SAULT COLLEGE
of Applied Arts and Technology
Sault Ste. Marie

COURSE OUTLINE

PULSE CIRCUITS

ELN 211-3

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PULSE CIRCUITS

TEXTS: Semiconductor Pulse & Switching Circuits, BASI

Industrial Solid State Electronics, MaLoney

REFERENCE TEXTS:

Pulse Fundamentals	Doyle
Instruction Manuals, Tektronics 547	Oscilloscope
Cathode Ray Tubes	Tektronics Circuit Concept Series
Digital Theory & Experimentation	Levine
Solid State Pulse Circuits	Bell
RCA Application Note Thyristors AN - 6865	

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GENERAL OBJECTIVES:

On successful completion of this course the student will:

a) be able to build and test circuits employed in the generation and shaping of pulse waveforms,

b) be capable of using the laboratory oscilloscope in both the non-delayed and delayed modes in the analysis of pulse waveforms,

c) be able to trouble shoot the Raster Generating Circuits of a typical video terminal.

ER	THEORY PERIODS	LAB PERIODS	TOPIC DESCRIPTION	REFERENCES
1	3	3	<u>Linear Waveshaping</u> Waveform Analysis R.C. filter networks, integrators and differentiators Active Integration & Differentiation	Mitchell Maloney
2	4	2	<u>Non-Linear Waveshaping</u> Limiting, DC Restoration	Mitchell
3	4	5	<u>Pulse Generators</u> Schmitt Trigger Bistable Multivibrator Monostable Multivibrator Voltage Control of Multivibrators Blocking Oscillator	 Mitchell Notes
	5	4	<u>Sweep Generation</u> Sawtooth generator Bootstrap Sweep Generator Constant Current Sweep Generator Miller Sweep Generator	
5	3	0	<u>Cathode Ray Tubes</u> Electromagnetic CRT	Handouts & Film
6	3	0	<u>Tektronics Oscilloscope Model 547</u> Block Diagram	Manufacturer Manual
7	6	6	<u>Pulse & Special Circuit Applications</u> Vertical Sweep Generator Horizontal Sweep Generator Secondary (Boosted) DC Voltage Generator Final Anode Voltage Generation	Manufacturer Manuals Quasar Volker-Craig

PULSE CIRCUITS

BLOCK 1 - LINEAR WAVESHAPING

1. With the aid of sketches recalled from memory, define the terms periodic, aperiodic and transient as applied to waveforms.

2. Draw a train of rectangular pulses (idealized and identify the leading edge, trailing edge, pulse width (duration) and pulse recurrence time.

3. Sketch a typical (practical) rectangular pulse and clearly identify rise time, fall time, pulse width, overshoot, undershoot, tilt and ringing.

4. Recall that waveshaping is achieved initially through the generation of one or more of three basic waveforms; namely: step, ramp and exponential.

5. Sketch the following waveforms:

   Positive Ramp
   Triangular
   Exponential
   Spike
   Negative Ramp
   Sawtooth
   Exponential and Step
   Trapezoidal

6. Recall that duty cycle = $\frac{\text{pulse width}}{\text{P.R.T.}}$ and is usually expressed as a percentage.

7. Define the term "market/space ratio".

8. Given the pertinent characteristics of a waveform, calculate tilt, average value, duty cycle, PRT, width and peak.

9. Illustrate frequency synthesis of a square wave by Point-by-Point addition of the fundamental frequency and the third and fifth harmonics.

10. Recall that the frequency of the highest harmonic that must be passed for accurate reproduction of a square wave may be determined as follows:

    $$\text{Highest harmonic frequency} = \frac{\text{PRF}}{\text{Duty Cycle}}$$

11. Discuss and illustrate how a square wave may become distorted due to the following characteristics of an amplifier:

    a) high cut-off frequency
    b) low cut-off frequency
    c) over emphasis of high frequencies

12. Given the high cut-off frequency (F_{HCO}) determine the rise-time distortion of an ideal square wave input.

    $$t_r = 0.35 \times \text{Period}_{HCO}$$

    $$t_r = \frac{0.35}{F_{HCO}}$$

13. Given the low cut-off frequency (F_{LCO}) of an amplifier, determine the fractional tilt that will be imparted to an ideal square wave input.

Fractional tilt = $\frac{F_{LCO}}{f}$ $t_t = \frac{16}{f_{LCO}}$ where t_t = tilt time

14. Apply objectives 1-13 in resolving problems concerning pulse waveforms.

15. Using an oscilliscope, identify and measure rise time (t.r.), fall time (t.d.), amplitude, pulse duration (t.d.) pulse repitition time (p.r.t.), pulse repitition frequency (p.r.f.), duty cycle (d.c.), overshoot, undershoot, tilt and ringing.

16. Solve mathematical problems relating to charging and discharging circuits using the exponential expression.

17. Recall that a high-pass R.C. filter network, also referred to as a low frequency discriminator, consists of a resistor and a capacitor connected in series, with the out taken across the resistor.

18. Recall that a short time constant high-pass filter circuit is one in which T.C. 1 t.p. and along time constant circuit is one in which T.C. 10tp. t.p.

19. Explain, with the aid of diagrams, the response of short, medium and long time constant, high-pass circuits to rectangular pulses and square waves.

20. Explain, with the aid of diagrams, the response of short, medium and long time constant, high-pass filter circuits to a ramp voltage.

21. Recall that a high-pass R.C. filter network with a short time constant is known as a differentiating circuit where the output at each instant represents the rate of charge of input.

22. Given a composite waveform containing step and ramp function, draw a representative differentiated output waveform.

23. Recall that a low-pass R.C. filter network consists of a resistor and capacitor connected in series with the output taken across the capacitor.

24. Explain, with the aid of diagrams, the response of short, medium and long time constant, low-pass R.C. filter networks to rectangular pulses, square waves and ramp inputs.

25. Recall that a low-pass R.C. filter network with a long time constant is known as an integrating ciruit where the output at each instant represents the sum of the inputs.

26. Given a composite input waveform containing step and ramp functions, draw a representative integrated output waveform.

27. Given waveform parameters, components and breadboarding supplies, construct and test passive integrating and differentiating networks.

Explain the operation of OP AMP integrators and differentiators and calculate the value of feedback capacitor and resistor.

BLOCK 2 - NON-LINEAR WAVESHAPING

When the student has successfully completed this block he will be able to perform the following specific objectives:

1. Draw from memory (with component values) a series diode clipper which will clip either half cycle of an input pulse and explain the operation with the aid of waveforms.
2. Draw from memory, a diode shunt clipper (with component values) which will clip either half cycle of an input pulse and explain the circuit's operation with the aid of waveforms.
3. Draw from memory the various shunt diode clippers (including component values) with either reverse or forward bias and explain the circuit's operation.
4. Draw from memory the shunt double clipper (including component values) and explain the circuit's operation.
5. Explain with the aid of diagrams, the operation of a zener diode clipper.
6. Recall that driving a transistor between saturation and cutoff will produce clipping action.
7. Draw from memory, a transistor limiter and explain the operation of the circuit.
8. Define the term clamping (d.c. restoration).
9. Draw from memory, a positive diode clamping circuit and given the input waveform and component values, show the output waveforms in proper time relationship and explain the circuit's operation.
10. Repeat 9 for a negative diode clamper.
11. Repeat 9 for a biased diode clamper.

BLOCK 3 - PULSE GENERATING CIRCUITS

1. With the aid of a circuit diagram recalled from memory, describe the operation of each of the following:

    a) Bistable Multivibrator
    b) Monostable Multivibrator
    c) Astable Multivibrator
    d) Schmitt Trigger
    e) Blocking Oscillator

2. Draw the waveforms for the circuits in (1) above.

3. Recall that in the multivibrator circuit, the duration of cut-off time for each transistor is determined by the time constant of the resistor and capacitor connected to it's base. The time can be calculated as follows:

    $T = 0.7\ R_B C$ (where T is in sec., R_B is the base resistor)

4. Recall that if the two base circuits are identical, a balance waveform is produced and the period for a complete cycle is calculated as follows:

    $P = 1.4\ R_B C$

5. Recall that to satisfy the conditions for saturation:

    $B \quad \frac{R_B}{R_C}$ (where R_B is the base resistor R_C is the collector resistor)

6. Recall that an I.C. astable multi car be made with two inverter gates by "cross-coupling" outputs to inputs as shown.

7. Construct and test an astable multivibrator and a monostable multivibrator circuit using:

   a) a 555 timer
   b) I.C.'s 74121 and 7400

8. Recall that the shcmitt trigger circuit is a voltage level detector. When the input voltage is below the upper trip level (UTL) the output voltage is at the zero logic level. When the input is above the UTL the output is a logic one. The output will switch from logic one to logic zero when the input voltage is reduced to the lower trip level (LTL).

9. Recall that the LTL is lower than the UTL and the difference voltage is commonly referred to as hysteresis.

10. Recall that the shcmitt trigger can be used to convert a slowly changing signal to one with rapid transitions. For example, it can be used to develop a square wave from a sine wave input.

11. Recall that a shcmitt trigger can be constructed with I.C.s as shown below:

12. Construct and test schmitt trigger circuits using:

   a) I.C.s 7403 and 7414

13. With the aid of circuit diagrams recalled from memory, describe the operation and triggering of:

   a) the bistable multivibrator
   b) a monostable multivibrator

   In each case, be able to discuss both the common emiter and the collector coupled multivibrator.

BLOCK 4 - SWEEP GENERATORS

1. Recall that basically, all sawtooth voltage waveforms are generated by charging a capacitor through a resistance, and that only the first part of the exponential curve (10% or less) is reasonably linear.

2. Draw a diagram of a simple sawtooth generator and explain it's operation.

3. Recall that the disadvantages of the simple sawtooth generator are:

   a) no ramp recovery assurance
   b) less than desirable linearity
   c) large power supply requirement for low ramp voltage

4. Draw the schematic diagram of a simple bootstrap sweep generator and describe how sweep linearity is improved by positive feedback.

5. Recall that for optimum linearity in the bootstrap circuit:

   a) the gain of the feedback loop must be unity
   b) the charge on the bootstrap capacity must remain constant

6. Recall that the bootstrap circuit can be designed to produce a sweep of good linearity and of sufficient amplitude to provide direct drive to CRT deflection plates.

   (N.B. The objectives above include both solid state and vacuum tube circuits.)

7. With the aid of a simple diagram recalled from memory, describe the operation of a constant current ramp generator.

8. Recall that the miller effect is an effective increase in input capacitance brought about by feedback in an inverter-amplifier. In a vacuum tube amplifier the miller effect capacitance is determined as follows:

   $C_{MILLER} = (A + 1)\ Cpg$ where A = stage gain without feedback

9. Recall that the effective input capacitance

   $C_{EEF} = Cgk + C_{MILLER}$ (where Cgk = grid-cathode capacitance)

10. a) With the aid of a simple diagram, describe the operation of an operational integrater.

    b) Recall that the output of the integrator, at the end of some time interval, is proportional to the net number of volts seconds applied to the input.

    c) Ideally, all of the current through R^1 will flow through C_M and the output ram voltage slope can be determined by

$$\text{Ramp slope} = \frac{V^1}{R^1 C_M}$$

(where V^1 and R^1 are therein equivalent input circuit)

11. Given the circuit diagram of a practical Miller run up sweep generator, describe it's operation and draw idealized waveforms.

12. Construct and test a sweep generator circuit using a 555 time I.C.

13 Given the circuit diagram describe the operation of a thyristor type deflection circuit.

BLOCK 5 - ELECTROMAGNETIC CATHODE RAY TUBE

1. With the aid of simple diagrams, explain how bean deflection is accomplished by electromagnetic means.

2. Recall that modern circuits using magnetic deflection, include a focus anode in the electron gun.

3. Recall that focusing may be accomplished using permanent magents or electromagnets.

4. With the aid of a simple diagram, describe the action of a focus coil on the electron beam.

5. Recall that a circuit using magnetic deflection, must employ external means for beam centering, such as:

   a) mechanical adjustment of the position of the focusing device
   b) mechanical adjustment of the position of a magnetic shunt in the focusing device
   c) the use of two magnetized rings mounted behind the deflection yoke

6. Explain the term "ion burn" and with the aid of a simple diagram, explain the action of an ion trap.

7. Recall that an aluminized screen prevents ion pentration, provides better contrast and increased brilliance.

8. Recall that the colour and persistence of the spot depend on the type of phosphor material forming the fluorescent screen.

9. With the aid of a simple diagram, explain the terms:

   a) build-up time
   b) fluorescence
   c) phosphorescence (Decay time or resistence)

10. Recall that in some applications, the display will not be viewed with the human eye but other light sensitive devices such as photographic film, photo cells, etc. will. The selection of the Phosphor will depend on the spectral response of the sensing device.

11. Recall that a dual trace display may be produced by use of:

    a) a circuit having two electron guns separately controlled, each having it's own vertical and horizontal amplifiers.
    b) electronic switching to permit time sharing of a single beam.

12. With the aid of simple diagrams, explain how dual beam display is achieved through time sharing of a single beam.

13. Describe how a raster is generated in a TV set or a video terminal.

b) State the function of each block.

2. Demonstrate the ability to use the 547 oscilloscope in both the non-delayed and delayed modes.

BLOCK 7 - CRT RASTER GENERATING CIRCUITS

1. Given the circuit diagram of the raster generator for the Volker-Craig video terminal,

    a) describe the circuit operation
    b) troubleshoot the circuit and isolate failed components

2. Given the circuit diagram of Quasar model 942 TV sweep generating circuits,

    a) describe the circuit operation
    b) troubleshoot the circuits and isolate failed components