Department of Electrical and Electronic Engineering (EEE)
Bangladesh University of Engineering and Technology (BUET)

EEE 310: Communication Laboratory

EXPERIMENT NO: 4
SAMPLING AND SIGNAL RECONSTRUCTION

Performance Objectives:

A) Investigate methods used to sample a signal and to recognize the signal that results form each method.
B) Investigate a method used to reconstruct the intelligence from a sampled signal and demonstrate how the sampling signal frequency and the lowpass filter characteristic affect reconstruction.

Equipment and Materials:

1) Power source
2) Oscilloscope
3) AF generator
4) Frequency counter
5) Pulse Modulation Trainer Board
6) Patch chord

Basic Concept:

1) Sampling is a method used in pulse modulation to identify the intelligence signal by a sequence of pulses that represents the intelligence signal by a sequence of pulses that represents the intelligence at a particular time.
2) Natural sampling is a type of sampled signal in which the to of each sample pulse follows the intelligence signal during the pulse-width time of the sampling signal.
3) Flat-topped sampling is a type of sampled signal in which the to of each sample pulse represents a signal level of intelligence during the pulse-width time of the sampling signal.
4) The sampling principle states that the intelligence can be reconstructed by filtering when the sampling signal frequency or sampling (Fs) is greater then twice the maximum intelligence signal frequency (Fm).
5) The Nyquist rate is a condition that occurs when the sampling signal frequency is equal to twice the maximum intelligence signal frequency ($Fs = 2Fm$, where Fs is the sampling signal frequency and Fm is the maximum frequency of the intelligence signal).
6) The frequency response of the low-pass filter must be capable of passing the maximum intelligence signal to reconstruct the intelligence signal frequency while rejecting side band frequencies of the sampling signal to reconstruct the intelligence free of distortion.

Exercise Procedure:

Objective A: **Investigate methods used to sample a signal and to recognize the signal that results from each method**.

1. a) Connect a +15Vdc supply voltage across the +15V and GND jack and –15Vdc-supply voltage across the –15V and GND jacks on the trainer, as described in the power supply connection diagram.

   b) Connect the circuit shown in figure 8-1, which uses natural sampling. Turn the FREQ ADJ control on the CLOCK circuit fully counterclockwise. Turn the trainer power on. Trigger the scope on channel 1. Set the AF generator for a sine wave out put of 3Vp-p at 1Khz or below. This is the intelligence signal input to the sampler circuit.

   c) Connect a second probe from channel 2 of the oscilloscope to J8. This is the sampled output. Observed the output of the sampler circuit at J8 and carefully adjust the AF generator to stabilize the waveform. Explain how the sampled output at J8 is related to the intelligence signal input at J6.

   Note: This adjustment is sensitive since the oscilloscope is displaying two unrelated frequencies.

   d) Move the scope prove connected at J6 to J9. The signal at J9 is a pulse train that represents the sampling signal for a sampler circuit.

   e) Turn off power to the trainer.

2. a) Now connect the circuit shown in figure 8-2, which uses flat-topped sampling. Turn on power to the trainer and observe the signal at J14 on channel 1. The signals input to J14 represent the intelligence signal to the sampler/hold circuit.

   b) Connect a second scope probe from channel 2 of the oscilloscope to J17. Trigger the oscilloscope on channel 1. The signal at J17 is a pulse train, which represent the sampling signal input to the sampler circuit.

   c) Move the scope probe connector at J17 to the output of the sampler/hold circuit at J16. Trigger the scope on channel 1. Carefully adjust the AF generator to stabilize 4 the waveform displayed on channel 2 (see note in step 1. ©. Explain the signal output at J16.

   d) Move the channel 1 probe connected at J14 to the output of the sampler circuit at J8. Move the channel 2 probe connected at J16 to the sampling signal input of the sampler circuit at J9. Identify and describe the signal at J8 and J9.

   e) Turn off power to all equipment.

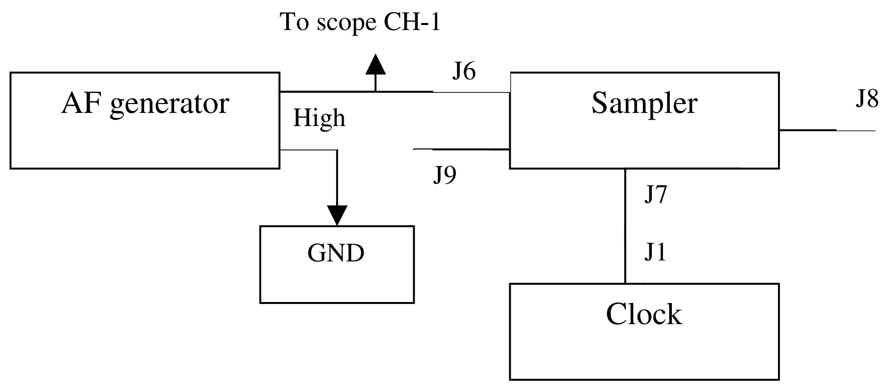

Fig. 4-1

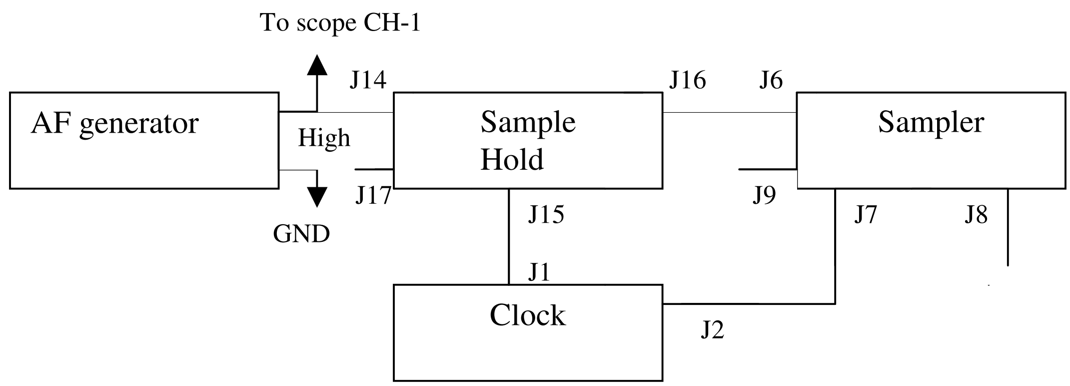

Fig. 4-2

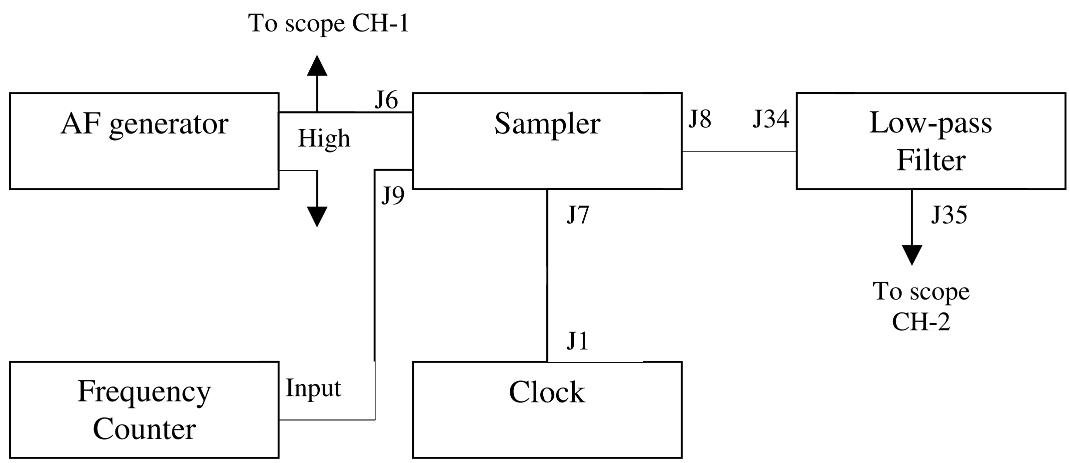

Fig. 4- 3

Objective B: Investigate a method used to reconstruct the intelligence from a sampled signal and demonstrate how the sampling signal frequency and the lowpass filter characteristic affect reconstruction.

3. a) Connect the circuit shown in figure 8-3. Turn the FREQ ADJ control on the CLOCK circuit to have a sampling frequency of Fs=16 kHz. Turn on power to the trainer and set the AF generator to 5 kHz 3Vp-p. the signal output from the low pass filter at J35 (displayed on channel 2 of the oscilloscope) represents the reconstructed intelligence signal.

   b) Observe the reconstructed intelligence and the original intelligence. Is there distortion in the reconstructed intelligence signal?

   c) Record the exact sampling frequency, f_s =- -------------kHz. How does the sampling signal frequency compare with the Nyquist rate for the intelligence signal?

   d) What reason can be given to indicate why the reconstructed intelligence output from the low pass filter at J35 contain some distortion even if $f_s > 3f_m$?

   e) Connect the second low pass filter in cascade with the first (connect a jumper wire from J35 to J36). Connect the channel 2 probe to J37. Observe the reconstructed intelligence signal at J37. What effect does cascading the second low pass filter produce on the reconstructed intelligence signal? Explain –

   f) Slowly rotate the FREQ ADJ control counterclockwise while observing the reconstructed intelligence signal. What sampling signal frequency starts to distort the reconstructed intelligence signal? F_s=---------------- kHz.

   g) use the value of f_s recorded in step (f) to determine how it compares with the Nyquist rate and the value recorded in step(c). Relate the f_s value to the resulting reconstructed intelligence and filter circuitry used. What can you conclude?

   h) Move the channel 1 probe connected at j6 to j35 to view the reconstructed intelligence output from the first lowpass filter. Rotate the FREQ ADJ control to set the sampling signal frequency at 6kHz. Sketch the signals.

   i) Rotate the FREQ ADJ control to set the sampling signal frequency such that the lower side band frequency of f_s falls below f_m. What condition does this create? Explain.

   j) Turn off Power to all equipment.

Report:

i) All your observations including the sketch of the waveforms at various stages.
ii) Draw the amplitude spectrum of a sine wave before and after the sampling process.
iii) Describe the required characteristics of the lowpass filter, and the sampling frequency to reconstruct the intelligence signal.

Labsheet Revised by:
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