

Experiment 5-1. A/D & D/A Conversion

1. Objectives of Experiment

1. To understand converting process of Analog-Digital and Digital-Analog.
2. To understand the method of counter type A/D conversion.
3. To understand the method of parallel D/A conversion

2. Requiring Equipments

- (1) Power Supply(U-2920A)
- (2) Signal Source(U-2920B)
- (3) Pulse Code Modulation I (Counter-Type)(U-2920E)
- (4) Digital Storage Oscilloscope (2-CH, 60[MHz])
- (5) Digital Multimeter(EDM-4760)

3. Excrement Procedures

(1) Prepare module and measuring equipment as following figure 5-6. Set all ADJ control terminals to MIN respectively and provide the power to all devices.



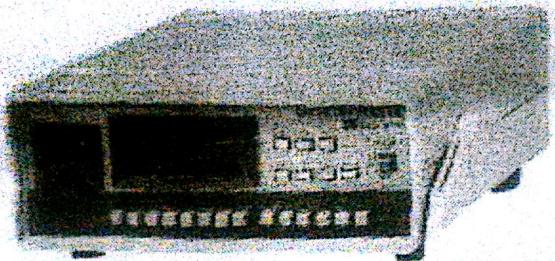


Figure 5-6. Test module & measuring equipments for experiment

- (2) Set frequency selector in Signal source to 8[kHz].
- (3) Connect CLK, RAMP, SINE terminal output of signal source to CLK, RAMP, AUDIO INPUT terminal of PCM I module.
- (4) Connect 32[kHz] of signal generator from signal source to CLK×4 terminal and connect 128[kHz] to CLK×16 terminal of PCM I module.
- (5) Set oscilloscope as follows:

TIME/DIV

0.2[ms]

CH-1 VOLT/DIV
CH-2 VOLT/DIV
TRIGGER MODE
TRIGGER SOURCE
VERTICAL MODE
INPUT COUPLING
SLOPE

5 [V]
5 [V]
AUTO
CH-1
DUAL
DC

- (6) Connect CH-1 input probe of oscilloscope to TP1 of PCM 1, set the frequency to $1[\text{kHz}]$ by adjusting frequency ADJ. control terminal of audio generator and set amplitude to $8[\text{V}_{\text{pp}}]$ by adjusting Amplitude ADJ. control terminal.
- (7) Connect CH-1 input probe of oscilloscope to TP2 of PCM 1, set ramp voltage to $9[\text{V}_{\text{r-r}}]$ by adjusting Amplitude ADJ. control terminal in ramp generator.
- (8) If CH-1, 2 input probe of oscilloscope would be connected to TP1 and J1 of PCM module, two wave forms would be appeared as figure 5-7.

P. 8

- a What's the name of two wave forms appeared in figure 5-7?
- b How many times of sampling and size of phase within one cycle of instantaneous sampling wave form indicated in figure 5-7?

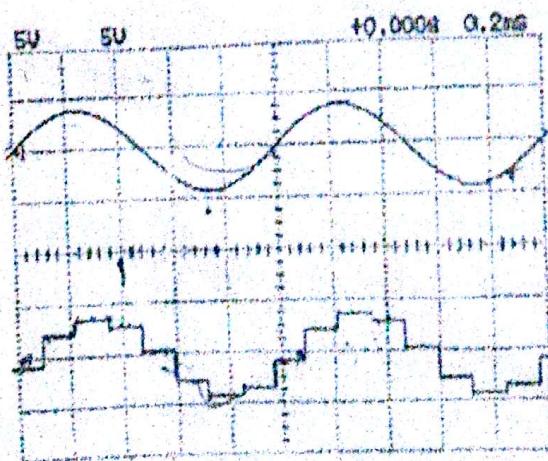


Figure 5-7. Message Signal (above) and Sample-Hold output (below)

- (9) Remove CH-1, 2 input probe of oscilloscope connected to TP1 and J1 terminal of PCM I module and connect J1 terminal and J2 terminal.
- (10) Check whether wave form of oscilloscope as figure 5-8 appears on the screen or not, when input probe of oscilloscope CH-1 would be connected to TP3 of PCM I module. At that time, set TIME/DIV of oscilloscope to 0.1ms.

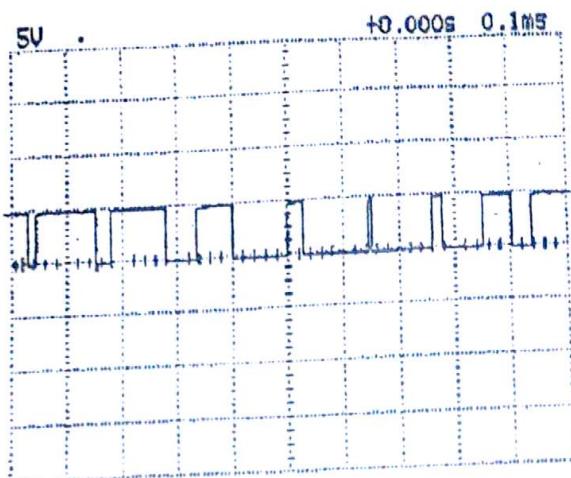


Figure 5-8. TP3's wave form

- » How message signal would be modulated into this wave form?
- (11) If input probe of oscilloscope CH-1, 2 would be connected to SYNC, CLK and PCM OUTPUT terminal of PCM I module, wave form of oscilloscope as figure 5-9 will be appeared. At that time, set TIME/DIV of oscilloscope to $50\mu s$.

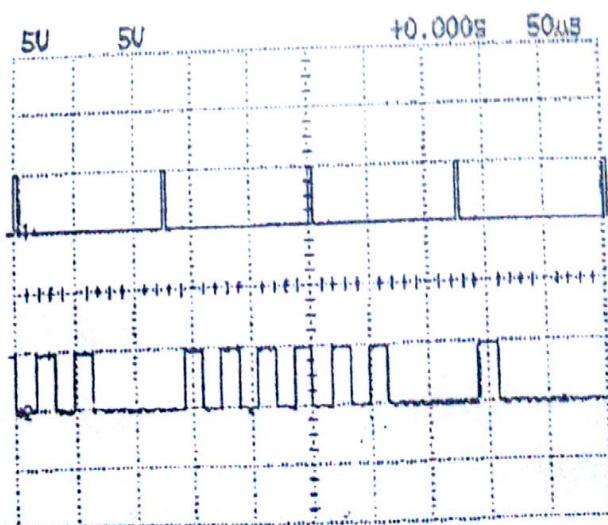


Figure 5-9. Clock signal(above) and PCM direct signal(below)

- n Check how many number of pulse wave form of CH-2 would be included during CH-1 input wave form of oscilloscope. Enter 4-bit codes. (10)
- (12) If input probe of oscilloscope CH 1, 2 would be connected to J1 and PCM OUTPUT terminal of PCM 1 module, wave form of oscilloscope as figure 5-10 will be appeared. At that time, adjust TIME/DIV to 50[μ s] for making the size of quantization phase to appear on the oscilloscope screen with about four pieces.

But PCM direct output signal would be appeared with delay as much as one cycle of quantization phase. That is to say, we can realize that it would be appeared by delaying with one cycle toward right side in oscilloscope.

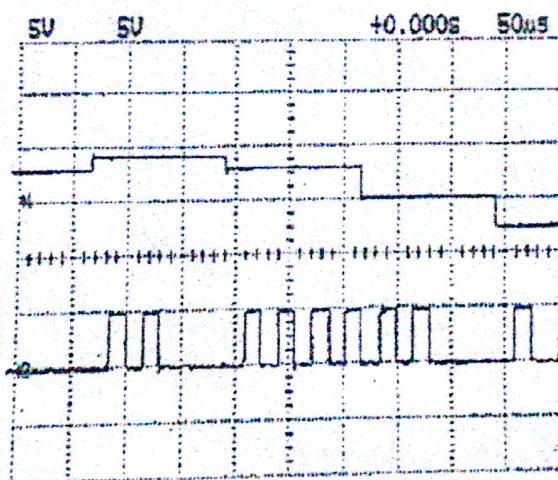


Figure 5-10. Phase size of Instantaneous sampling(above) & PCM direct signal (below)

o How many pulse of PCM signal against maximum phase size of instantaneous sampling wave form?

o Please explain scaling A/D conversion process? ✓

(13) Remove AUDIO INPUT of PCM I module connected to SINE input of SIGNAL SOURCE temporarily and also remove connection line connecting J1 terminal and J2 terminal temporarily.

(14) Connect DC VOLTAGE $\pm 5[V]$ output terminal of POWER SUPPLY to J2

terminal of PCM-I module.

(15) Make lighting status of ENCODER DISPLAY Diode to equal with table 5-2 by adjusting DC VOLTAGE ADJ. control terminal.

At that time, measure the voltage range of J2 terminal and record it into table 5-2.

Table 5-2. 4-bit A/D Conversion's Code word

ENCODE DISPLAY				Voltage Range [V]
D3	D2	D1	D0	
ON	ON	ON	ON	~
ON	ON	ON	OFF	~
ON	ON	OFF	ON	~
ON	ON	OFF	OFF	~
ON	OFF	ON	ON	~
ON	OFF	ON	OFF	~
ON	OFF	OFF	ON	~
ON	OFF	OFF	OFF	~
OFF	ON	ON	ON	~
OFF	ON	ON	OFF	~
OFF	ON	OFF	ON	~
OFF	ON	OFF	OFF	~
OFF	OFF	ON	ON	~
OFF	OFF	ON	OFF	~
OFF	OFF	OFF	ON	~
OFF	OFF	OFF	OFF	~

» The phase size of A/D conversion?

(16) From now on, we will perform the test on D/A conversion and PCM demodulation.

Connect AUDIO INPUT of PCM I module to SINE output of SIGNAL SOURCE again, remove DC VOLTAGE ±5[V] terminal connected with J2 terminal, and then connect J1 terminal and J2 terminal again.

(17) Connect SYNC. CLK, CLK×4, and PCM OUTPUT of DECODER to SYNC. CLK, CLK×4, and PCM INPUT respectively. And then connect J3 terminal and J4 terminal.

(18) If we set INPUT COUPLING of oscilloscope CH-1, 2 to AC and connect each probe to TPI and J3 terminal of PCM I, wave form of figure 5-11 would be appeared in oscilloscope screen. At that time, set TIME/DIV of oscilloscope to 50[μ s].

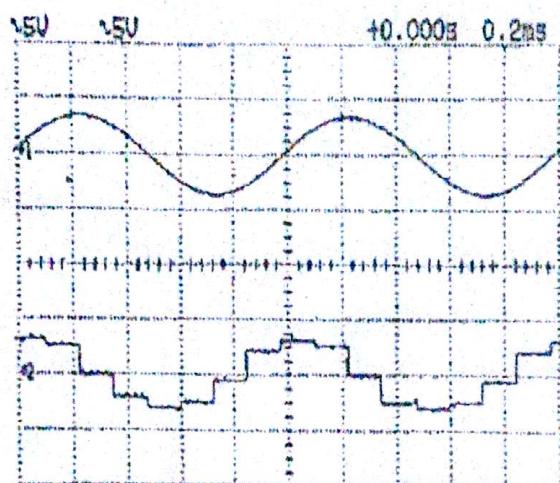


Figure 5-11. Message Signal(above) & D/A conversion demodulation output(below)

- Please explain the form of demodulation message signal processed with D/A conversion.
 - When we measure amplitude of input message signal and demodulation message signal, what is difference?
- (19) Compare and observe input message signal and demodulation message signal by connecting CH-1 input probe of oscilloscope to AUDIO OUTPUT of PCM I module.
- These two signals are similar?
- (20) Connect CH-2 input probe of oscilloscope to J3 terminal of PCM I module.
- (21) Make the ramp voltage to 6[Vp-p] by adjusting Amplitude ADL control terminal of RAMP GENERATOR from PCM I. At that time, oscilloscope would be appeared as figure 5-12.

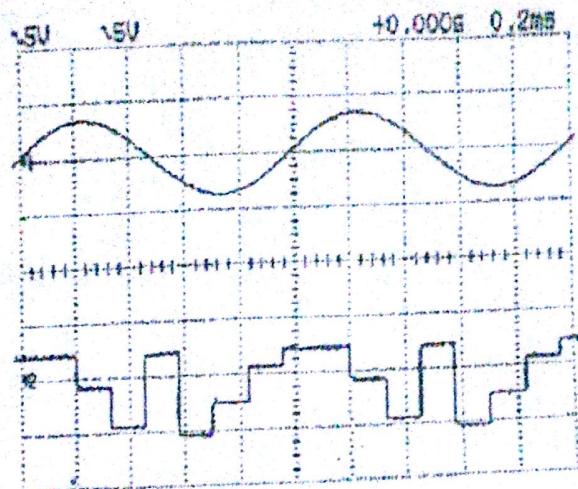


Figure 5-12. Message signal(Above) & Clipping D/A conversion output(below)

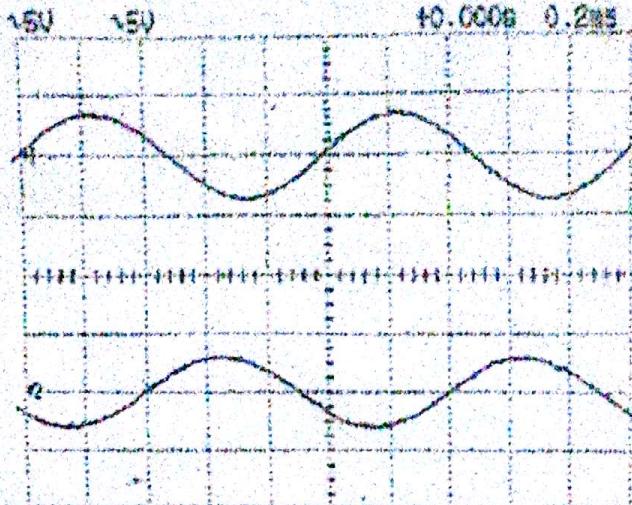
- Why distortion would be occurred in recovered message signal?
- What is the name of this kind of distortion?

(22) Adjust ramp voltage to $9[V_{ref}]$ by adjusting Amplitude ADJ. control terminal of RAMP GENERATOR again.

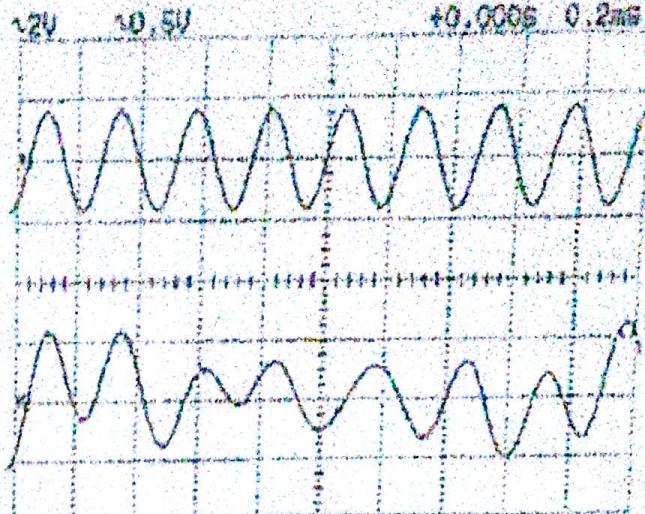
If we connect CH-2 input probe of oscilloscope to AUDIO OUTPUT of PCM I, wave form like as figure 5-13(a) would be appeared.

(23) Adjust frequency to $40kHz$ by adjusting Frequency ADJ. control terminal of AUDIO GENERATOR in SIGNAL SOURCE.

If we connect CH-2 input probe of oscilloscope to AUDIO OUTPUT of PCM I, wave form like as figure 5-13(b) would be appeared.



(a) Status without Aliasing



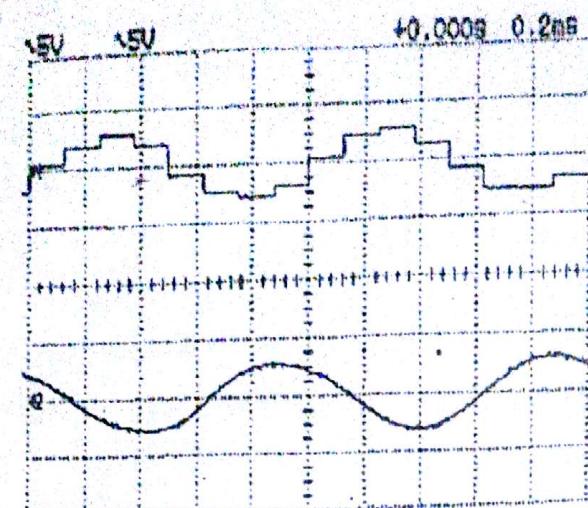
(b) Status with Aliasing

Figure 5-13. Message signal(Above) & Demodulation message signal(below)

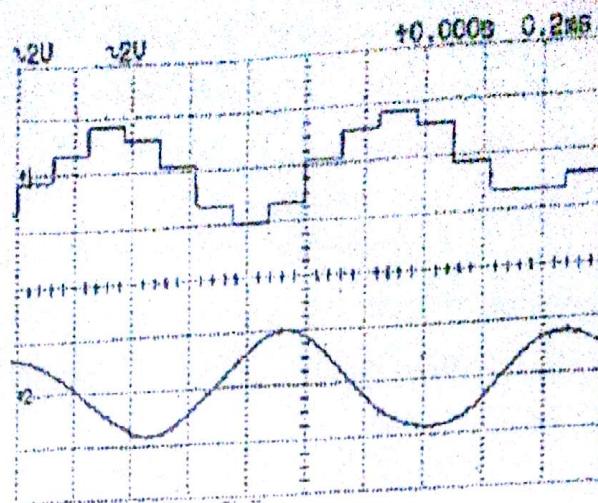
- Why distortion would be occurred in demodulation message signal?
- What is the name of this kind of distortion?

- (24) Adjust frequency to 1[kHz] by adjusting Frequency ADJ. control terminal of AUDIO GENERATOR in SIGNAL SOURCE.
- (25) If we connect CH-1, 2 input probe of oscilloscope to J3 terminal and AUDIO OUTPUT of PCM 1 module, wave form like as figure 5-14(a) would be appeared in the screen.
- (26) Make 3-bit code word by connecting 128[kHz] of SIGNAL GENERATOR connected to CLK×16 terminal of PCM 1 module to 64kHz. If we set VOLT/DIV of oscilloscope to 2[V], the result would be indicated like as figure 5-14(b).
- (27) Make 2-bit code word by connecting CLK×16 terminal of SIGNAL GENERATOR to 32[kHz]. If we set VOLT/DIV of oscilloscope to 1[V], the result would be indicated like as figure 5-14(c).
- (28) Make 1-bit code word by connecting CLK×16 terminal of PCM 1 module to 16[kHz] of SIGNAL GENERATOR.

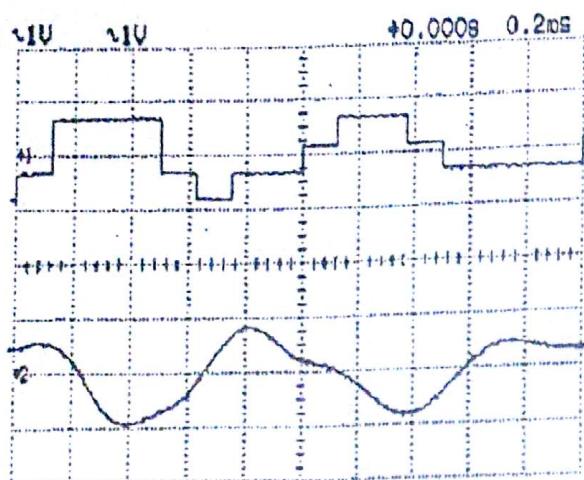
The screen of oscilloscope appears like as figure 5-14(d).



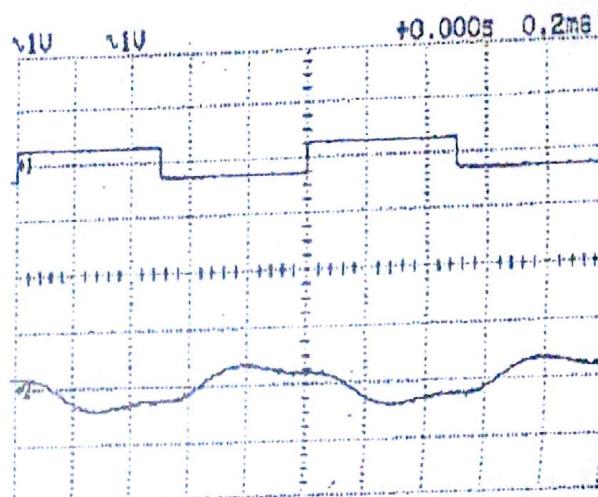
(a) 4-bit Code word



(b) 3-bit Code word



(c) 2-bit Code word



(d) 1-bit Code word

Figure 5-14. Lowpass Filtering Effect against the length of code word

- Is recovered message similar to original message signal?
 - What's the reason for distortion occurred in recovered signal? Also is there any method for protecting distortion?
- (28) Connect CLK $\times 16$ terminal of PCM 1 module and 128[kHz] output terminal of SIGNAL GENERATOR again for driving 4-bit code word.
- (29) Remove AUDIO INPUT terminal of PCM 1 module connected with SINE output of SIGNAL SOURCE and then remove connection line between J1 terminal and J2 terminal.

(30) Connect DC VOLTAGE $\pm 5[V]$ output terminal of POWER SUPPLY to J2 terminal of PCM I.

(31) Set FUNCTION of Digital Multimeter to DC V and RANGE to 20[V] respectively.

(32) Make lighting status of ENCODER DISPLAY Diode to equal with table 5-3 by adjusting DC VOLTAGE ADJ. control terminal.

At that time, measure the J3 terminal voltage by using Digital Multimeter and record it into table 5-3.

In Digital Multimeter, (+) measuring terminal would be connected to GND and (-) measuring terminal would be connected to J3 terminal.
Because signal would be reversed by internal amplifier.

Table 5-3. 4-bit D/A conversion's output voltage

DECODE DISPLAY				Output Voltage [V]
D3	D2	D1	D0	
ON	ON	ON	ON	
ON	ON	ON	OFF	
ON	ON	OFF	ON	
ON	ON	OFF	OFF	
ON	OFF	ON	ON	
ON	OFF	ON	OFF	
ON	OFF	OFF	ON	
ON	OFF	OFF	OFF	
OFF	ON	ON	ON	
OFF	ON	ON	OFF	
OFF	ON	OFF	ON	
OFF	ON	OFF	OFF	
OFF	OFF	ON	ON	
OFF	OFF	ON	OFF	
OFF	OFF	OFF	ON	
OFF	OFF	OFF	OFF	

☞ What is step size of D/A conversion?

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

