Mixed Signal

Please study the interesting and appropriate sections of H&H, Ch. 10, 12,and 13.5.1. You should already be familiar with the mathematical "Boolean" sections, so please concentrate on the sections relating to electrical characteristics, flip-flops, one-shots, debouncing, etc.as well as sampling theory.

Part1, PWM Modulation/Demodulation

Design a circuit that will produce a PWM waveform that will be the digital representation of an input signal. This waveform will be sent over a transmission channel to a receiver/converter which will reconstruct the original signal. The transmitter and receiver will be coupled by an opto coupler which will substitute for an optical fiber link or other digital transmission channel.

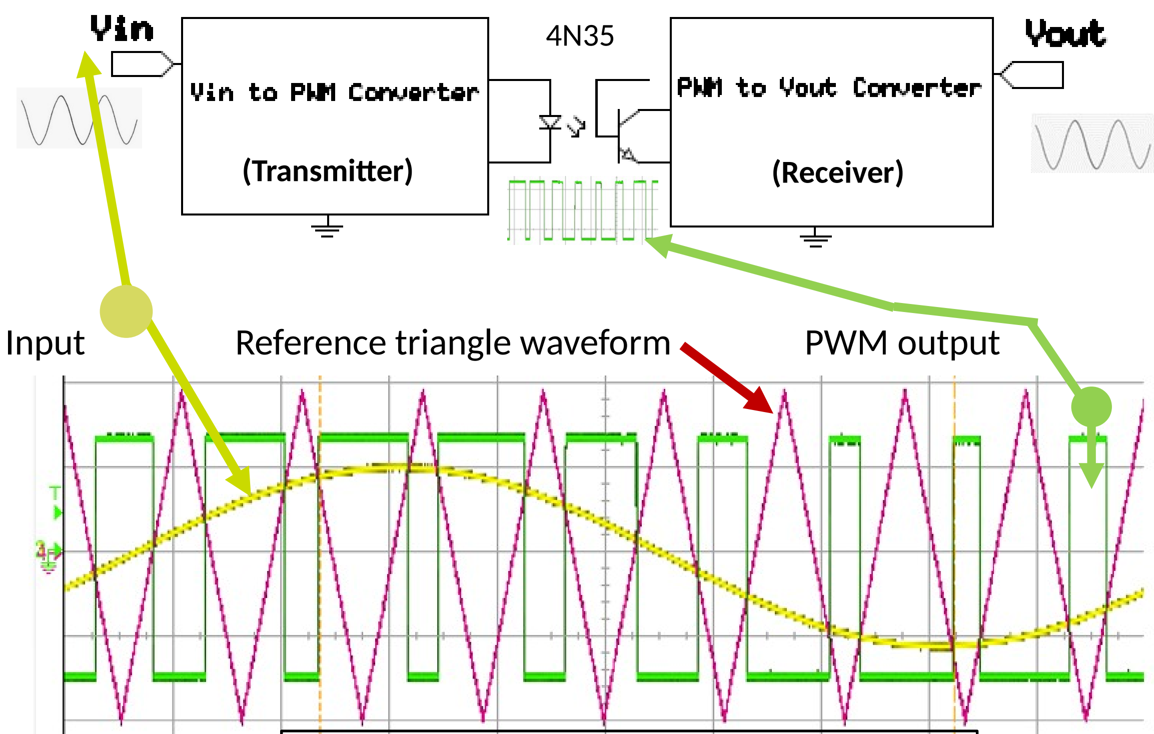


Fig.1, Vin to PWM CONVERTERSION

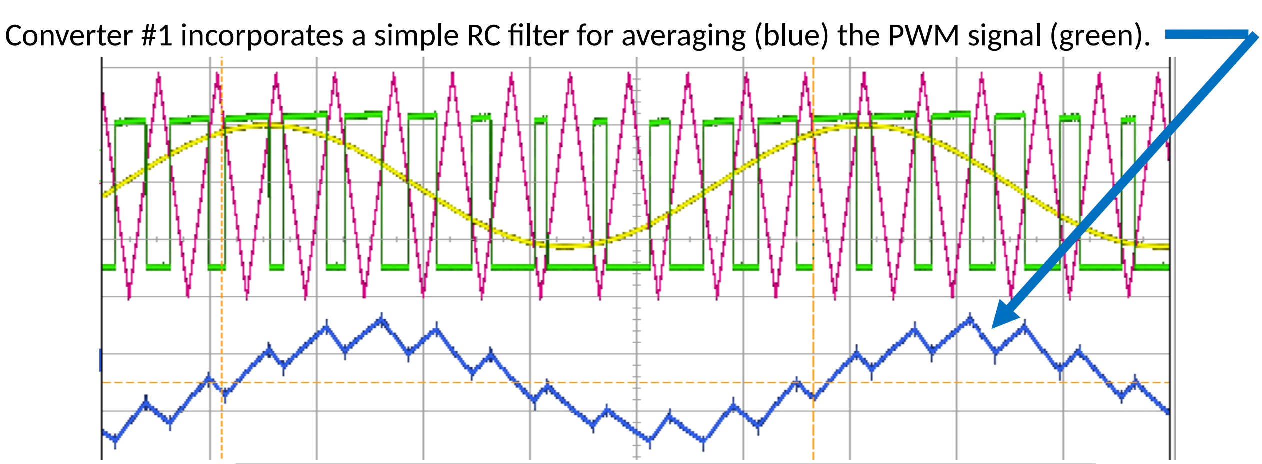
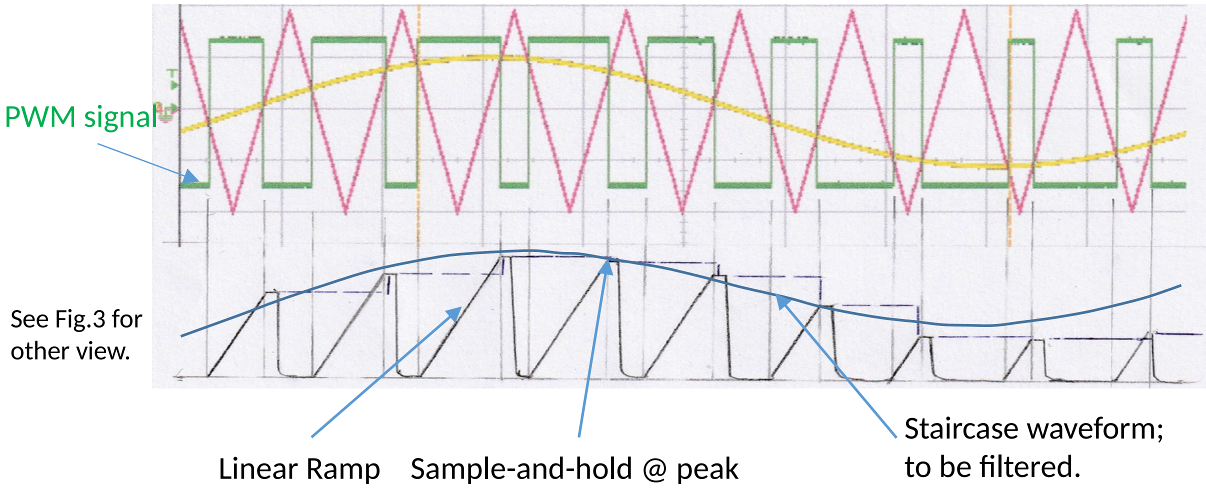


Fig.2, PWM to Vout, with CONVERTER #1:

Fig.3, PWM to Vout, <u>CONVERTER #2</u>:

Converter #2 produces a "staircase" output using a linear ramp and a sample-and hold; this is much easier to filter and provides a better result than converter #1.



<u>You will use Converter #2</u> (much easier to filter)

Specifications:
<u>Input</u>: DC to 200 Hz sinewave from generator, 1Vpp to 10Vpp. (Be careful with the triangle-wave amplitude, which does not vary).
<u>Output</u>: Same as input. Will drive a 1K load.
<u>Power Supply</u>: Both transmitter and receiver, +/- 7.5 volts (to facilitate use of CMOS 4066 analog switch).
Consult a 4N35 data sheet for its specifications.

<u>Discussion</u>: This is a circuit design course, so you should not be too concerned with theoretical aspects of sampling. Nevertheless, you will want to vary the ratio of sampling rate to the frequency of the input sine wave and see what happens. Can you relate this to Nyquist criterion? Also try different input wave shapes other than the sine wave; remember that waveforms other than a sinewave include higher- frequency components that must be considered when sampling. Use approach #2 In Figure 3 above.

Before you jump into the design and head to the lab, carefully draw accurate diagrams of the waveforms that you will be working with. These waveforms should precisely reflect amplitude and timing relationships; only then can you begin to design the required circuitry.

<u>For Saturday</u>. Provide a block diagram, waveforms, and preliminary schematic for both the transmitter and receiver.

<u>To record oscilloscope traces:</u> Do not use a camera. Use a USB stick and press *Save/Recall* under *Measurement*; then the *Press to Save* soft button. Transfer your picture to PowerPoint and then clearly and unambiguously annotate the trace.

Fig. 3

LAB 8 Receiver Waveforms: PWM input / Staircase Output

Yellow = PWM signal from optoisolator. Green = one-shot. Red = sawtooth. Blue = staircase = output

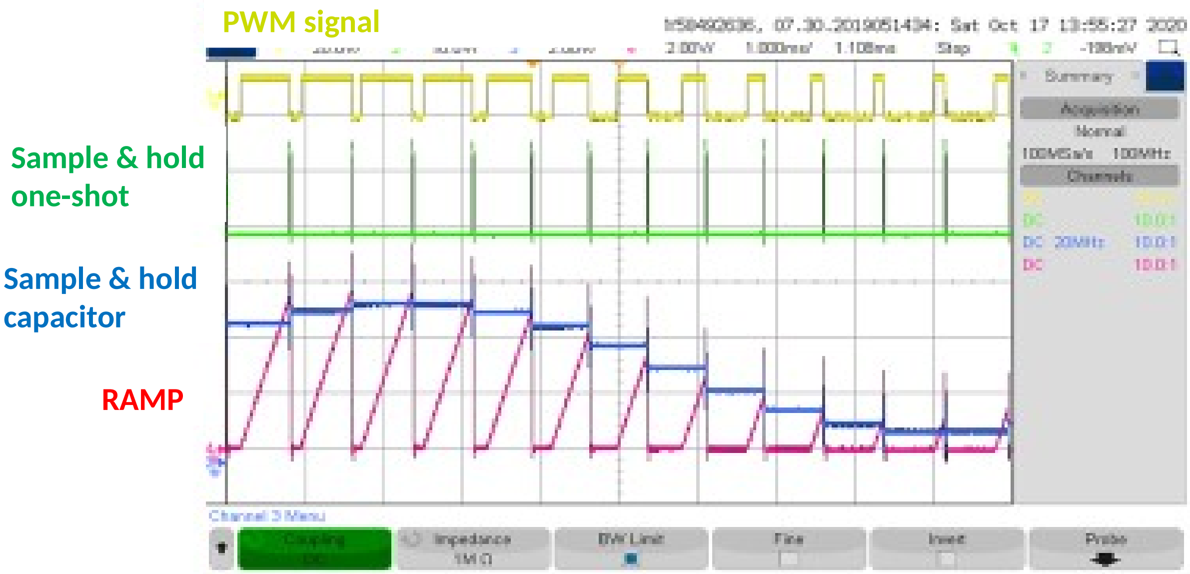
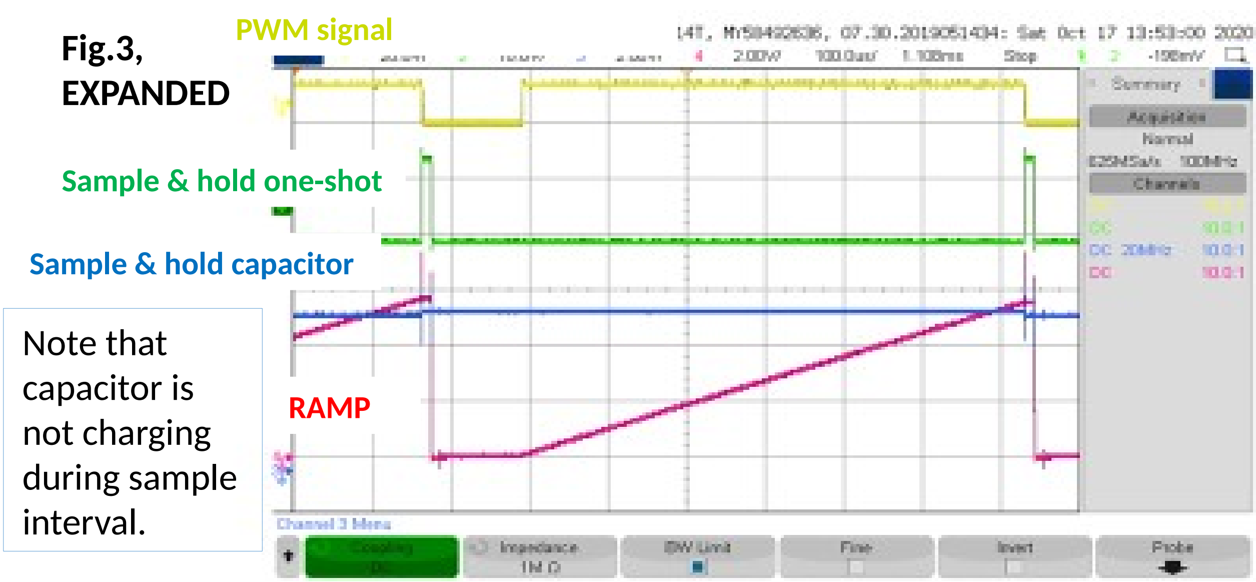


Fig.3, EXPANDED



The sequence is:

ramp – halt ramp – sample (and hold) – reset ramp

__In your Lab Report.__ Provide clear, complete schematics and scope traces: For the transmitter, show input, triangle, and PWM output waveforms (simultaneously, use 3 channels). For the receiver show input PWM, ramp, and staircase waveform. If a fourth scope probe is available, or in a separate display, show the output sine wave. It is only necessary to record scope traces at a single, representative input frequency and amplitude. __The oscilloscope should be set up to clearly depict waveforms with enough amplitude and horizontal resolution to provide a meaningful, informative display__.

TEST to verify performance:

1. **Measure THD:** Compare the THD of the input waveform with the THD of the reconstructed waveform at the output record results.
2. **DC accuracy and linearity:** Input 1.00 and 5.00 VDC and measure the DC output; use a DMM. Record results.

Please set up your circuit to demo for your recitation.

POINTS TO PONDER REGARDING LAB #8

•Before you design your circuit, be sure to prepare a timing diagram to show the various states and timing of your circuit. An example is shown below. Be sure to show amplitude (above and below ground?), pulse length, etc.

•**Before you go too far, be sure you completely understand the sequence of operations and have determined the maximum and minimum values of amplitude and period that you expect.**

•Be sure that you understand the relationships and limits of certain basic functions. For example, you might use an analog switch to discharge an integrating capacitor used in a ramp-generating circuit. In this case, a key consideration is the size of the capacitor. To determine its value, you would probably first determine a reasonable constant-current value with which to charge the capacitor and create the ramp; to determine this current, you might start with considering the possible range of current values. An example of a maximum value might be the short-circuit current limit of the op amp or transistor that is charging the capacitor. On the other hand, the minimum value might be determined by capacitor leakage (unlikely) or, if the capacitor is driving an op amp while charging, you would want the charging current to be much, much greater than the input bias current. (Use a better op-amp?) When it comes to quickly discharging the capacitor with the analog switch, you have to consider the ON resistance of the analog switch; if the capacitor is too large you may not be able to discharge it quickly enough. In any case, you would probably never use capacitors less than a few hundred picofarads; it is important to swamp out the parasitic capacitance of the solderless breadboard and wiring.

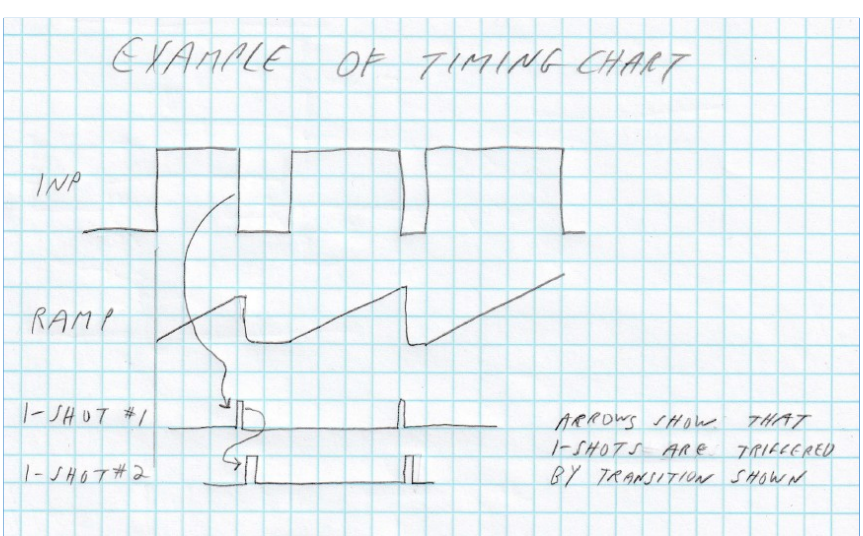
•In this lab you may be using comparators, op amps, one- shots, logic, and analog switches. Start with a split supply, but make sure you pay strict attention to where you connect the various supply and common connections. Some may operate some parts on +/--7.5V, but others may operate between ground and a rail. Check your design and wiring!

• Remember to build and test step-by-step where possible. Learn to obsessively glance at the *AMPS* display on your power supply; this will help you notice if you have miss-wired, plugged in a component backwards, shorted something out, etc. Review the Lecture, "Digital Logic V22.x" in Canvas *modules*.

•It may be helpful to test with a steady DC voltage instead of a sine wave; it's a good way to troubleshoot.

•It's not necessary to excessively filter your output sine wave; I'm much more interested in seeing that the ramp and sample- and- hold are correct. In fact, filtering may not even be necessary. For your recitation lab report, please provide, at the very minimum, scope waveforms similar to the ones attached. Remember that scope traces should always be clearly annotated. For example, showing more than a few cycles may make your sine wave look good, but may be useless because of minimal resolution. Also, be sure that the displayed amplitude of the traces is optimized.

There are several changing, interrelated things going on here, so DO NOT GUESS AT VALUES. Carefully look at your timing diagram and calculate one-shot periods, slope of the ramp, signal swings, etc.



PART 2; <u>DEBOUNCE CIRCUIT AND 555 ONE-SHOT</u>

Design, build, and test a one-shot circuit using a 555. The one-shot should produce a single, 1ms pulse every time a SPST switch is closed (and only when it is closed, not when it is opened). Incorporate an anti-bounce circuit, using CMOS logic, to interface with the switch. Assume that the duration of the contact-bounce pulse train may be as long as 100 ms. and contain several bounces. For recitation, provide a clear schematic and a 3-channel scope trace showing the switch waveform, the anti-bounce circuit output, and the 1-shot output. The maximum switch closure-rate will be twice per second. **(P)**

Use a push button of your choice, or the provided 3-position toggle switch using only one switch position (throw, two wires). You might also investigate the characteristics of one or two switches or pushbuttons that you find in the flea market. Operate the switch and circuit on a 15 VDC supply.

PART 3; <u>Tachometer</u>

Design, build, and test, a tachometer circuit that will provide a voltage proportional to the speed of the motor shown below. Use the reed switch to sense rotation. The output of your circuit should be 1.00 VDC per 1000 RPM.

Be sure that your circuit accommodates contact bounce on both opening and closing. You may select a different reed switch connection; pulling up, for example.