture time)