Chapter 2 Pulse

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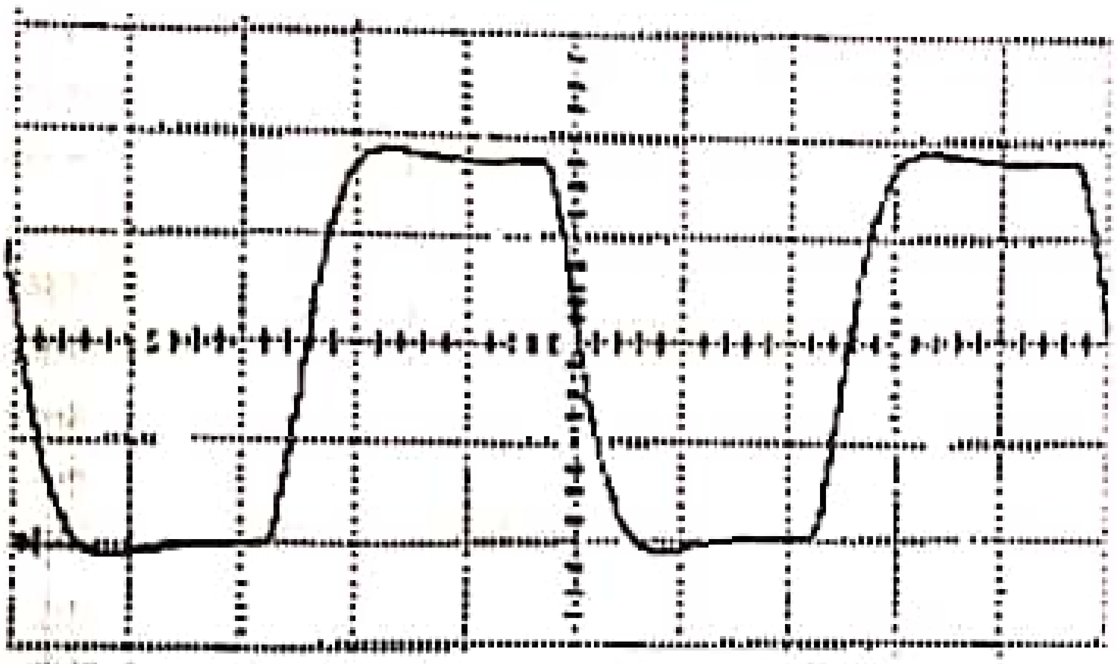


In this experiment, we will learn pulse used in digital communication, the concept of pulse within time domain, noise in pulse transmission, and the method to calculate S/N ratio of pulse signal having much noise.

Also we can express pulse as time and frequency function like as all electric signal. Oscilloscope would be used for observing pulse signal as time function and spectrum analyzer would be used for observing frequency function.

In this chapter, we will observe and measure the characteristics of pulse within time domain such as cycle, width, and peak value.

Experiment 2-1. The Characteristics of Pulse

1. Objectives of Experiment

1. To understand parameter of pulse used in digital communication.
2. To understand the influence when pulse signal pass band limited system.

2. Requiring Equipments

(1) Power Supply(U-2920A)

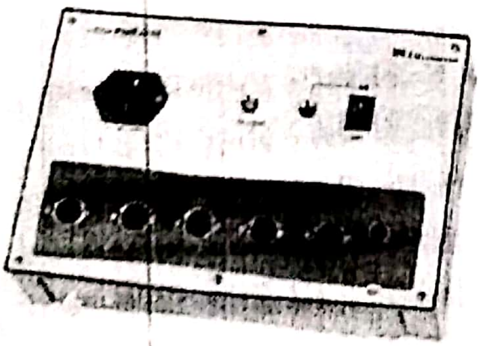
(2) Signal Source(U-2920B)

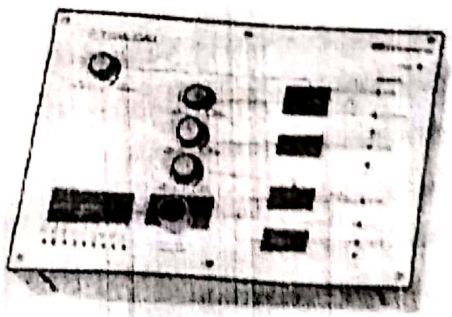
(3) Pulse Amplitude Modulation(U-2920C)

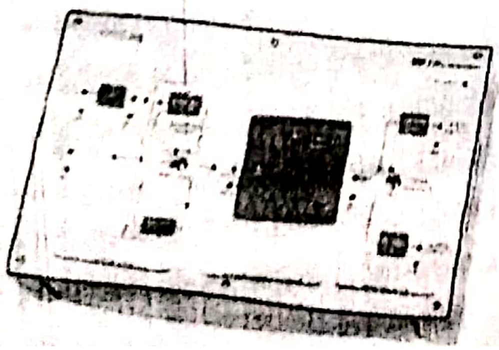
(4) Digital Storage Oscilloscope(2-CH, 60[MHz])

3. Experiment Procedures

(1) Prepare module and measuring device like as figure 2-4. Provide power to device.







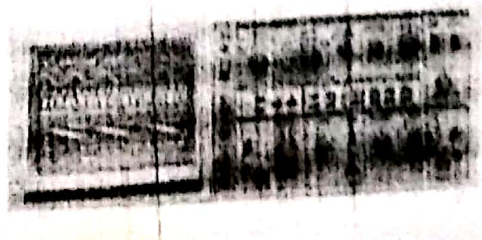


Figure 2-4. Module and Measuring device for experiment

(2) Set oscilloscope to as following:

TIME/DIV	0.2 [ms]	250 μs
VOLT/DIV 1	1 [V]	
TRIGGER MODE	AUTO	
TRIGGER SOURCE	CH-1	
VERTICAL MODE	CH-1	
INPUT COUPLING	DC	
SLOPE	+	

(3) Set FREQUENCY SELECTOR in SIGNAL SOURCE to 1[kHz]

(4) Set INPUT COUPLING of oscilloscope to GND. Set to DC again after making sta line to accord with third line from the bottom by adjusting VERTICAL POSI terminal.

If you connect CH-1 input probe of oscilloscope to CLK terminal of SIGNAL SOURC screen like as figure 2-5 would be appeared.

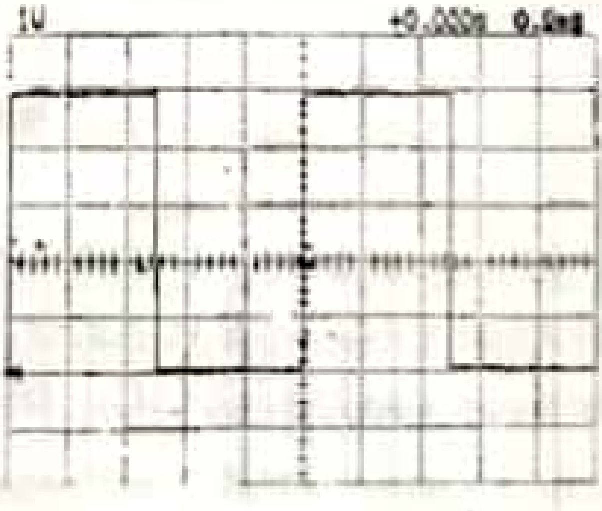


Figure 2-5. pulse parameter measurement

□ What is amplitude value[V] of pulse signal measured by oscilloscope?

□ What is cycle value[sec] of pulse signal measured by oscilloscope?

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ㄷ What is pulse repetition frequency([Hz]) of pulse signal measured by oscilloscope?
ㄷ What is duty cycle value ([%]) of pulse signal?

(5) If you set TIME/DIV of oscilloscope to 0.1[μs], wave form like as figure 2-6(a) would be appeared. And then set SLOPE to (-) and adjust TRIGGER LEVEL to display like as figure 2-6(b).

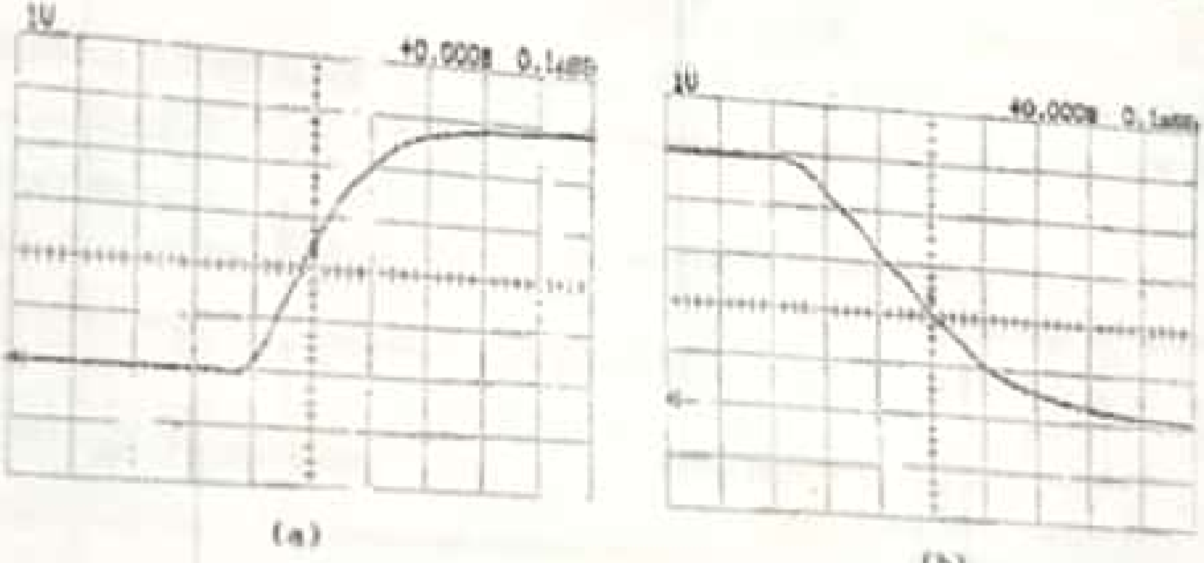

Figure 2-6. (a) Rising time & (b) falling time of pulse

ㄷ What's the value of rising time measured in figure 2-6(a)?
ㄷ What's the value of rising time measured in figure 2-6(b)?

(6) Connect CLK terminal of SIGNAL SOURCE to AUDIO INPUT of PAM module, set VOLT/DIV of oscilloscope to 2[V] and set TIME/DIV to 0.2[ms]. 250µs

If you connect CH-1 input probe of oscilloscope to J1 terminal of PAM module, figure 2-7 would be appeared in oscilloscope screen.

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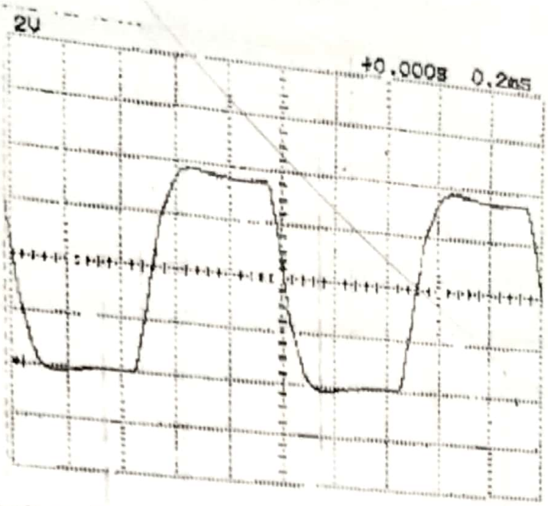


Figure 2-7. Output pulse parameter measurement of low-pass filter

□ What's the amplitude [V] value of pulse signal measured by oscilloscope?

□ What's the cycle and pulse repetition frequency [sec] value of pulse signal measured by oscilloscope?

□ What's the duty cycle and tilt [%] of pulse signal measured by oscilloscope?

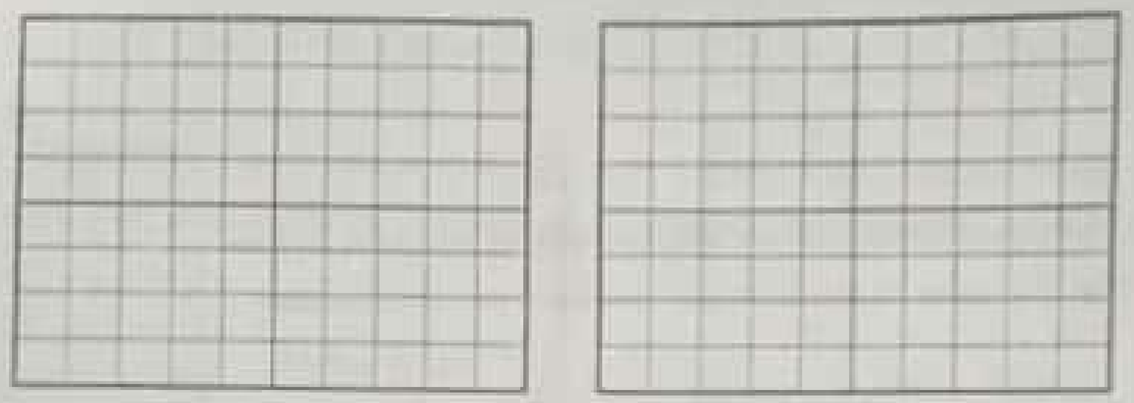
□ What's the value of rising time and falling time [μs] measured by oscilloscope?

□ What's the value of over shoot and under shoot measured by oscilloscope?

(7) Set FREQUENCY SELECTOR to 2[kHz] in SIGNAL SOURCE, set VOLT/DIV of oscilloscope to 2[V] and set TIME/DIV to 0.2[ms].

Draw the shape of output pulse of low-pass filter (Cutoff frequency: f_c = 3.4[kHz]) displayed in oscilloscope screen into figure 2-8(a) by connecting CH-1 input probe of oscilloscope to J1 of PAM module.

(8) Draw the shape of output pulse displayed in oscilloscope screen into figure 2-8(b) with graphic form after setting FREQUENCY SELECTOR to 4[kHz] in SIGNAL SOURCE, VOLT/DIV of oscilloscope to 2[V] and TIME/DIV to 50[μs].



(a) Input frequency 2[KHz] (b) Input frequency 4[KHz]

Figure 2-8. Output pulse of low-pass filter

ⓒ Explain the relationship between cutoff frequency of low-pass filter and input pulse frequency.

(9) Set all power to OFF and remove all connection.

4. Self-Check

1. Define cycle, width and duty cycle of real pulse signal.

2. Calculate the duty cycle when cycle of pulse signal is 50[μs] and the pulse width is 10 [μs].

3. Explain over shoot and under shoot.

4. How pulse signal can affect on output pulse when it pass the low-pass filter?

5. Define the tilt?

Experiment 2-2. The Characteristics of Band Limitation

1. Objectives of Experiment

1. To understand the characteristics of band limitation in time domain.
2. To understand the influence of pulse signal when it pass the band limited system.
3. To learn the relationship rising time and bandwidth of pulse signal.

2. Requiring Equipments

(1) Power Supply(U-2920A)

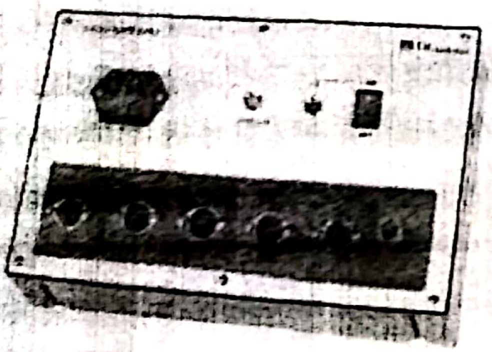
(2) Signal Source(U-2920B)

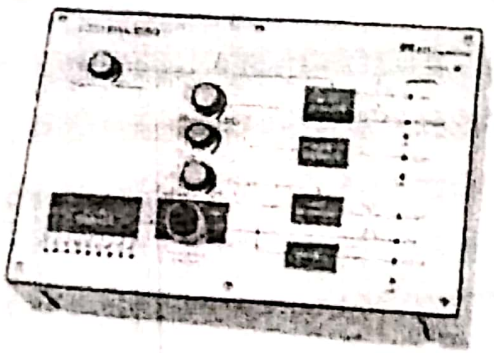
(3) Pulse Amplitude Modulation(U-2920C)

(4) Digital Storage Oscilloscope(2-CH, 60[MHz])

3. Experiment Procedures

(1) Prepare module and measuring device like as figure 2-12 provide power to all devices.





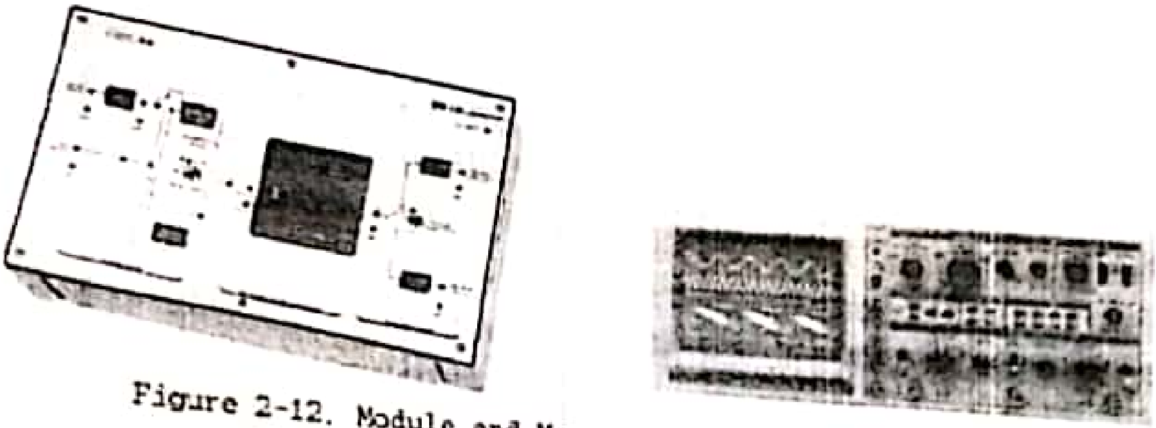


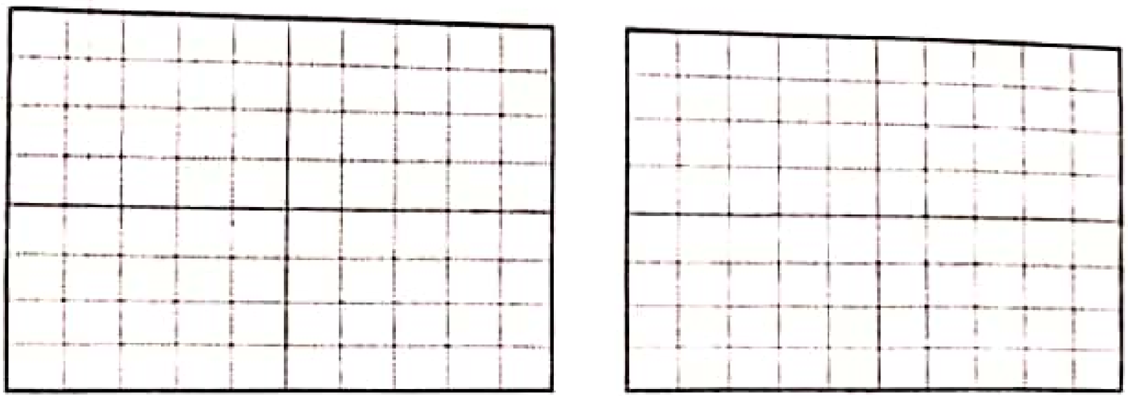
Figure 2-12. Module and Measuring device for experiment

(2) Set oscilloscope to as following:

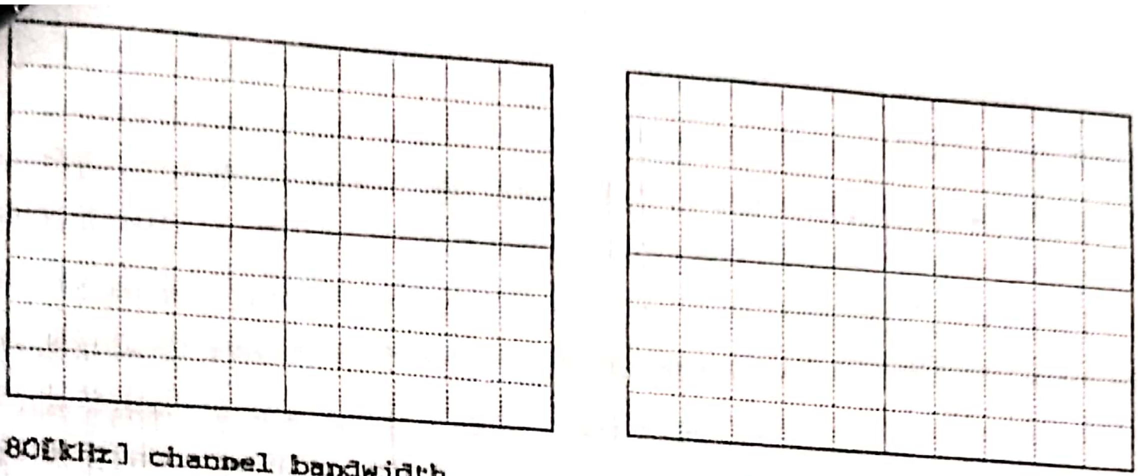
TIME/DIV	20[μs]	25 μs
VOLT/DIV1	2[V]	
TRIGGER MODE	AUTO	
TRIGGER SOURCE	CH-1	
VERTICAL MODE	CH-1	
INPUT COUPLING	DC	

(3) Set FREQUENCY SELECTOR to 8[kHz] in SIGNAL SOURCE.

(4) Draw pulse wave form before the band limitation by connecting CH-1 probe of oscilloscope to CLK terminal of SIGNAL SOURCE into figure 2-13(a).



(a) Pulse before band limitation (b) 40[KHz] channel bandwidth



(c) 80[kHz] channel bandwidth

(d) 160[kHz] channel bandwidth

Figure 2-13. Band limitation characteristics of pulse signal

(5) Remove CH-1 probe of oscilloscope from the CLK terminal of SIGNAL SOURCE.

(6) Connect CLK terminal of SIGNAL SOURCE to J7 terminal, input of channel bandwidth 40[kHz] in PAM module, and connect CH-1 probe of oscilloscope to J8 terminal.

Draw the wave form displayed in figure 2-13(b) into oscilloscope screen. At that time, adjust VERTICAL POSITION terminal for making lower part of pulse to be placed on horizontal gradation of oscilloscope screen.

(7) Set TIME/DIV of oscilloscope to 5[μs] (to be displayed only a half cycle of pulse), measure falling time (t_r) of pulse, record measured value, and then draw it into figure 2-13(b) in diagram.

Table 2-3. Rising time measurement

Cutoff frequency f_H [kHz]	$0.35/f_H$ [μs]	Rising time t_r [μs]
40		
80		
160		

(8) Change the channel bandwidth of PAM module to 80[kHz] and 160[kHz] and then repeat experiment procedure (6) and (7). And then draw the result into figure 2-13(c) and (d) in

diagram.

Frequency displayed on each transmission channel of PAM module indicates the highest cutoff frequency of 2nd low-pass filter and the lowest cutoff frequency is zero. The highest cutoff frequency of low-pass filter(f_H) is almost same as bandwidth B.

(9) Record the result after calculating $0.35/f_H$, against bandwidth of each transmission channel provided in table 2-3.

(10) Draw the result of table 2-3 in graph to indicate rising time against bandwidth into figure 2-14.

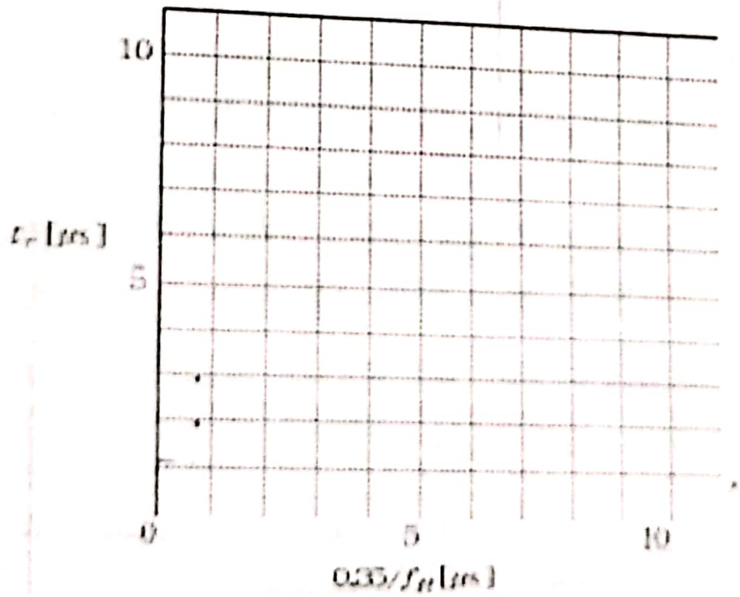


Figure 2-14. Relationship between bandwidth and rising time

☞ Explain the relationship between rising time (t_r) and bandwidth B.

(11) Set all power to OFF and remove all connection

Experiment 2-3. Measurement of Signal & Noise Power

1. Objectives of Experiment

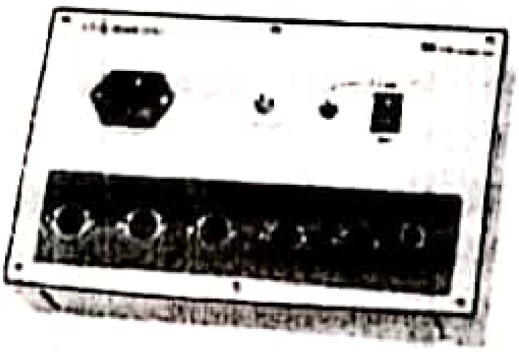
1. To measure noise power and learn the relationship between noise bandwidth and noise power.
2. To measure power of pulse signal and signal to noise ratio of noise signal.

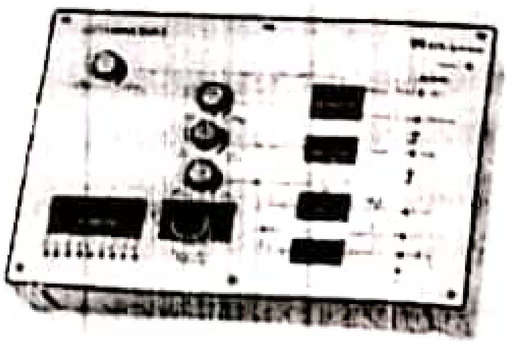
2. Requiring Equipments

(1) Power Supply(U-2920A)
(2) Signal Source(U-2920B)
(3) Pulse Amplitude Modulation(U-2920C)
(4) Distortion Meter(DM-0402)
(5) Digital Multimeter(EDM-4760)
(6) Digital Storage Oscilloscope(2-CH, 60[MHz])

3. Experiment Procedures

(1) Prepare module and measuring device like as figure 2-16 and provide power to all devices.





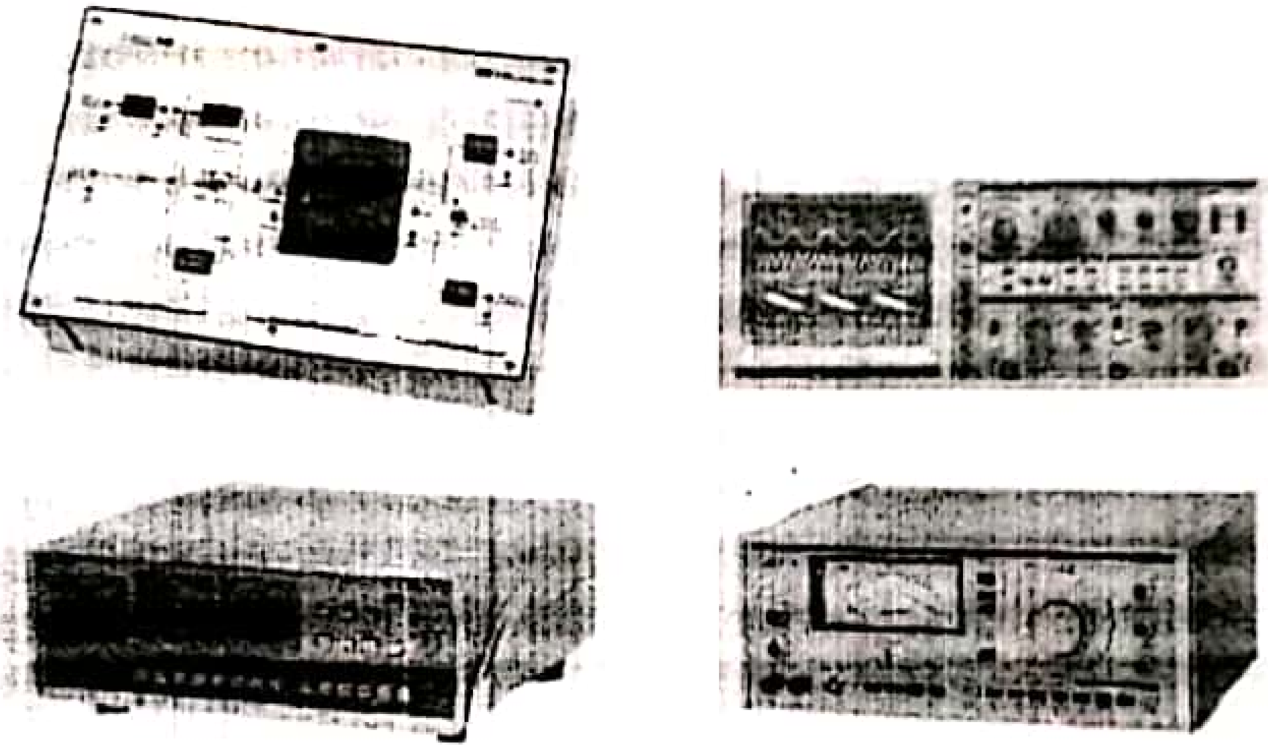


Figure 2-16. Module and Measuring device for experiment

(1) Connect NOISE output terminal of SIGNAL SOURCE to NOISE input terminal J5 o
PAM module.

(2) Connect J6 terminal of PAM module to J11 terminal, transmission channel bandwidth
CH 3(1600[Hz]), and connect 600[Ω] load to where between J12 terminal and GND.

(3) Select FUNCTION of Distortion Meter to [mV], select RANGE to 100[mV], and connec
input terminal to both edges of 600[Ω] load.

(4) Increase Amplitude ADJ. of NOISE GENERATOR in SIGNAL SOURCE little by littl
until Distortion Meter display 60[mV].

(5) Calculate noise power by using $P_n = V_n^2/Z$ formula and record the result into table 2-4

Table 2-4. Noise power depending on bandwidth

bandwidth B [kHz]	noise voltage V_n [mV]	noise power P_n [μW]	noise power spectrum density S_n [W/Hz]
160	60		
80			
40			
load Impedance Z = 600[Ω]			

(6) Set transmission channel bandwidth to CH-2(80[kHz]) and CH-1(40[kHz]) respectively, measure noise voltage V_n, calculate noise power P_n and then record the result into table 2-4.

(7) Calculate noise power spectrum density (S_n) with value of bandwidth B and noise power(P_n) by using formula, $P_n = S_n \times B$ in table 2-4. The process of calculation is as follows.

$$S_n[\mathrm{W/Hz}] = \frac{P_n[\mathrm{W}]}{B[\mathrm{Hz}]} = \frac{10^{-6} \times P_n[\mu\mathrm{W}]}{B[\mathrm{Hz}]}$$

(8) Draw the relationship of noise power (P_n[μW]) against bandwidth B[kHz] into figure 2-17

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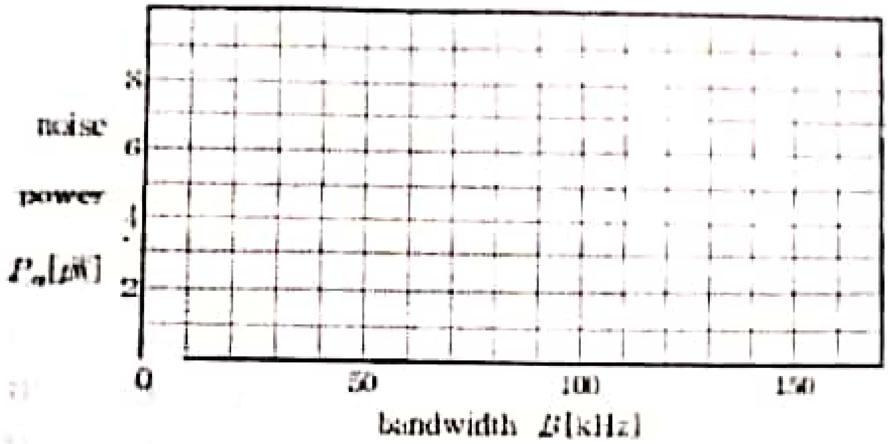


Figure 2-17. Relationship between noise power and bandwidth

□ Explain the relationship between bandwidth and noise power.

(9) Remove all connections that connected with both SIGNAL SOURCE and PAM module and set Amplitude ADJ. terminal of NOISE GENERATOR to MIN.

(10) Set FREQUENCY SELECTOR in SIGNAL SOURCE to 1[kHz] and connect CH-1 input probe of oscilloscope to CLK terminal.

(11) Set oscilloscope to as following:

TIME/DIV	1 [ms]
VOLT/DIV1	1 [V]
TRIGGER MODE	AUTO
TRIGGER SOURCE	CH-1
VERTICAL MODE	CH-1
INPUT COUPLING	DC
SLOPE	+

□ Adjust VERTICAL POSITION terminal for making the lower part of pulse to be located on second horizontal gradation from the bottom.

□ Adjust HORIZONTAL POSITION terminal for making the starting point of pulse to be located on vertical gradation that located in left side of screen.

(12) Remove CH-1 input probe of oscilloscope that connected with CLK terminal of SIGNAL SOURCE and connect 600[Ω] load to where between CLK terminal and GND.

(13) Select FUNCTION of Digital Multimeter to DC V, select RANGE to 20[V], and connect to both edges of 600[Ω] load. And read the direct voltage V_{dc} of pulse signal indicated by DC Voltmeter and record that value into table 2-5.

(14) Select FUNCTION of Distortion Meter to [V], select RANGE to 10[V], and connect to both edges of 600[Ω] load. And read the alternating voltage V_{ac} of pulse signal indicated by Distortion Meter and record that value into table 2-5.

Table 2-5. pulse signal power (50[%] duty cycle)

Measured DC voltage	Measured RMS voltage	signal power (Experimental value)			signal power (Theoretical value)
V_{dc}[V]	V_{ac}[V]	$P_{dc}=V_{dc}^2/Z$ [mW]	$P_{ac}=V_{ac}^2/Z$ [mW]	$P_s=P_{dc}+P_{ac}$ [mW]	$P_s=A^2(PW/T)/Z$ [mW]
$Z=600[\Omega]$, $A=5[V]$					

(15) Calculate P_{dc}, P_{ac}, and total signal power P_s by using V_{dc} and V_{ac} measured in table 2-5 and record the result in table 2-5.

□ Theoretical value and experimental value of signal power (P_s) are same?

□ How percentage of Alternate current of signal power against total signal power? [%]

(16) Remove Distortion Meter and 600[Ω] load that connected to SIGNAL SOURCE

(17) Select FREQUENCY SELECTOR in SIGNAL SOURCE to 1[kHz] and the connect CLK terminal to SIGNAL input terminal J1 of PAM module.

(18) Connect NOISE output terminal of SIGNAL SOURCE to NOISE input terminal J5 of PAM module. At that time, Amplitude ADJ. terminal of NOISE GENERATOR should be located in MIN.

(19) Connect J6 terminal of PAM module to input terminal J11 of transmission channel bandwidth CH-3(100[kHz]) and then connect 600[Ω] load to where between J11 and GND.

(20) Select FUNCTION of Digital Multimeter to DC V, select RANGE to 20[V], and connect to both edges of 600[Ω] load. At that time, connect as opposite to polarity of DC Voltmeter measuring terminal. It is because that internal adder of module has the inverting amplifier type.

Measure direct voltage V_{dc} of pulse signal indicated by Digital Multimeter.

□ V_{dc} = ______[V]

(21) Select FUNCTION of Distortion Meter to [V], select RANGE to 10[V], and connect to both edges of 600[Ω] load.

Measure alternating voltage V_{ac} of pulse signal indicated by Distortion Meter.

□ V_{ac} = ______[V]

(22) Calculate V_s by using formula $V_s = \sqrt{V_{dc}^2 + V_{ac}^2}$ and then record relative signal power P_s [dB] by using formula $P_s\,[\mathrm{dB}] = 10\log(V_s^2/Z)$ into upper part of table 2-6.

Table 2-6. Measurement of signal-to-noise ratio signal voltage V_s = ______ [V], relative signal power P_s = ______ [dB]

relative noise power P_n[dB]	noise voltage V_n[V]	$S/N = (V_s/V_n)^2$	S/N (dB) $= 10\log(S/N)$	S/N (dB) $= P_s$ [dB] $- P_n$ [dB]
(a) -15				
(b) -10				
(c) -5				

(23) Remove the connection between J4 terminal of PAM module and CLK terminal of SIGNAL SOURCE.

(24) Select FUNCTION of Distortion Meter to [V], select RANGE to 1[V], and connect to both edges of 600[Ω] load.

(25) Indicate relative noise power P_n[dB] provided into first column of row(a) in table 2-6 into Decibel [dB] gradation panel of Distortion Meter by increasing Amplitude ADJ. of NOISE GENERATOR in SIGNAL SOURCE little by little.

At that time, if you read most upper gradation of Distortion Meter, it can measure noise voltage V_n. Record this measured voltage to second column of row(a) in table 2-6.

(26) Set oscilloscope to as following:

TIME/DIV	1 [ms]
VOLT/DIV1	1 [V]
TRIGGER MODE	AUTO
TRIGGER SOURCE	CH-1
VERTICAL MODE	CH-1
INPUT COUPLING	AC
SLOPE	-

a Set INPUT COUPLING to GND and adjust VERTICAL POSITION terminal for making standard line to be correspond with horizontal gradation in the center.

(27) Remove Distortion Meter that connected to the both edges of 600[Ω] load and connect CH-1 input probe of oscilloscope to that terminal.

(28) If you connect removed CLK terminal of SIGNAL SOURCE and J4 terminal of PAM module again, the screen like as figure 2-18(a) would be appeared on oscilloscope screen.

(29) Repeat experiment procedure (23)~(28) and record the value row (b) and (c) of table 2-6.

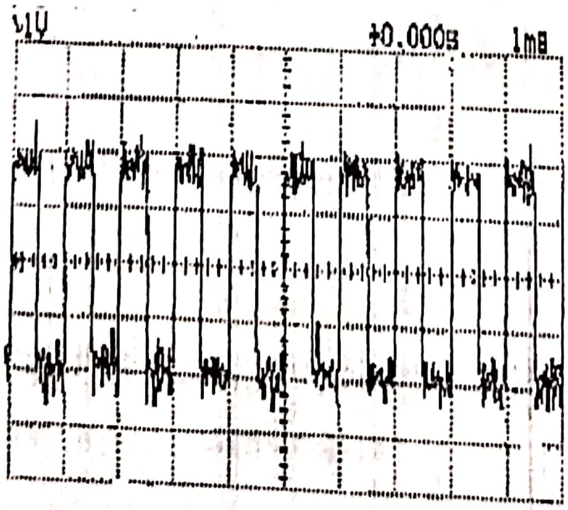
In each case, figure 2-18(b) and (c) would be appeared on oscilloscope screen that connected to the both edges of 600[Ω] load respectively.

(30) Calculate each signal-to-noise ratio by using formula $S/N=(V_s/V_n)^2$, $S/N\,[dB]=10\log[S/N]$, $S/N\,[dB]=P_s\,[dB]-P_n\,[dB]$ and then record results in relevant column of table 2-6.

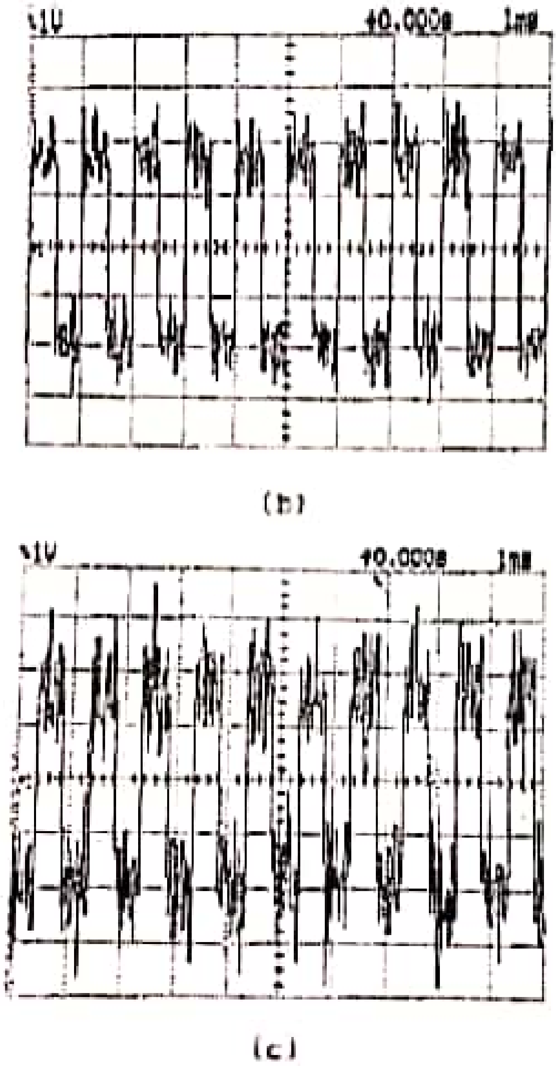
□ The calculated signal-to-noise ratio by using formula $S/N\,[dB]=10\log[S/N]$ 와 $S/N\,[dB]=P_s\,[dB]-P_n\,[dB]$ are same?

□ Explain how the decreasing of signal-to-noise ratio would effect on signal shape.

(31) Set all power to OFF and remove all connection lines.



(a)



(b)

(c)

Figure 2-18. Noise in pulse signal

5. Self-Check

1. What is white noise?

2. What about power of band limited white noise if bandwidth would be increased?

3. Define the decibel.

4. What's the value of valid noise power in output of system? In this system noise power spectrum density S_n is 3×10^{-8}[W/Hz] and bandwidth is 1[MHz].

5. How about signal-to-noise ratio[dB] if signal power is 5[mW] and noise power is 0.1[mW]?

Chapter Test

Q 1. What's the value of old duty cycle of pulse having 10[μs] pulse width and 10[ms] cycle?

① 0.001[%] ② 0.01[%]

③ 0.1[%] ④ 10[%]

Q 2. What's rising time of pulse?

① Time needed for reaching from 10% to 25% of average amplitude.