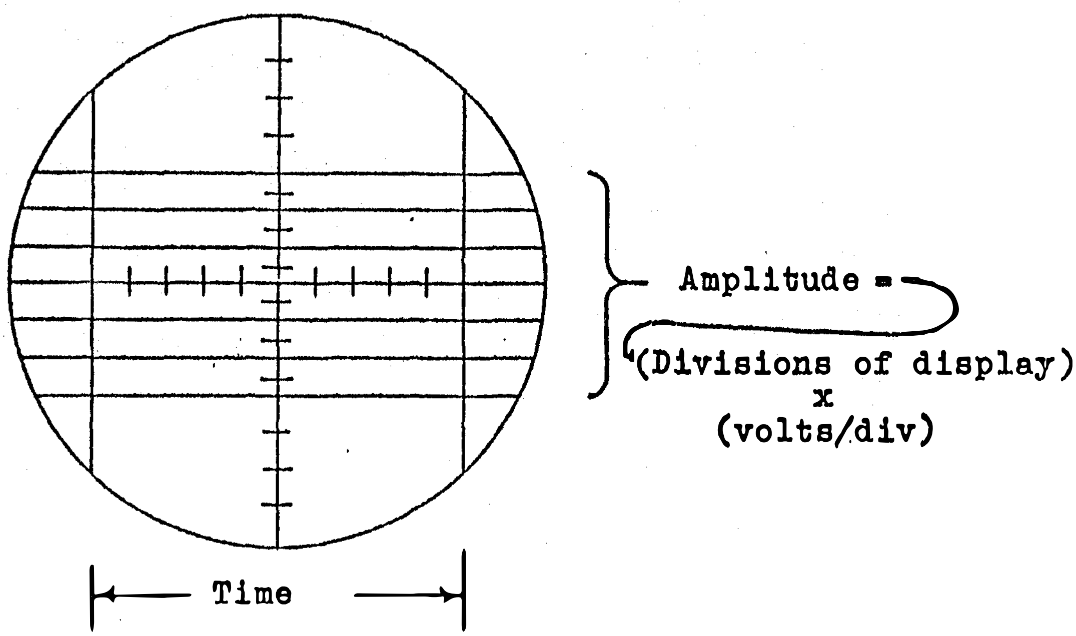
TEKTRONIX, INC.

Lecture notes on:

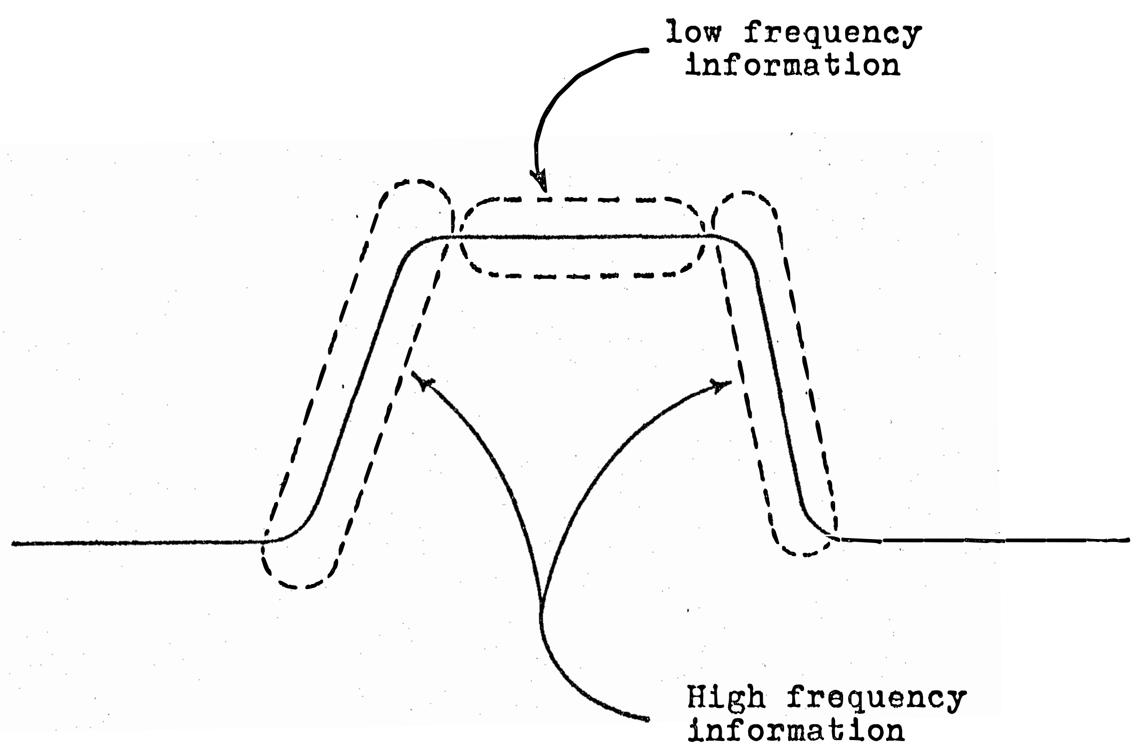
FUNDAMENTAL ELECTRONIC CONCEPTS FOR OSCILLOSCOPE USE & MAINTENANCE

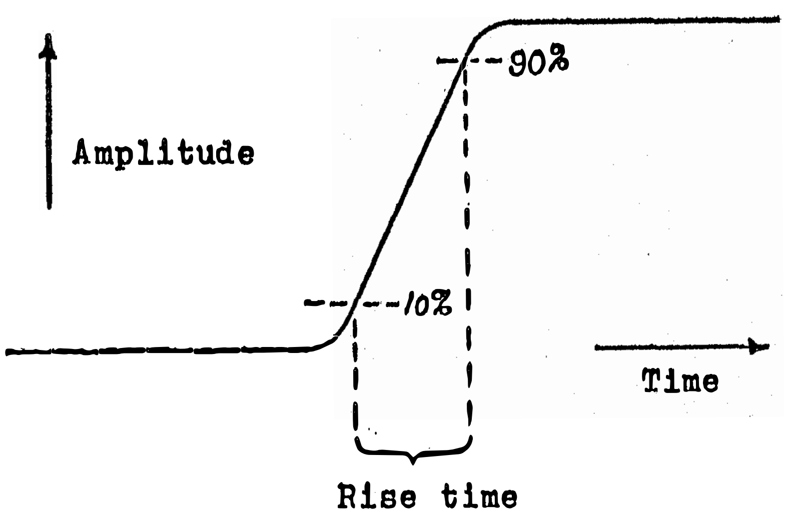
February 10, 1956/cs
Revised April 20, 1956/cs

Information obtained from a
Cathode-ray Oscilloscope:

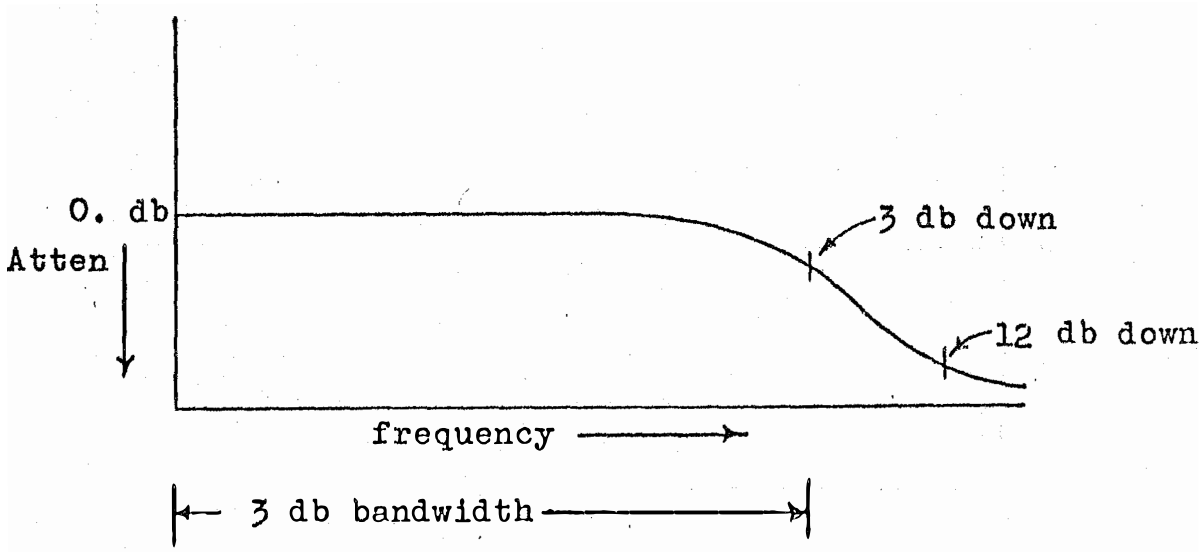


Time = (Divisions of display)(Time/div)


low frequency
information
High frequency
information

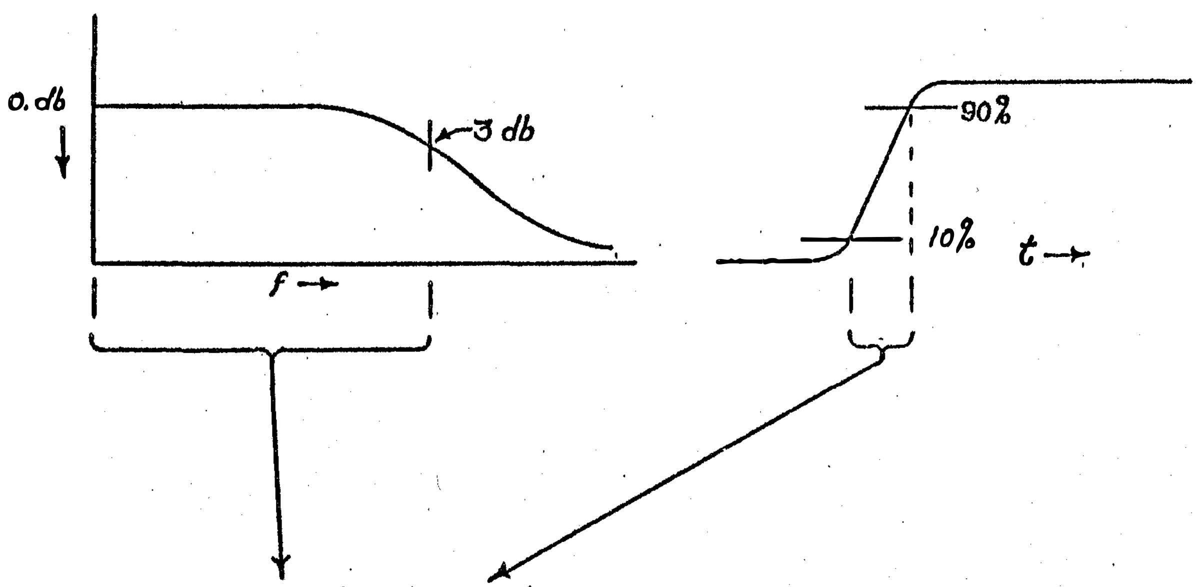


90%
Amplitude
10%
Time
Rise time



Amplitude-frequency response curve

Note that frequency plotted is logarithmic --- for a "rule of thumb", if the 3 db down point occurs at 10 mc, then the 12 db down point will fall approximately at 20 mc



$(BW_{cps})\ (RT_{sec}) = k$; k is a value between .33 and .5 depending upon amount of high-frequency compensation.

$= .35$ (typical value used by TEK)

LIMITS: Overshoot on leading edge less than 2-3%

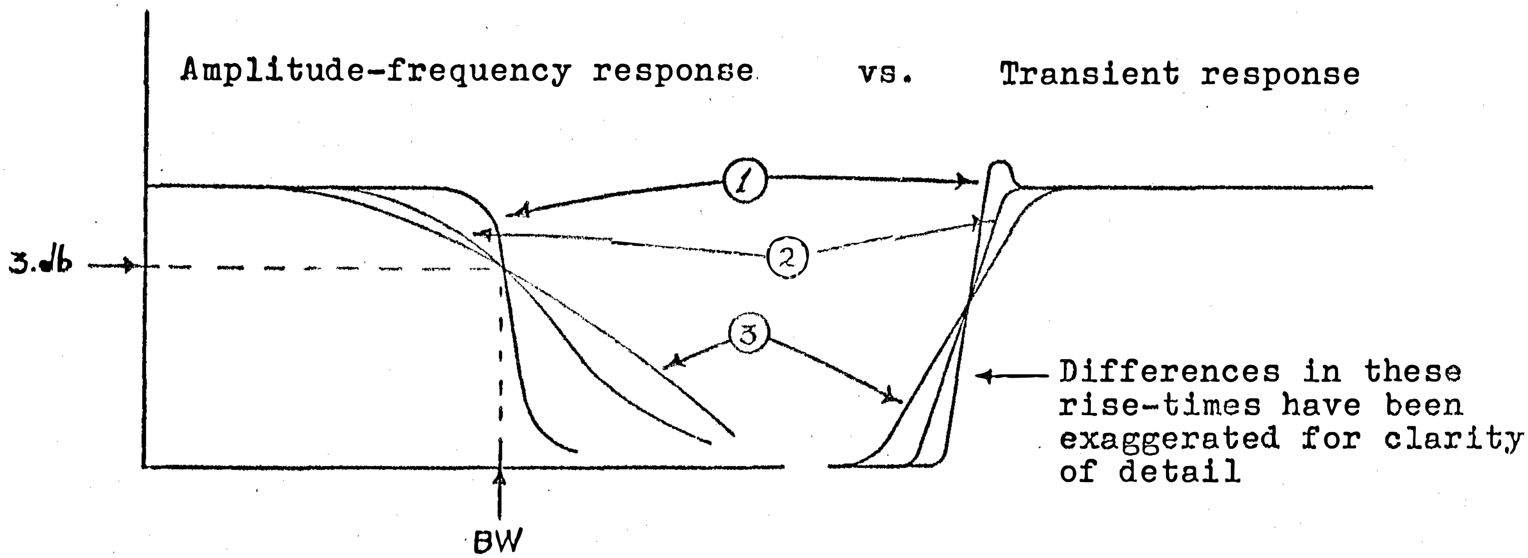
$$(BW)\ (RT) = .35$$

Limits: Overshoot less than 2-3%

$$(RT) = \frac{.35}{(BW)}$$

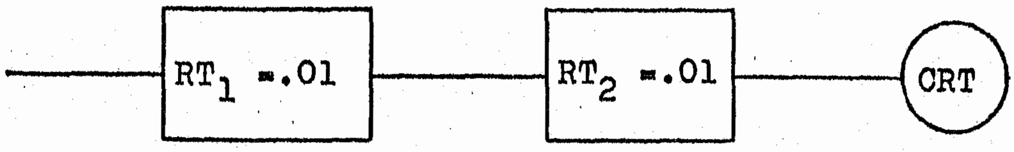
$$(BW) = \frac{.35}{(RT)}$$

EXAMPLE: $RT_{\mu sec} = \frac{.35}{10_{mc}} = 0.035\ \mu sec$



1. Amplitude-frequency response curve "falls off" too rapidly --- causes transient response to show overshoot & ringing;
2. Amplitude-frequency response curve "falls off" along a Gaussian curve and produces the optimum transient response --- the sharpest corner free from overshoot & ringing;
3. Amplitude-frequency response curve "falls off" too slowly --- causing undershoot

Effect of passing a signal through two identical stages:



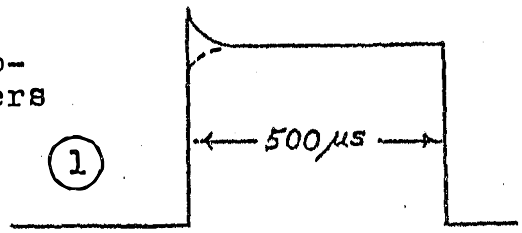
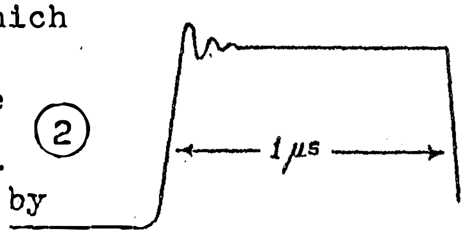
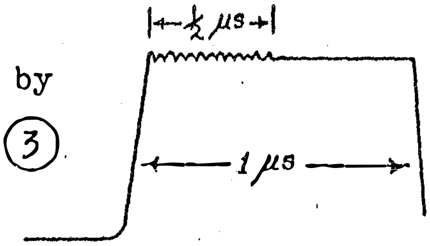
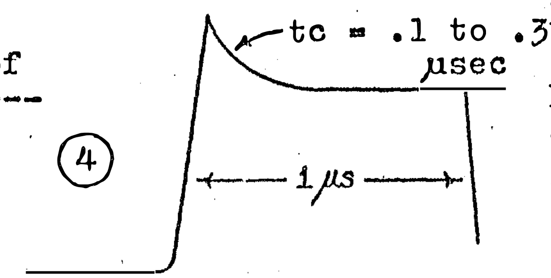
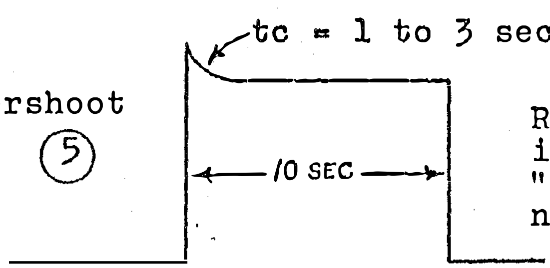
$$RT_t = \sqrt{RT_1^2 + RT_2^2 \ldots\ldots RT_n^2}$$

$RT_1^2 = .0001$

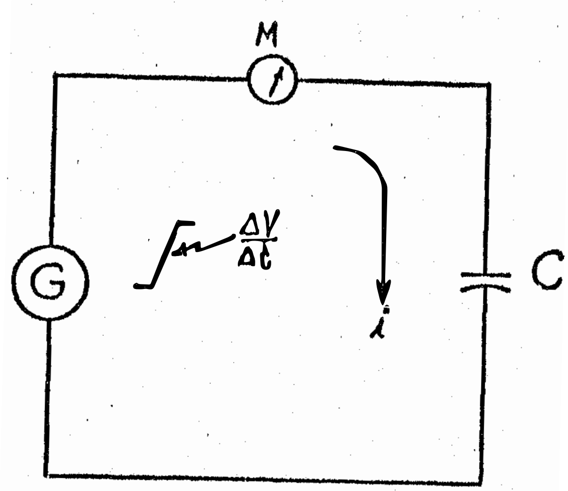
$RT_2^2 = .0001$

$RT_t = \sqrt{.0002} = .014$ (shows a 40% increase in rise-time--just due to passing signal through two equal stages of a video system)

TYPES OF OVERSHOOT

Description & Cause	Display	Cure
Typical overshoot (or undershoot) caused by mis-adjustment of compensated voltage-dividers	(1) 	Adjust compensated voltage-divider trimmer capacitors as required.
Overshoot followed by a high-frequency ring which decays exponentially; typical of video stage or system with excess high frequency gain -- usually brought about by too much inductive or capacitive compensation	(2) 	Adjust high-frequency compensation networks
Typical wrinkles caused by delay line; brought about by inter-section impedance mis-matches, with resulting reflections and standing waves	(3) 	Adjust all trimmers (or as necessary) on the delay line <u>but</u> only after all other sources of overshoot have been eliminated
Typical severe case of "cathode interface" --- a vacuum tube defect	(4) 	Replace tubes until a set is found which shows very little "interface".
Typical "DC-shift" overshoot caused by a vacuum tube defect	(5) 	Replace tube(s) involved or adjust "DC-shift" compensation network.

NOTE: You may have all five of these overshoots present in a vertical amplifier at one time!



$$i = \frac{\Delta V}{\Delta t} C$$

Example:

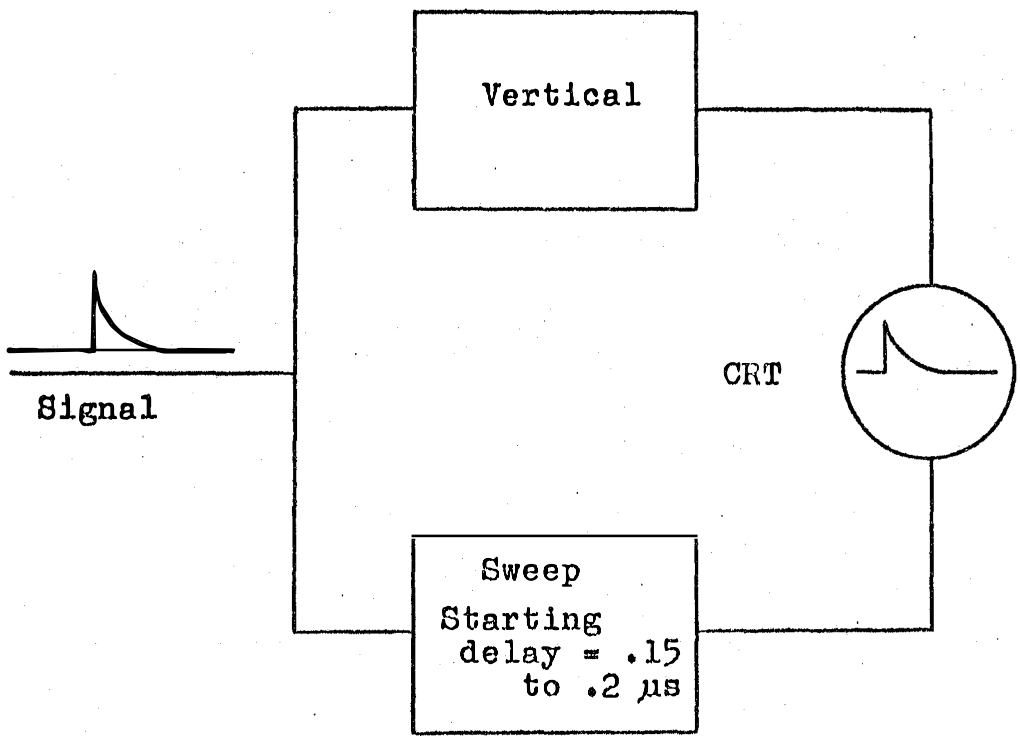
$V = 100.$ volts

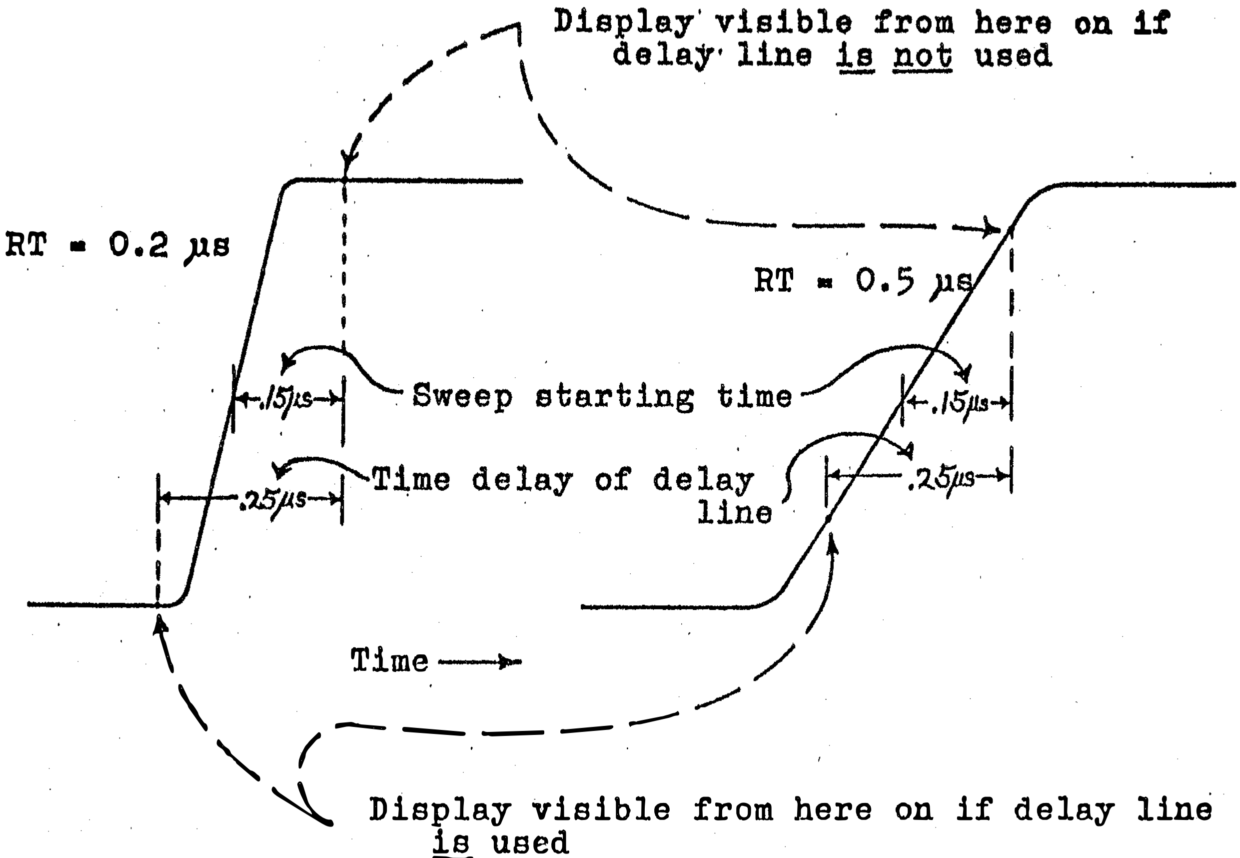
$C = 5\ \mu\mu fd.$

$t = .005$ microseconds

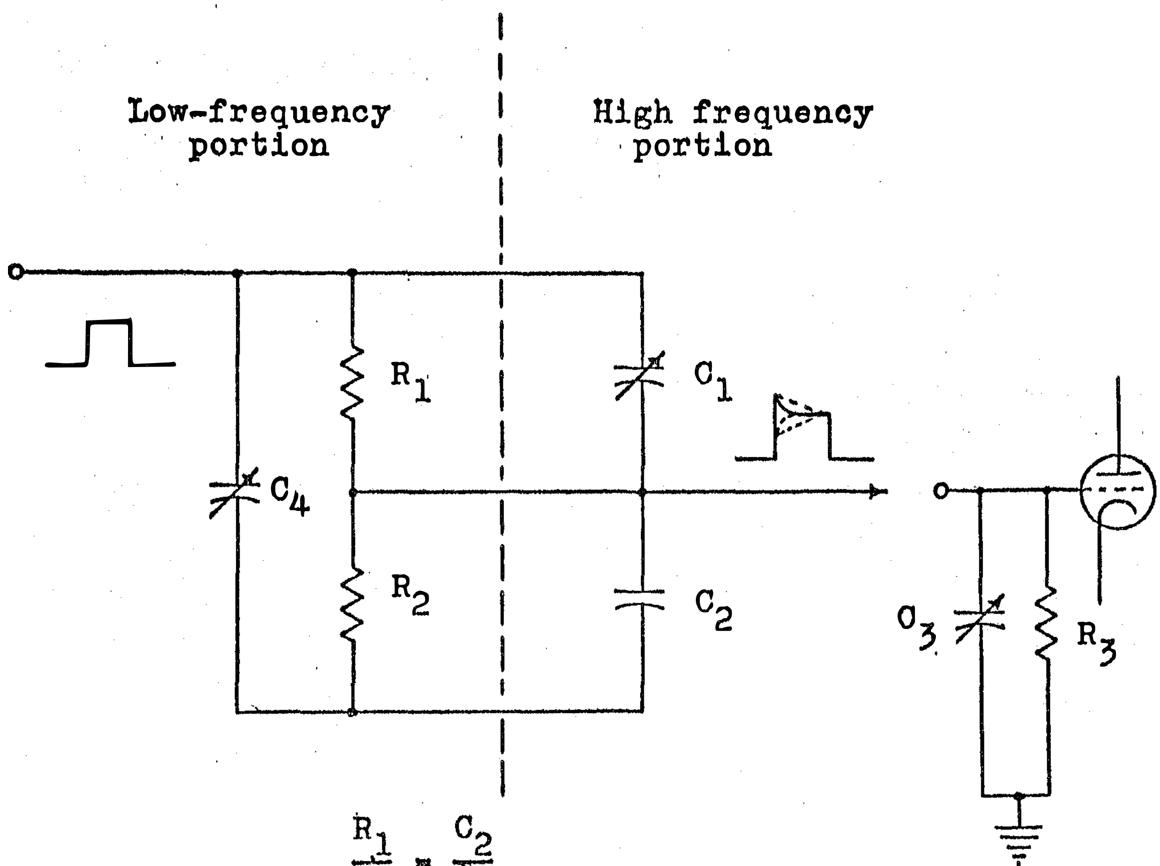
$$i = \frac{(100)\ (5)\ (10^{-12})}{(.005)\ (10^{-6})}, \text{ amperes}; \quad = 100 \text{ mA}$$

Vertical must have about 0.25 µs
delay line




Display visible from here on if delay line is not used
RT = 0.2 µs
RT = 0.5 µs
.15µs
Sweep starting time
.15µs
.25µs
Time delay of delay line
.25µs
Time
Display visible from here on if delay line is used

COMPENSATED VOLTAGE DIVIDER

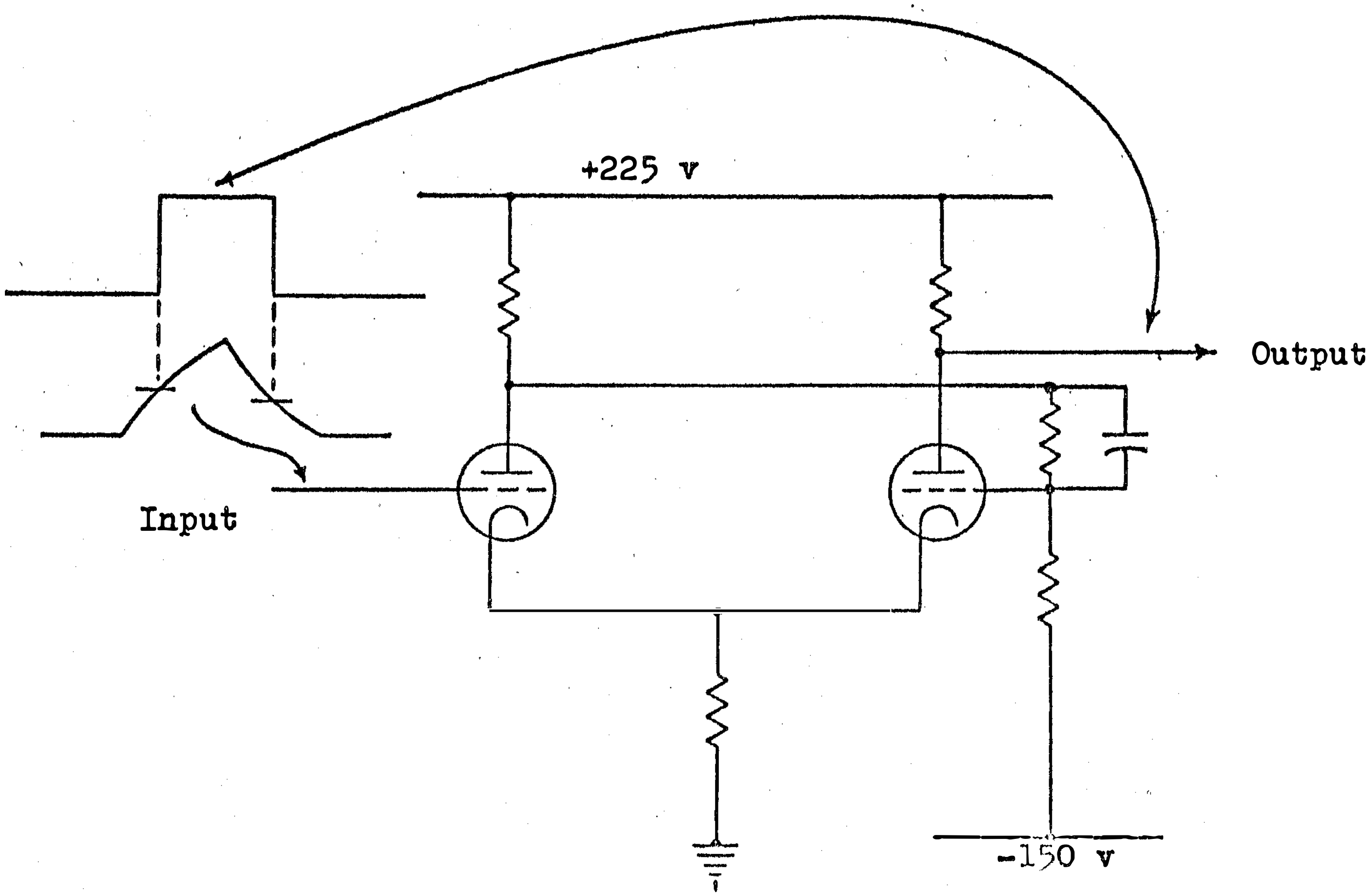


$$\frac{R_1}{R_2} = \frac{C_2}{C_1}$$

or

$$R_1 C_1 = R_2 C_2 \quad \text{(Time constants equal)}$$

BISTABLE MULTIVIBRATOR

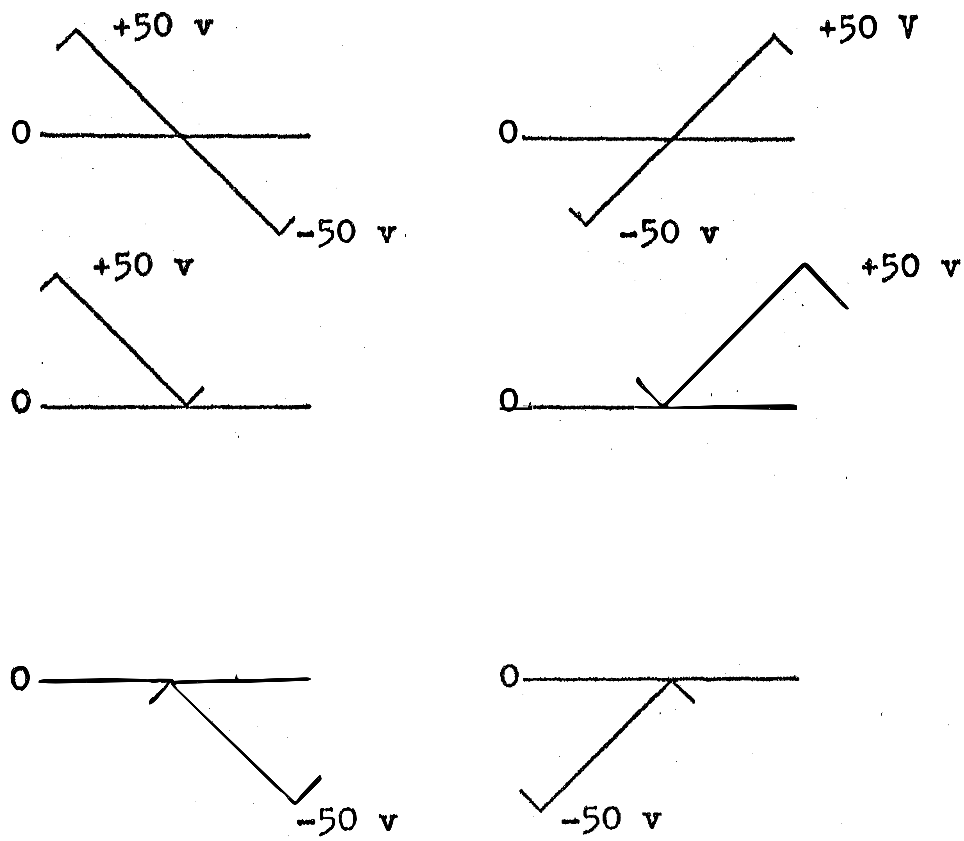


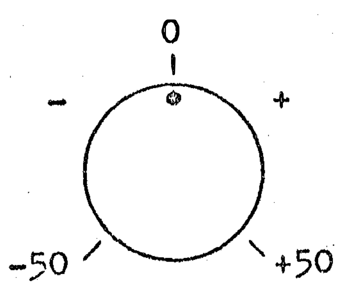
\- Slope:

-Ext
-Int
-Line

\+ Slope:

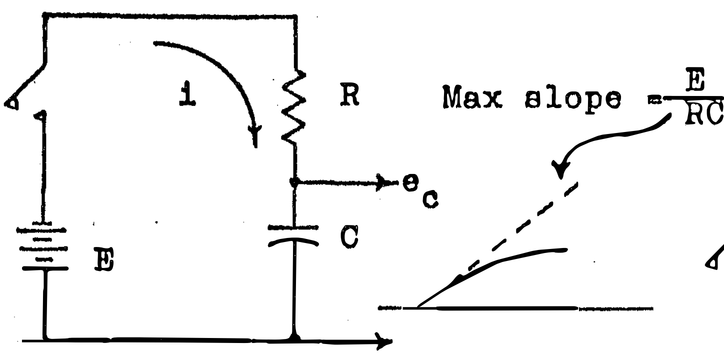
+Ext
+Int
+Line





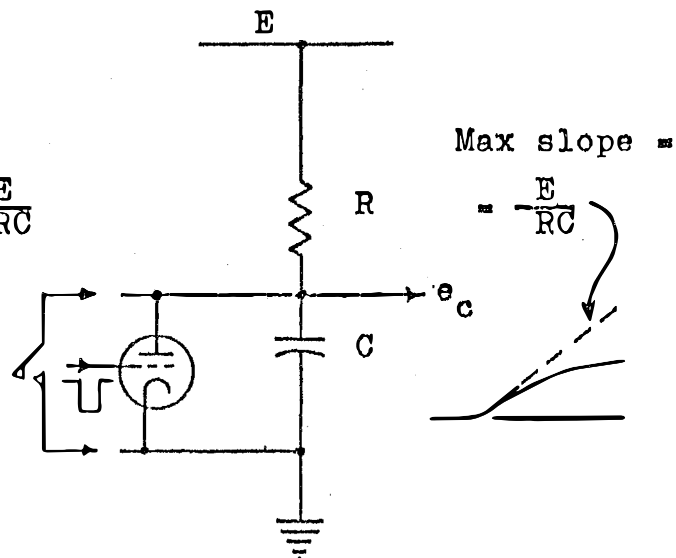
TRIGGERING LEVEL

CLAMP TUBE SWEEP GENERATOR



$$i = \frac{E}{R} e^{-\frac{t}{RC}}$$

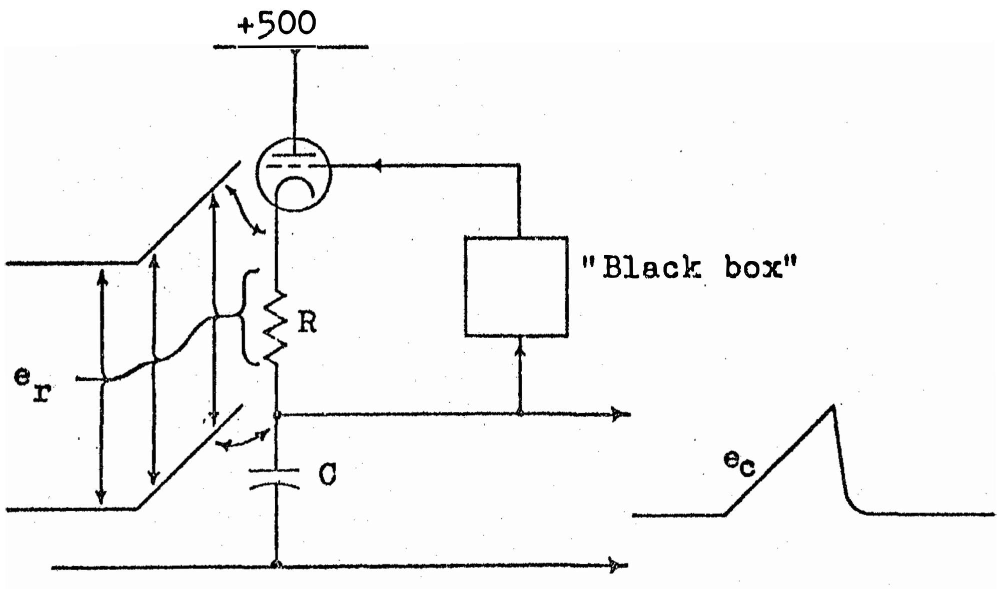
$$e_c = E(1 - e^{-\frac{t}{RC}})$$



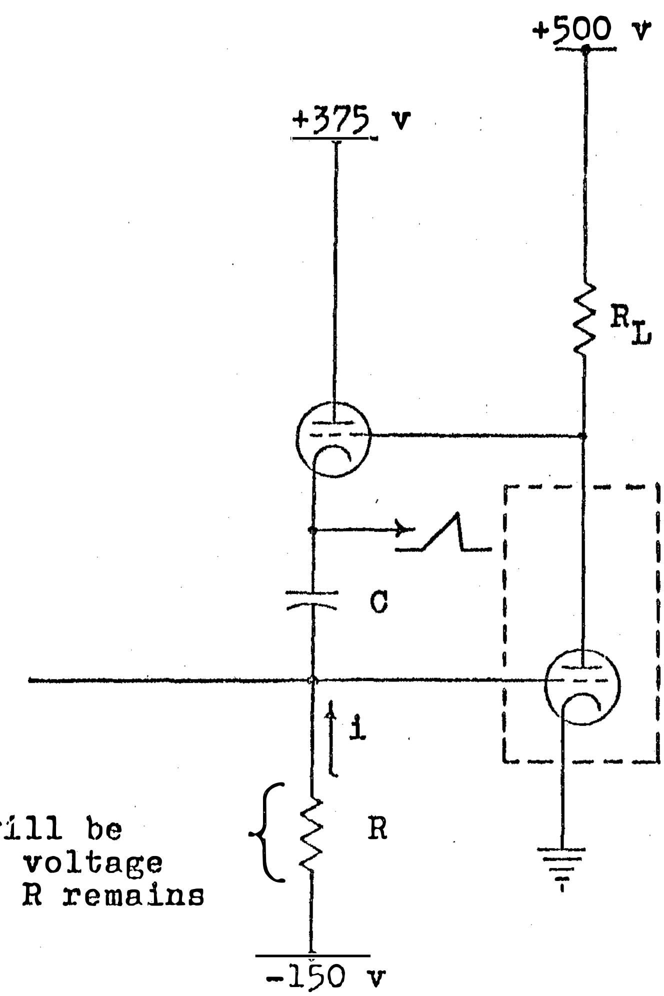
Why is waveshape exponential?

As capacitor charges, voltage drop across resistor steadily decreases --- causing a steadily descreasing current flow into the capacitor per unit of time.

BASIC BOOTSTRAP CIRCUIT



MILLER RUN-UP SWEEP GENERATOR



Current i will be constant if voltage drop across R remains constant.