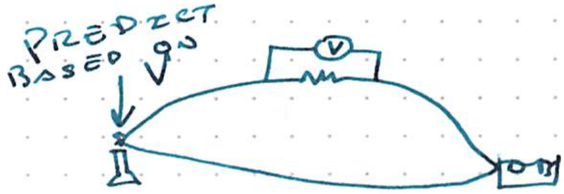
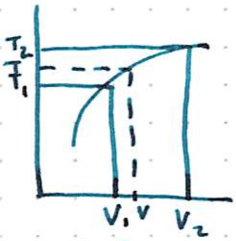
JAN 22, 2018



TRANSDUCERS
↳ TEMP
↳ THERMOCOUPLE
↳ SEEBECK EFFECT
↳ USING 2 DIFF. METALS @ 2 DIFF JUNCTIONS, A ~~CURRENT~~ CHANGE OF TEMP CAN INDUCE A CURRENT
↳ USED TO MEASURE TEMP BASED ON CURRENT
↳ USES COLD REFERENCE FOR CALIBRATION
↳ TC EXAMPLE:
A TYPE J TC HAS 0°C REF. A VOLTAGE OF 4.617mV IS READ. WHAT IS THE ACTUAL TEMP @ THE JUNCTION?
↳ USE TYPE J CONVERSION TABLE
(ROWS TELL 10'S, COLUMNS TELL 1'S BASED ON V)

TYPE J → REF = 20°C V = 36.69mV
ADD V FROM 20°C TO 36.69mV TO FIND PROPER V FOR 0°C REFERENCE
∴ V = 37.709mV
TEMP = 677°C



TO FIND A NON-LISTED VOLTAGE, FIND THE TEMPS BOUNDING & USE LINEAR INTERPOLATION

$T(V) = T_1 + (T - T_1)$

$$\left(\frac{V-V_1}{V_2-V_1}\right) = \left(\frac{T-T_1}{T_2-T_1}\right)$$

$$T(V) = T_1 + \frac{(T_2-T_1)(V-V_1)}{(V_2-V_1)}$$

RESISTANCE TEMP DETECTORS (RTD)
↳ Ω OF MOST METALS Δ AS TEMP Δ
$R[T] = R[T_0]\,(1 + \alpha_0(T - T_0))$
T = TEMP @ DESIRED RESISTANCE
R[T] = Ω @ T
RTD EX:
AN RTD HAS $\alpha_0 = 0.0037°C$ @ T = 50°C
$R[T_0] = 500\Omega$. FIND Ω @ 80°C
$R[T] = R[T_0]\,(1 + \alpha_0(T - T_0))$
$= 500\Omega\,(1 + 0.0037°C(80°C - 50°C))$
$= 555.5\,\Omega$

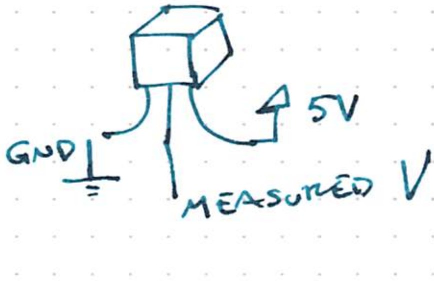
DUE TO SELF-HEATING, BY PASSING 30mA, TEMP CHANGES IF $P_D = 30mV/°C$

$$\Delta T = \frac{P}{P_D} = \frac{I^2R}{P_D} = \frac{(0.03)^2\,555.5}{0.03} = 16.665°C$$

THERMISTOR
↳ SEMICONDUCTOR BASED TRANSDUCER
$R[T] = R[T_0]\,e^{\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)}$

CALC Ω OF A THERMISTOR @ 100°C IF R[0°C] = 18kΩ
THE THERMISTOR TEMP COEF. = 2200K (0°C = 273K)
$R[T] = R[T_0]\,e^{\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)} = (18000\Omega)\,e^{2200K\left(\frac{1}{323K} - \frac{1}{273K}\right)} = 2074.8\,\Omega$

IC TEMP SENSORS
↳ VERY WELL LINEAR



OPTICAL SENSORS

- Photo Resistors
  - An analog device that measures how bright or dark an area is

LED THEORY

$\lambda = (1240/E)\,nm$

- In general, 400 – 700 nm is the visible spectrum

JAN 24, 2018

Photo Transducer

- OPB745 - IR LED w/ Phototransistor
  - Phototransistor responds to IR LED radiation only when a reflective object passes in front of the field of view
    - LED off: No I
    - LED on: I flows

Displacement Transducers

Potential Displacement Sensor
- Resistance Δ as wiper position Δ
- Pro: cheap
- Con: wears out over time
- 3 terminals b/c one is tap

Linear Variable Differential Transformer
- Displacement sensor (online notes for figure)

Strain Gage
- Ω of platinum wire Δ based on tension
  - $R = \rho \frac{l}{A}$; $R = \Omega$, ρ = resistivity, l = length, A = x-section area
- Ex: $\rho = 44.2\text{E-}6\ \Omega\,cm$, $l = 10\,cm$, $r = 0.01\,mm$

$$R = (44.2\text{E-}6\ \Omega cm)\ \frac{10cm}{\pi(0.01mm)^2} = 141\ \Omega$$

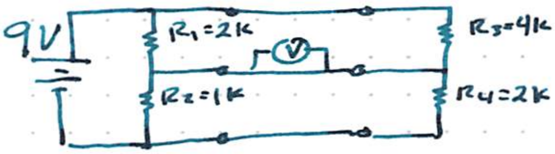
JAN 26, 2018

Schmitt Trigger: 
- Use hysteresis band to fix noisy signals
  - Add a high & a low threshold

ADC

- Resolution of A/D: $\frac{V_{REF}}{(2^N - 1)}$

Wheatstone Bridge:



- Can be used to measure unknown Ω
- Combines 2 voltage dividers
  - Ex: R_D is a sensor R_s

BAL $\longrightarrow$ $R_A = 1k\Omega$, $R_B = 2k\Omega$, $R_C = 3k\Omega$, $R_S = 6k\Omega$, $V_c = 10V$ $\quad V = V_{B_1} - V_{B_2}$

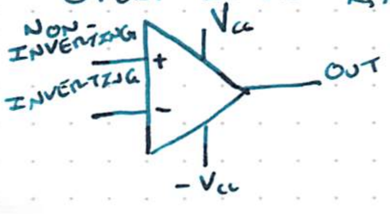
$V_- = V_+ = V\frac{R_B}{R_A + R_B} = 10V\left(\frac{2}{3}\right) = 6.667V$ $\quad$ Balanced: $\frac{R_A}{R_B} = \frac{R_C}{R_D}$

Non-Bal: $R_s = 6.6k\Omega$ (+10%)

$V_+ - V_- = V\frac{R_B}{R_A + R_B} - V\frac{R_s}{R_c + R_s} = 10\left(\frac{2}{3}\right) - 10\left(\frac{6600}{9000}\right) = -0.208V$

JAN 31, 2018

Operational Amplifiers



From KCL:

$i_o = i_{c_+} + i_{c_-} + i_p + i_n$

$V_o = \underbrace{A}_{\text{Gain}}(V_p - V_n)$

Ideal: $V_o = A(V_p - V_n)$

$\frac{V_o}{A} = 0$

$V_p = V_n$

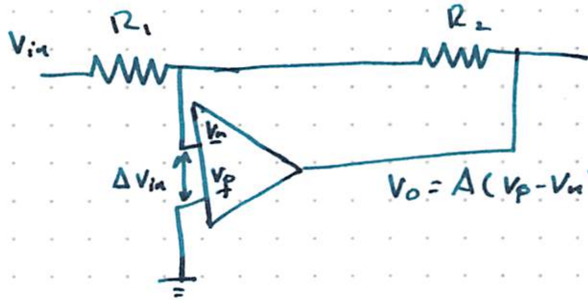
$R_i = \infty$

$R_o = 0$

FEEDBACK

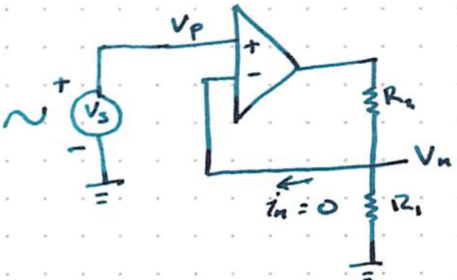
NEGATIVE
↳ PART OF OUTPUT IS RETURNED IN OPPOSITION TO SOURCE

POSITIVE
↳ OUTPUT SIGNAL ADDS ORIGINAL



$$V_o = A(V_p - V_n)$$

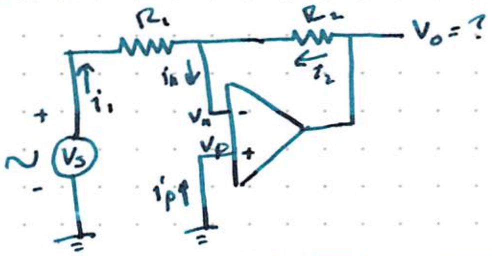
NON-INVERTING OP-AMP



$$V_p = V_s = V_n$$
$$V_n = V_o\left(\frac{R_1}{R_1+R_2}\right)$$
$$V_s = V_o\left(\frac{R_1}{R_1+R_2}\right)$$
$$V_o = V_s\left(\frac{R_1+R_2}{R_1}\right)$$
$$V_o = V_s\underbrace{\left(1+\frac{R_2}{R_1}\right)}_{A}$$

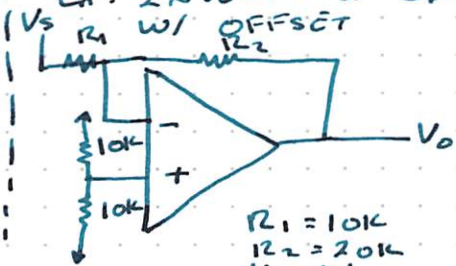
USUALLY RESTRICT $\{R_1, R_2\}$ TO BE BTWN $1K\Omega$ & $1M\Omega$

INVERTING OP-AMP



$$V_p = V_n = 0$$
$$i_1 = \frac{V_s - V_n}{R_1} = \frac{V_s}{R_1}$$
$$i_2 = \frac{V_o - V_n}{R_2} = \frac{V_o}{R_2}$$

EX: INVERTING OP-AMP W/ OFFSET

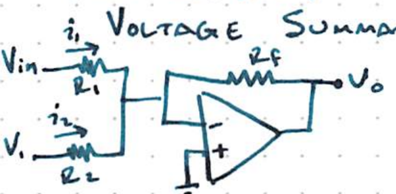


$R_1 = 10K$
$R_2 = 20K$
$V_s = 6V$

$$V_o = -(V_s - V_n)\frac{R_2}{R_1} + V_n$$
$$= -(6V - 5V)\frac{20k}{10k} + 5V$$
$$= 3V$$

FEB 02, 2018

VOLTAGE SUMMATION



$$V_o = -V_{in}\frac{R_f}{R_1} - V_1\frac{R_f}{R_2}$$

LEVEL SHIFTING & SCALING

IF $V_1 = -12V$, $R_f = R_1 = R_o = 15K\Omega$

SOLVE FOR R_2 SO THAT WE SCALE SHIFT FROM OUR SENSOR RANGE OF $-1.5V \rightarrow 3.5V$ TO $0V \rightarrow 5V$

$$V_o = V_{in}\frac{R_f}{R_1} - V_1\frac{R_f}{R_2}$$

$$0 = -1.5\frac{R_f}{R_1} - V_1\frac{R_f}{R_2}$$
$$= -1.5 + 12\frac{15K}{R_2}$$
$$R_2 = 120K\Omega$$

$$5 = 3.5\frac{R_f}{R_1} - V_1\frac{R_f}{R_2}$$
$$R_2 = 120K\Omega$$

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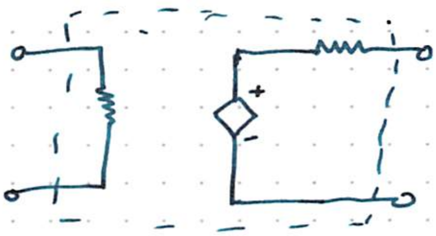
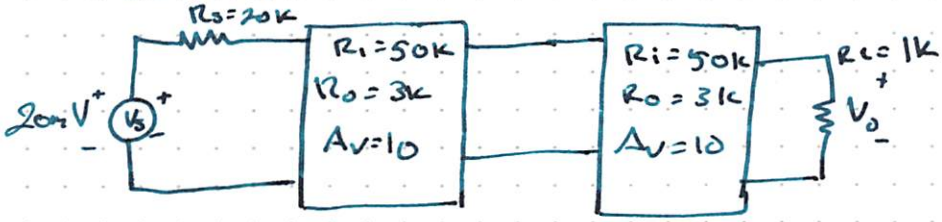
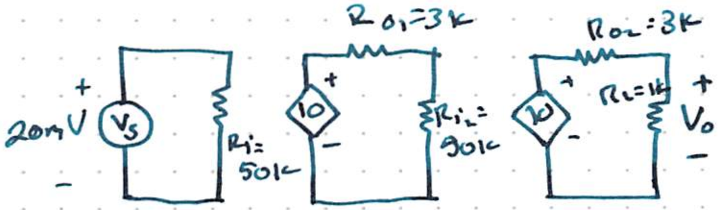
AMPLIFIER SIGNAL MODEL



CASCADE AMPLIFIERS





$$\frac{V_o}{V_s} = \frac{V_o}{V_{i_2}} \cdot \frac{V_{i_2}}{V_{i_1}} \cdot \frac{V_{i_1}}{V_s}$$

$$V_o = 10V_{i_2}\left(\frac{R_L}{R_L + R_{o_2}}\right) ; \quad V_{i_2} = 10V_{i_1}\left(\frac{R_{i_2}}{R_{i_2} + R_{o_1}}\right)$$

$$V_{i_1} = V_S\left(\frac{R_{i_1}}{R_{i_1} + R_S}\right)$$

$$\frac{V_o}{V_s} = (2.5)(9.434)(0.7143)$$
$$= 16.85$$

$$\frac{V_o}{V_{i_2}} = 10\left(\frac{R_L}{R_L + R_{o_2}}\right) = 10\left(\frac{1000}{4000}\right) = 2.5$$

$$V_o = (20mV)(16.85) = 0.337V$$

$$\frac{V_{i_2}}{V_{i_1}} = 10\left(\frac{50{,}000}{53{,}000}\right) = 9.434$$

$$\frac{V_{i_1}}{V_S} = \cancel{10}\left(\frac{50000}{70000}\right) = 0.7143$$

NOISE

- ↳ THERMAL NOISE
  - ↳ $N_{TH} = kTB$
    - ↳ N_{TH} = NOISE POWER IN WATTS
    - ↳ $k = 1.38E{-23}$ (BOLTZMANN'S CONSTANT)
    - ↳ T = ABSOLUTE TEMP IN K
    - ↳ B = BANDWIDTH (HZ)
- ↳ SHOT NOISE
  - ↳ $I_N^2 = 2qI_{dc}B$

LOW FREQ. NOISE
- ↳ DECREASES W/ FREQ INCREASE

FEB 09, 2018

IA TOTAL CMR

$A_0 = \frac{V_o}{V_{IN}}$

$$CMR = \frac{\overset{\text{GOOD}}{A_{DIFF}} \rightarrow \text{HIGH}}{\underset{\text{BAD}}{A_{CM}} \rightarrow \text{LOW}}$$

$CMR_{TOTAL} = CMR_1 \cdot CMR_2$

$\boxed{\text{SLIDES FOR GRANT CIRCUIT}}$

OPEN LOOP GAIN: NO EXTRA LOAD AFTER OP AMP

$$CMR \ 1^{ST} \ OP = \frac{CMR_1 \cdot CMR_{OPAMP}}{CMR_1 + CMR_{OPAMP}}$$

EXAMPLE 2 FROM SLIDES

ADCs & DACs

↳ CHECK OUT NXP CUP CAR
↳ ~~QUIZ~~ TEST 1 - FRI, FEB 23

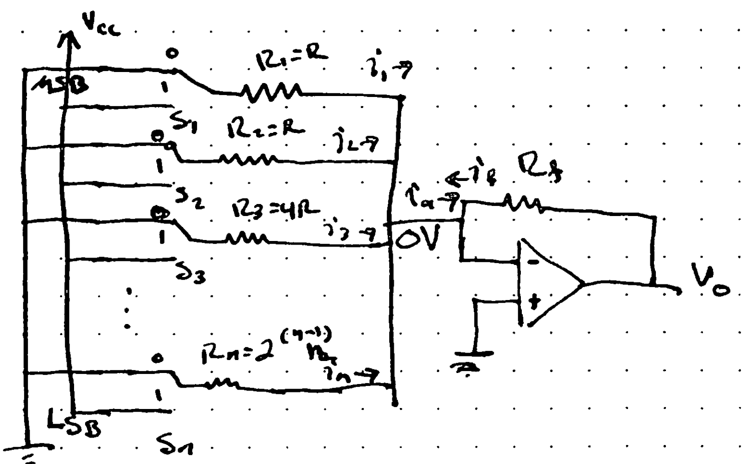
INTERFACING W/ THE REAL WORLD
↳ REAL WORLD HAS CONTINUOUS ANALOG SIGNALS
↳ MICROCONTROLLERS ONLY UNDERSTAND DISCRETE VALUES (BINARY)

ANALOG IN → TRANSDUCER → SIGNAL CONDITIONING → SAMPLE & HOLD → ADC

SPECS:
- RESOLUTION
- CONVERSION TIME
- ACCURACY

ACCURACY
↳ MORE BITS → MORE FIDELITY

DAC CIRCUIT



IF ALL SWITCHES = 1
$$V_o = -V_{cc}\left(\frac{R_f}{R_1 \| R_2 \| \ldots R_n}\right)$$

$$i_a = \sum_{i=1}^{n} \frac{a_i V_{cc}}{2^{i-1} R}$$

WHERE n = # OF BITS
a_i = EITHER 1 OR 0 BASED ON BIT

$$V_o - V_- = V_o = -i_a R_f$$

$$V_o = -i_a R_f = -R_f\left(\sum_{i=1}^{n} \frac{a_i V_{cc}}{2^{i-1} R}\right)$$

FEB 12, 2018

PROBLEMS: MORE BITS → LARGER RESISTORS
↳ LOW CURRENT
↳ HARD TO MANUFACTURE

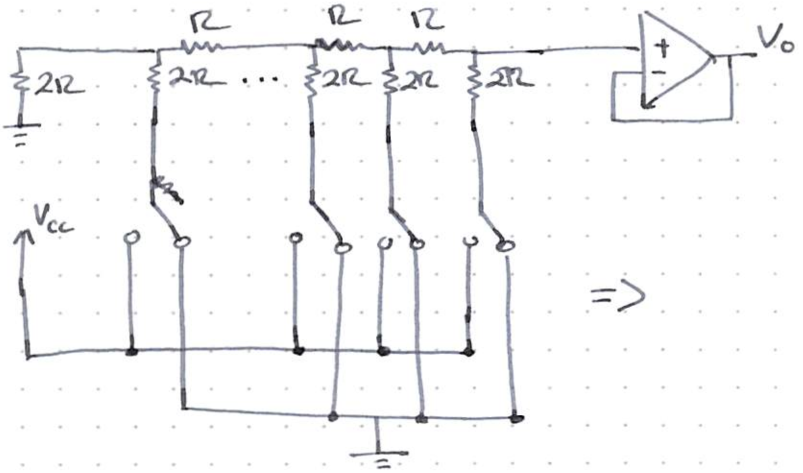
EXAMPLE:

SOLVE FOR R_f FOR 4-BITS LADDER & $R = 100\Omega$
WANT TO MAP 0-15 DIGITAL VALUES FOR
0-15V OUTPUT VALUES. ~~[illegible]~~ LOGIC 1 = 5V

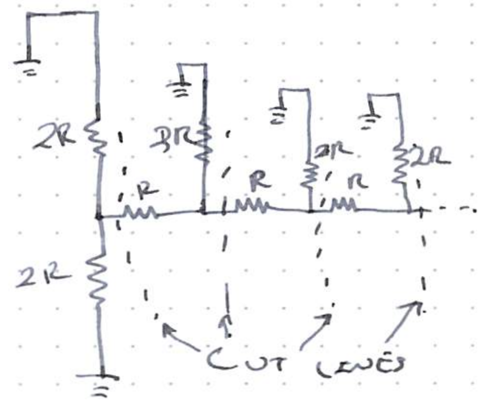
$$V_o = \frac{-R_f \ V_{cc}}{R}\left(\sum_{i=1}^{n} \frac{a_i}{2^{i-1}}\right)$$

FEB 12, 2018 (AGAIN...

R-2R RESISTANCE LADDER

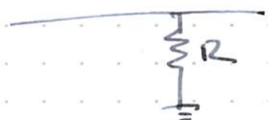


=>



$$V_{OUT} = V_{cc} \sum_{i=1}^{n} \frac{a_i}{2^i}$$

USE THEVENIN TO SIMPLIFY



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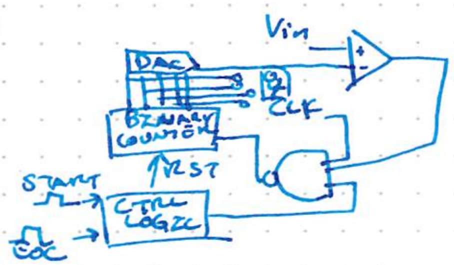
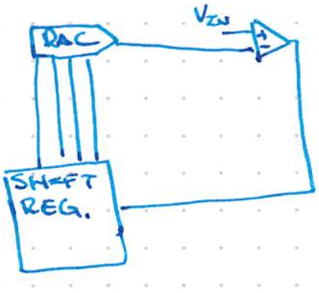
ADCs

SERVO ADC



SUCCESSIVE APPROX



CHECKS BIT-BY-BIT
TO CONFIRM ANALOG → VOLTAGE

IS $V_{in} \geq 10\left(\sum \frac{1}{2^n}\right)$

~~DSP~~ - FEB 16, 2018
IDE

ADC SPECIFICATIONS
↳ CONVERSION TIME, Δt $\quad \Delta t = \frac{1}{2f_{max}}$

↳ RESOLUTION, EITHER # OF BITS n
OR STEP VOLTAGE ΔV

↳

↳

EXAMPLE: A THERMISTOR IS USED TO MEASURE TEMPERATURE FROM 0°C TO 100°C. YOU WANT TO REPORT TEMP W/ A RESOLUTION OF ± 1°C. IT PRODUCES 0 → 5V OVER THE TEMP RANGE W/ 5mV OF NOISE.
· SPECIFY n BASED ON a) DYNAMIC RANGE
b) REQUIRED RESOLUTION

$$2^n \geq \frac{V_{max}}{V_{noise}}$$
$$\geq \frac{5V}{5mV}$$
$$\geq 1000$$
n MUST BE ≥ 10

EX: MAX CONVERSION TIMES FOR AN 8-BIT ADC TO DIGITIZE THE FOLLOWING SIGNALS?
↳ 1 Hz SIN → $\Delta t = \frac{1}{2f_{max}} = \frac{1}{2} = 0.5s$
↳ 1 kHz SIN $\quad \frac{1}{2000} = 0.5mS$
↳ 1 MHz SIN $\quad \frac{1}{2000000} = 0.5\mu s$

↳ MAX APERTURE TIME
↳ 1 Hz → $t_{AP} = \frac{1}{2\pi f_{max} 2^n} = \frac{1}{2\pi(1)2^8} = 0.62mS$
↳ 1 kHz $\quad = \frac{1}{2\pi(1000)2^8} = 0.62\mu S$
↳ 1 MHz $\quad = \frac{1}{2\pi(1000000)2^8} = 0.62nS$

GIVEN A +5V P-P SIGNAL W/ 5mV P-P NOISE, $f_{max} = 3KHz$ SPECIFY:

↳ DYNAMIC RANGE: $\frac{V_{MAX}}{V_{NOISE}} = \frac{10V}{\cancel{10}\,5\,mV} = \cancel{1000}\ 2000$

↳ n : $2^n \geq \frac{V_{MAX}}{V_{NOISE}} = 2000$

$\therefore\ n \geq 11$

↳ MAX CONVERSION TIME: $\Delta t = \frac{1}{2 f_{max}}$

$= \frac{1}{2(3000)} = 170\,\mu s$

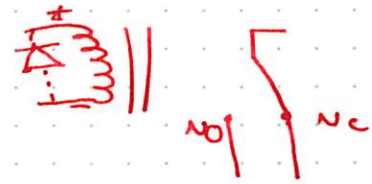
↳ CUTOFF FREQ FOR AA FILTER: $3KHz = f_{max}$

↳ APERTURE TIME: $t_{AP} = \frac{1}{2\pi f_{max} 2^n} = \frac{1}{2\pi (3000) 2^{11}} = 26ns$

FEB 19, 2018 - IDE

SWITCHING
↳ μCONTROLLERS ARE GOOD AT TURNING THINGS ON/OFF
↳ WE NEED TO AMPLIFY SIGNALS TO DRIVE MORE POWERFUL STUFF

RELAYS
↳ HIGH POWER ELECTROMECHANICAL SWITCH

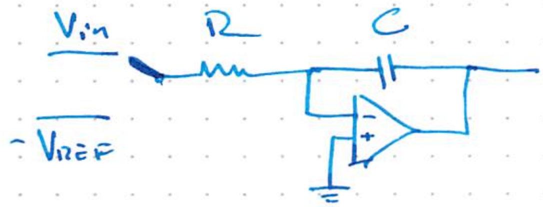


↳ PROTECTION DIODE
↳ WHEN THE RELAY IS SWITCHED OFF, THE SUDDEN FIELD COLLAPSE CAUSES A GIANT VOLTAGE SPIKE
↳ DIODE ALLOWS PATH TO HANDLE THE CURRENT

↳ CAN CASCADE RELAYS
↳ SMALLER ACTIVATES LARGER

FLASH ADC
- USES 1 COMPARATOR PER BIT
  - FAST
  - HIGH QUALITY

DUAL SLOPE



FEB 26, 2018

SWITCHES:
- MULTIPLE SWITCHES:
  - PARALLEL - ANY SWITCH TRIPS, THEY ALL TRIP
  - SERIES - ALL NEED TO TRIP SIMULTANEOUSLY
  - USE Ω NETWORK TO FORM A VOLTAGE DIVIDER

HYDRAULIC V. ELECTRIC V. PNEUMATIC
- ELECTRIC - ACCURACY OR CONTINUOUS MOVEMENT
- ~~HEAVY LOA~~ HYDRAULICS - HEAVY LOADS/SMOOTH MOVEMENT
- PNEUMATIC - FAST
  - COMPRESSED AIR IS HARD
  - CAN'T DO HEAVY LOADS

FEB 28, 2018

MOTORS
- A MOTOR IS A TRANSDUCER
- RATED VOLTAGE IS MOST EFFICIENT

READ SIZES

EX: WE WANT A 2-WHEELED, 2kg CAR TO GO UP A 30° SLOPE @ $V = 1/2$ ft/s
WHEEL DIAM: 3", $\mu = 0.7$ $T = ?$ RPM=?

$F_T = F_W + F_F$
$F_W = mg\sin\theta$
$F_F = \mu mg\cos\theta$

$F_T = F_W + F_F$
$= mg(\sin\theta + (\cos\theta)\mu)$
$= \left(\frac{2kg}{2}\right)(9.81\,m/s^2)(\sin(30°) + 0.7\cos(30°))$
$= 10.89\,N$

NECESSARY TORQUE

$T = F \cdot r$
$= (10.89\,N)(1.5")(2.54\,cm/in)\left(\frac{1m}{100cm}\right) = 0.4149\,Nm$

MAR 02, 2018

MORE MOTORS:

MAR 05, 2018

STEPPER MOTORS
↳ USE MAGNETS TO MOVE MOTOR TICK BY-TICK
↳ PRECISE MOVEMENT, LOW TORQUE

UNIPOLAR & BIPOLAR STEPPER MOTORS

UNIPOLAR ↓
MORE COMMON
4 SETS OF WINDINGS

BIPOLAR ↓
MORE SPEED & TORQUE
2 SETS OF WINDINGS

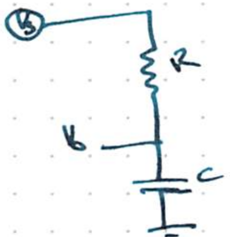
MAR 07, 2018

ENCODERS
↳ ABSOLUTE POSITION
↳ EXACT DEGREE OF WHEEL
↳ INCREMENTAL
↳ TELLS YOU WHEN YOU'VE ROTATED X-DEGREES

ENCODERS REQUIRE HYSTERESIS BAND

PASSIVE FILTER DESIGN

LOW PASS:

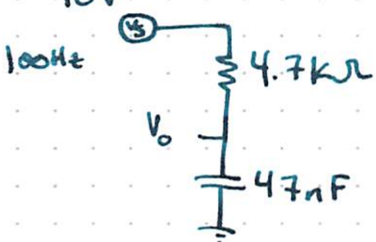


MAR 09, 2018

MAGNITUDE: $\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{1+(\omega RC)^2}}$

PHASE: $\angle\left(\frac{V_{out}}{V_{in}}\right) = -\tan^{-1}\left(\frac{\omega RC}{1}\right)$

10V



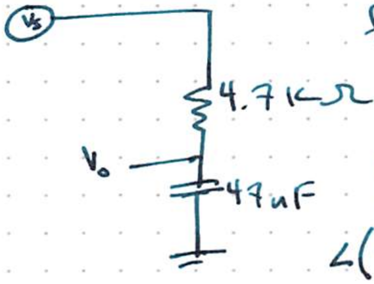
$V_o = V_s \frac{X_c}{\sqrt{R^2+X_c^2}} = 10V \frac{33863\Omega}{\sqrt{(4700)^2+(33863)^2}} = 9.9V$

$X_c = \frac{1}{2\pi(f)(C)} = \frac{1}{2\pi(100Hz)(47E-9)} = 33863\Omega$

$\omega = 2\pi f$
$f = 100;\ 10{,}000$
$\omega = 628;\ 62832$

$\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{1+(\omega RC)^2}} = \frac{1}{\sqrt{1+((628)(4700)(47E-9))^2}} = 0.99$

CALCULATING f_c & PHASE SHIFT



$$f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi(4700)(47E\text{-}9)} = 720\,Hz$$

$$\omega = 2\pi f = 4524$$

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{1+((4524)(4700)(47E\text{-}9))^2}} = 0.707$$

$$\angle\left(\frac{V_{out}}{V_{in}}\right) = -\tan^{-1}(\omega RC) = -45°$$

$$V_o = V_s\frac{X_c}{\sqrt{R^2+X_c^2}}\ ;\ X_c = \frac{1}{\omega C} = \frac{1}{(4524)(47E\text{-}9)} = 4703\,\Omega$$

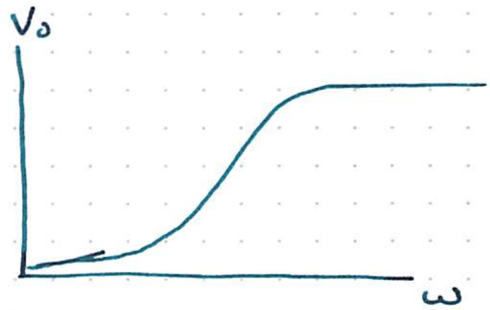
$$= 10\frac{(4703)}{\sqrt{(4700)^2+(4703)^2}} = 7.07V$$

HIGH PASS FILTER

$$V_o = V_s\frac{R}{R+X_c} \qquad X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

$$V_o = V_s\frac{R}{R+\frac{1}{\omega C}}$$

$$V_o = V_s = \frac{\omega RC}{\omega RC+1}$$



$$\frac{V_{out}}{V_{in}} = \frac{j\omega RC}{j\omega RC+1}$$

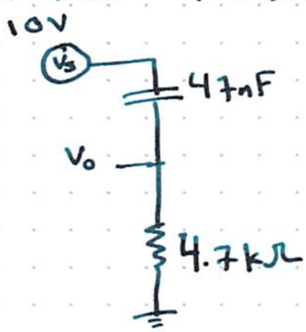
MAG: $$\left|\frac{V_{out}}{V_{in}}\right| = \frac{\omega RC}{\sqrt{1+(\omega RC)^2}} \qquad f_c = \frac{1}{2\pi RC}$$

PHASE: $$\angle\frac{V_{out}}{V_{in}} = \tan^{-1}\left(\frac{1}{\omega RC}\right)$$

MAR 19, 2018

EXAM NEXT FRIDAY

EX:



CALC f_c

CALC MAG, PHASE SHIFT, & V_o @ 720 Hz

$$f_c = \frac{1}{2\pi RC} = 720\,Hz\ ;\ \omega = 2\pi f_c = 4524 \text{ RAD}$$

$$\left|\frac{V_o}{V_i}\right| = \frac{\omega RC}{\sqrt{1+(\omega RC)^2}} = 0.707$$

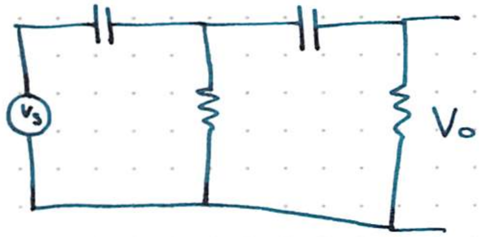
$$\angle(V_{out}/V_{in}) = \tan^{-1}\left(\frac{1}{\omega RC}\right) = 45°$$

$$X_c = \frac{1}{\omega C} = 4703\,\Omega$$

$$V_o = V_s\frac{R}{\sqrt{R^2+X_c^2}} = 10\frac{4700}{\sqrt{(4700)^2+(4703)^2}}$$

$$\boxed{= 7.07V}$$

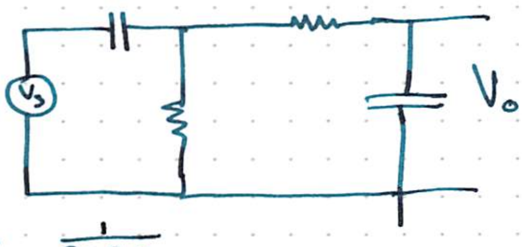
HIGER ORDER FILTERS

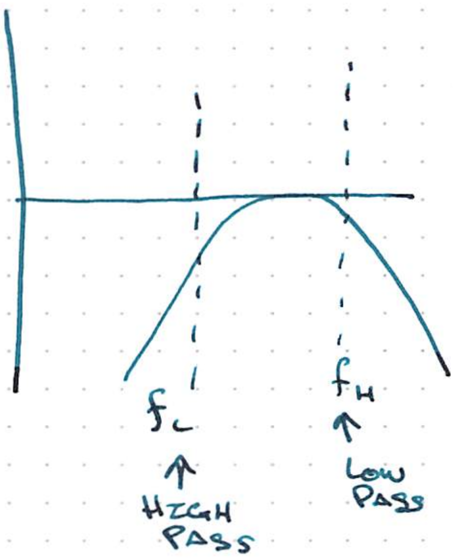


DIFFERENTIATOR CIRCUIT

HIGHER FREQ → EDGE ENHANCEMENT

BAND PASS





$f_L = \frac{1}{2\pi R_L C_L}$

$f_H = \frac{1}{2\pi R_H C_H}$

$f_{CENTER} = f_r = \sqrt{f_L f_H}$

ACTIVE FILTERS

EX: NON-INV ACTIVE LOW-PASS FILTER

$A_{DC} = 10$; $f_c = 159\,Hz$; INPUT IMPEDENCE $= 10k\Omega$

$A_{DC} = 1 + \frac{R_2}{R_1}$

$R_2 = R_1 (A_{DC} - 1)$

ASSUME $R_1 = 1k\Omega$

$R_2 = (1000)(9)$

$= 9k\Omega$

$C = \frac{1}{2\pi R f_c} = \frac{1}{2\pi (10k)(159)}$

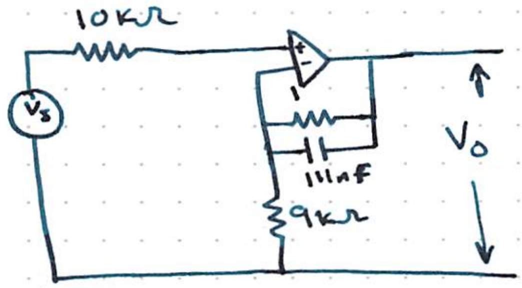
$= 100\,nF$

INTRO
↳ WHY WIDEBAND GAP MATERIALS?
↳ INTRINSIC PROPERTIES
↳ LARGE ENERGY GAP
↳ CAN HANDLE HIGH CURRENT DENSITY
↳ HIGHER V OPERATION
↳ SMALLER COMPONENTS

↳ SiC/GaN

MAR 21, 2018

FILTER IMPROVEMENTS



SALLEN-KEY 2ND ORDER LOW PASS ACTIVE FILTER

EX: 1ST ORDER HIGH-PASS NON-INV. OP-AMP
W/ A PASS BAND $A_{DC} = 2$, $C = 10nF$, $f_c = 1kHz$

$R = \frac{1}{2\pi C f_c} = 15.92k\Omega$

CHOICE, 10K EASIEST

$A_{DC} = 1 + \frac{R_2}{R_1}$

$2 = 1 + \frac{R_2}{R_1}$ $R_2 = R_1$ $(10k\Omega)$

~~MAR 23, 2018~~ APR 2, 2018

DIGITAL FILTERING
↳ TYPICALLY IN SOFTWARE

DIGITALLY FILTER FOR CAR (UNEVEN LIGHTING IN GYM)

AVERAGING FILTER CAN SMOOTH CAMERA NOISE.

DERIVATIVE FILTER
↳

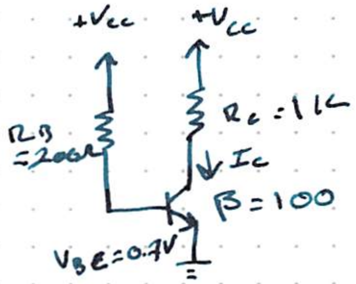
1) NORMALIZE
↳ COMPENSATE FOR LIGHTING
2) BLUR → REMOVE NOISE
3) DERIV. W/ ABS
4) FIND PEAKS & CENTER TRACK

BJT Ex. 2

$$I_B = \frac{I_C}{\beta} = \frac{4mA}{270} = 15\,\mu A$$

USE 3) $\frac{V_{CE} - V_{BE}}{I_B} = \frac{7.5V - 0.7V}{15\mu A} = 453k\Omega = R_B$

USE 2) $R_C = \frac{V_{CC} - V_{CE}}{I_B + I_C} = \frac{15 - 7.5}{15\mu A + 4mA} = 1.87k\Omega$



$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{15 - 0.7}{200} = 71.5mA$$

$I_C = \beta I_B = 7.15A$ ☆ ← CAN'T WORK IN SATURATION

$$V_{CE} = V_{CC} - I_C R_C = 15V - (7.15A)(1k\Omega)$$
$$= -7135V$$

SATURATION

WHAT ARE I_B & I_C @ EDGE OF SATURATION

ASSUME $V_{CE} = 0.2V$ WHEN OPERATING IN SATURATION

$$V_{CC} = V_{CE} + I_C R_C$$

$$I_C = \frac{V_{CC} - V_{CE}}{R_C} = \frac{15 - 0.2}{1000} = 14.8mA$$