MAS836 – Sensor Technologies for Interactive Environments

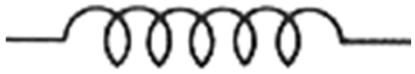
Lecture 2 – Analog Conditioning Electronics, Pt. 2

Reading…

- Horowitz and Hill
  - Finish Chapter 1, read Chapters 4&5
- Fraden
  - Interface Electronic Circuits Chapter (Chapter 4 of second edition)

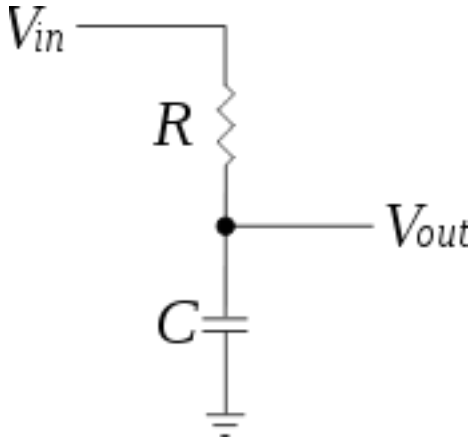
Reactive Impedance

- The Capacitor —||—
  - Adds in parallel like resistors add in series
  - Reciprocal-adds in series like resistors add in parallel
- Impedance of capacitor = $-j/\omega C = -j/(2\pi fC)$
  - Pass AC, block DC
    - Capacitor current: $Ic = CdV/dt$
- Impedance of inductor = $j\omega L = j(2\pi fL)$
  - Block AC, pass DC
    - Inductor Voltage: $V = LdI/dt$



Passive RC Filters

- Passive LP Filter: RC network: $f_c = 1/(2\pi RC)$



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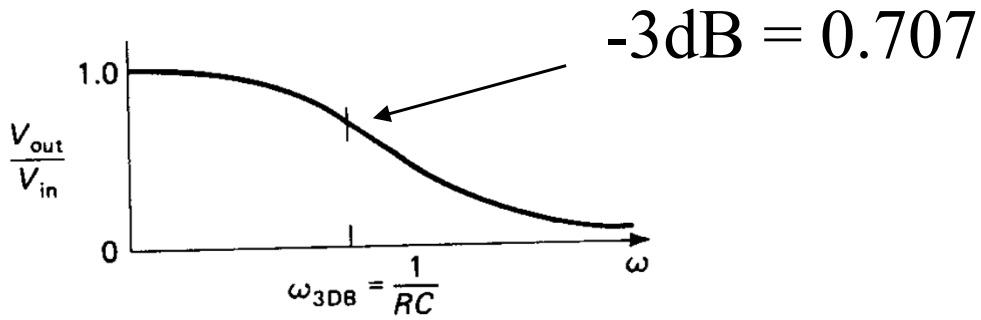
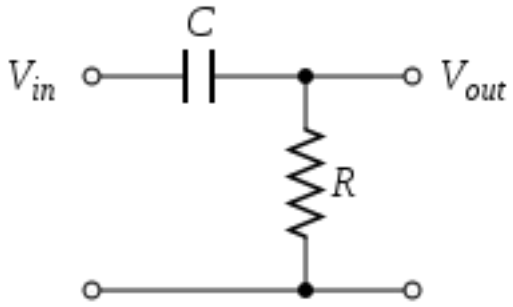


Figure 1.59. Frequency response of low-pass filter.

- Passive HP filter: RC network: $f_c = 1/(2\pi RC)$



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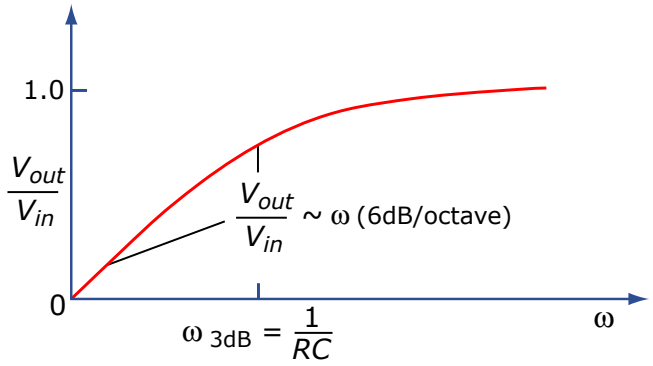
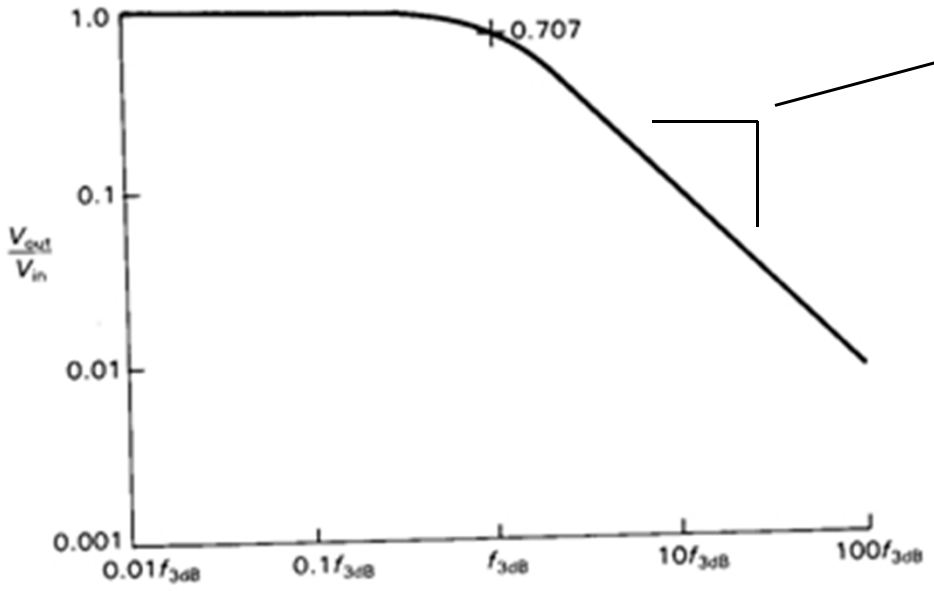


Frequency response of a high-pass filter.

Passive RC Filter Rolloff

The rest of this figure has been removed due to copyright restrictions. It can be viewed on page 38 of *The Art of Electronics*, P. Horowitz and W. Hill.
See: page 38 of The Art of Electronics on Google Books.

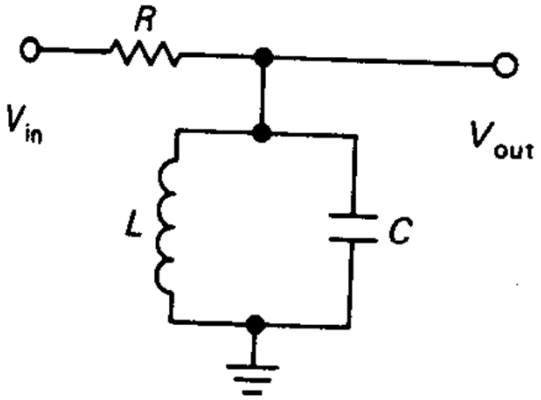
Bode Plot:
Freq. Response as a log-log plot

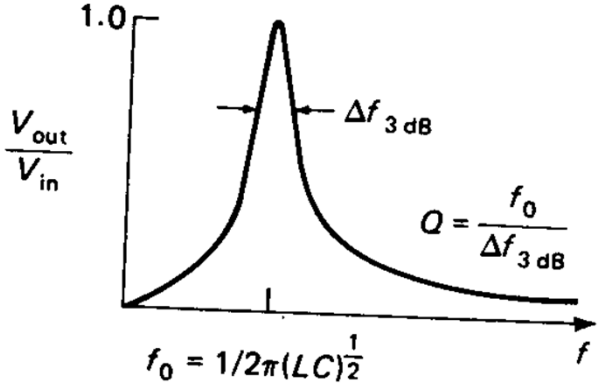


Rolloff is 6 dB per Octave (2x)
20 dB per Decade (10x)

Passive RLC Filters

- Resonant parallel RLC bandpass filters

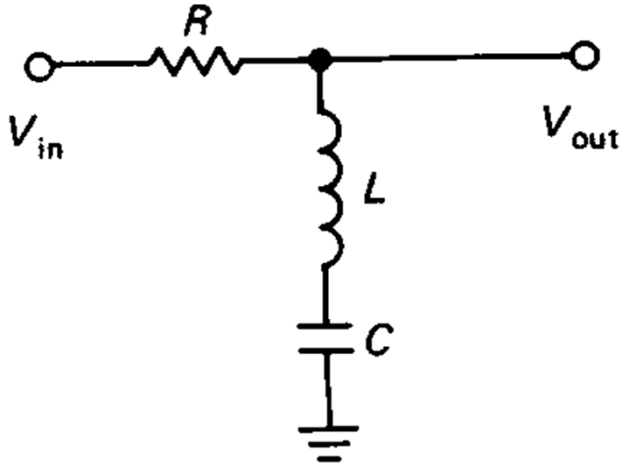


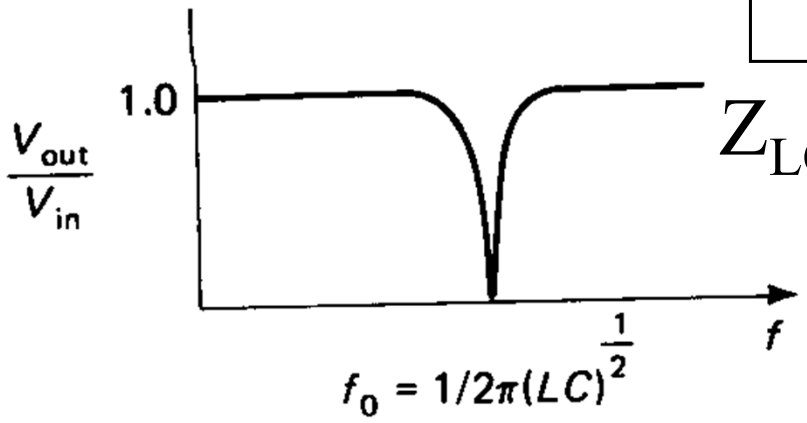


$$Q = \omega_0 RC = f_0/\Delta f_{3dB}$$

$$Z_{LC} \rightarrow \infty \text{ @ } f_0$$

- Resonant series RLC notch filters





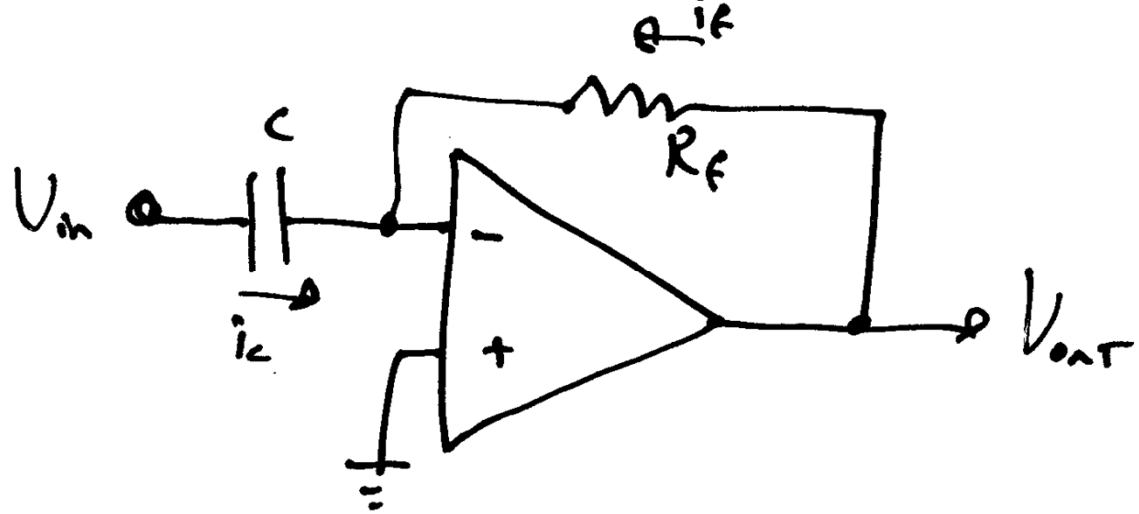
$$Q = \omega_0 (L/R) = f0/\Delta f_{3dB}$$

$$Z_{LC} \rightarrow 0 \text{ @ } f_0$$

Active Filters

- The Differentiator
- The Active High-Pass Filter
- Principle of Feedback Inversion
- The Integrator
- The Leaky Integrator (LP filter)
- Buffered Passive Second-Order Filter
- Sallen-Key (or VCVS) LP, HP, BP filters
- Single-OpAmp VCVS BP filter

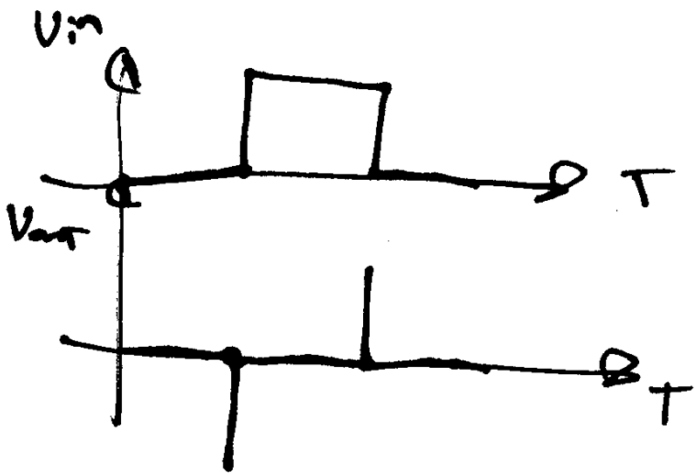
The Differentiator



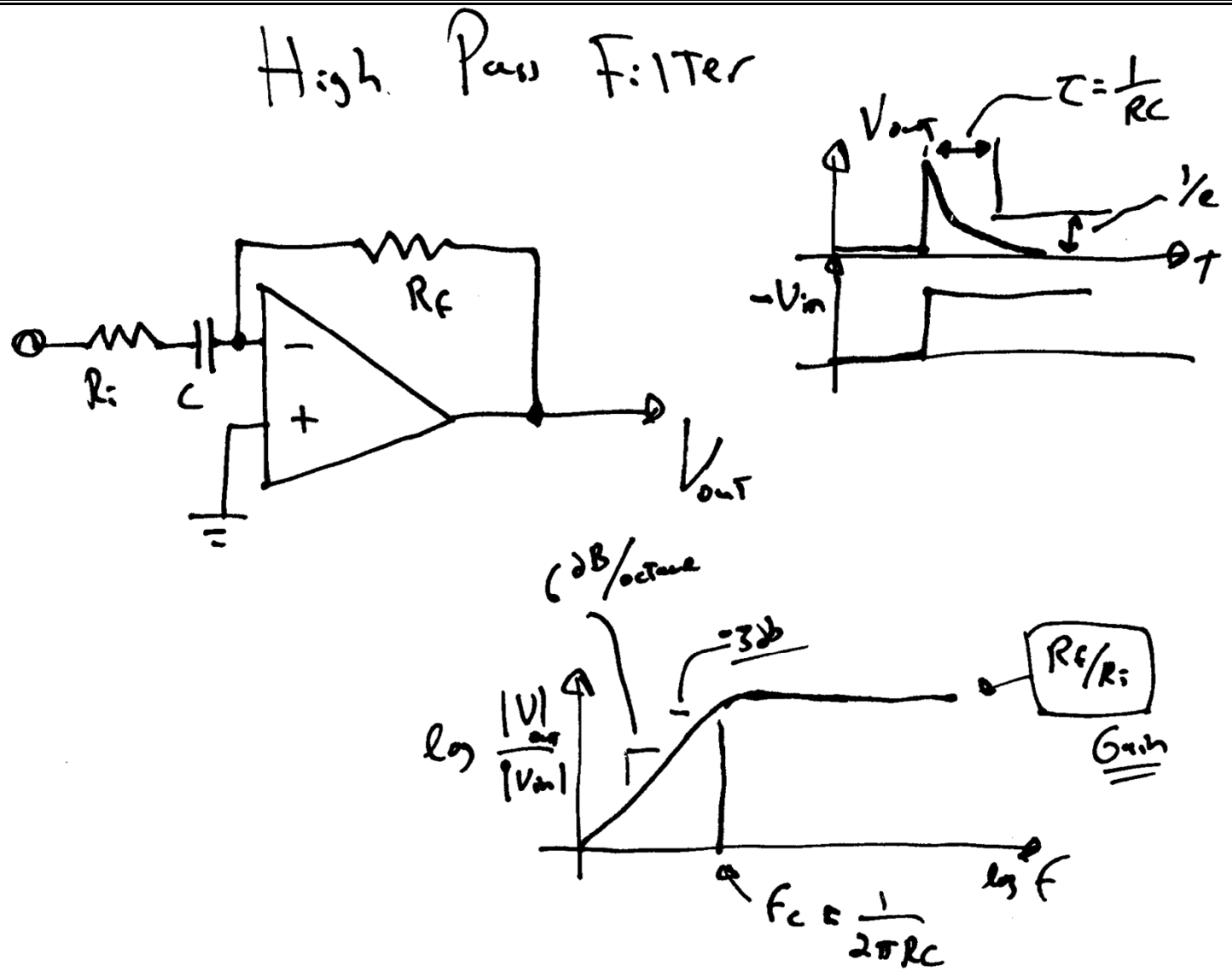
$$i_f = -i_c$$

$$\frac{V_{out}}{R_f} = -C\frac{dV_{in}}{dT}$$

$$V_{out} = -R_f C \frac{dV_{in}}{dT}$$

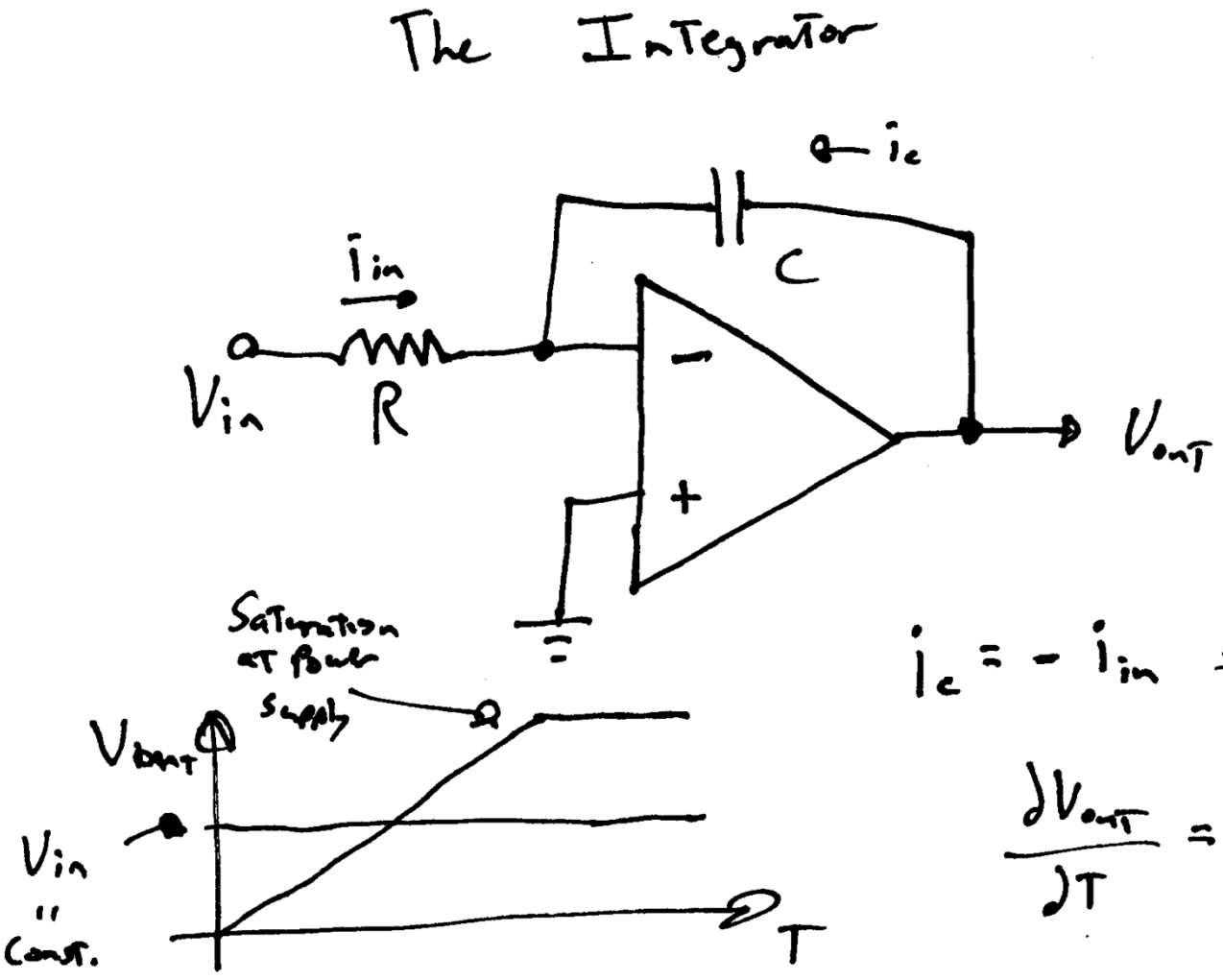


The First-Order Active High Pass Filter



- Low impedance drive
- Voltage gain via R_f/R_i

The Integrator



$$Z_c = \frac{1}{j\omega C}$$

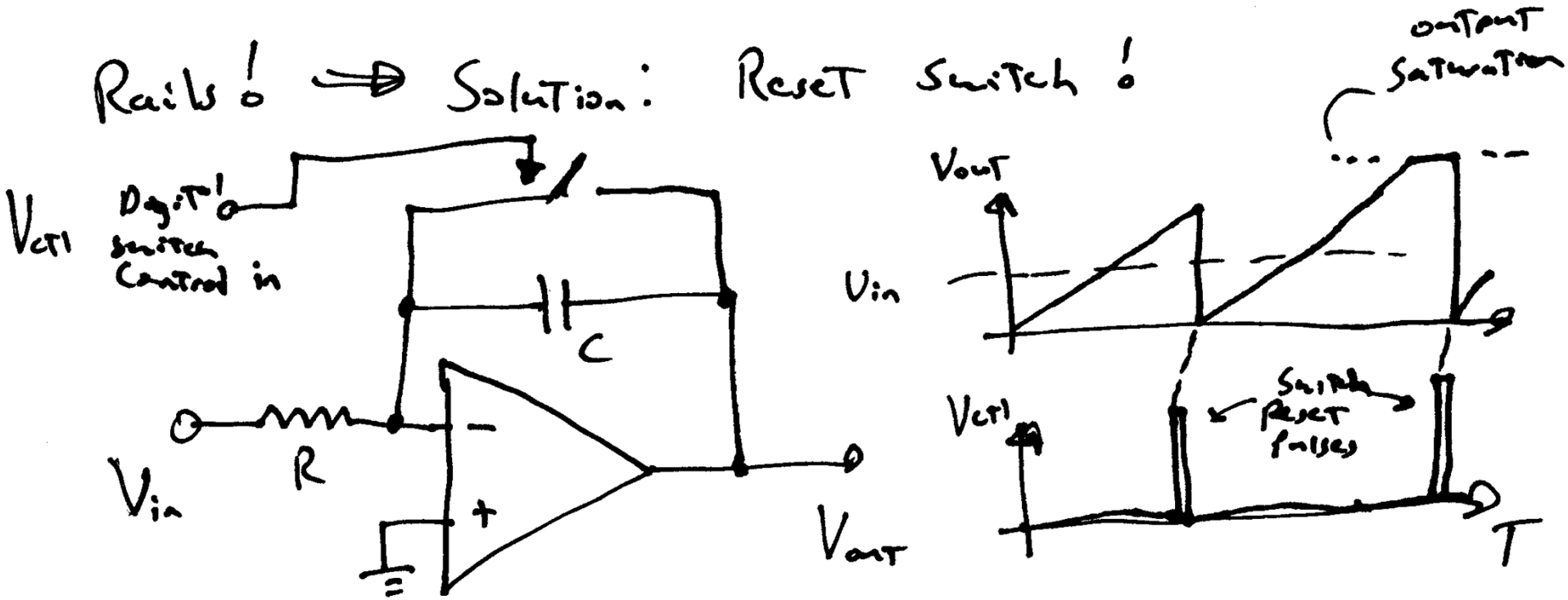
$$i_c = C \frac{dV}{dT}$$

$$i_c = -i_{in} \Rightarrow C\frac{dV_{out}}{dT} = -\frac{V_{in}}{R}$$

$$\frac{dV_{out}}{dT} = -\frac{V_{in}}{RC} \Rightarrow V_{out} = \frac{-1}{RC}\int V_{in}\,dt$$

Saturates at rail!!

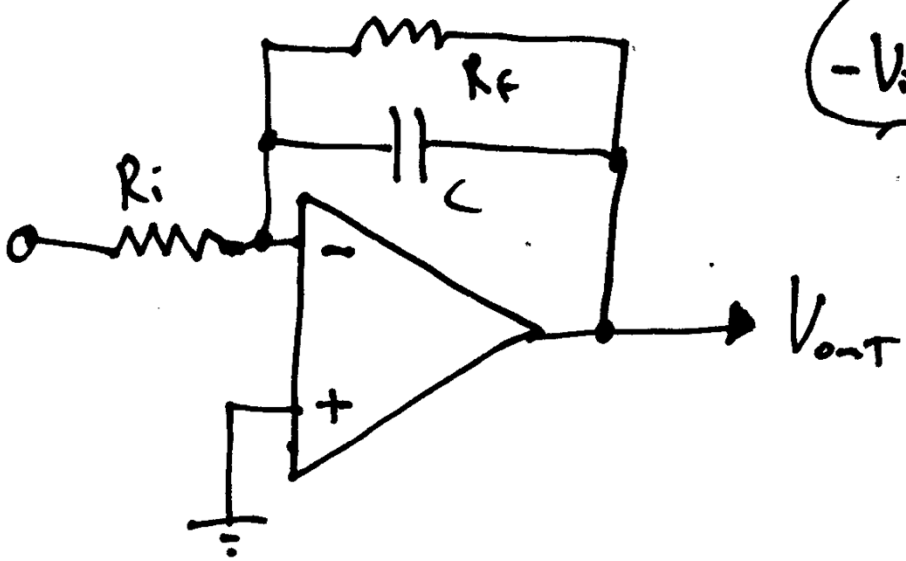
Integrator with Reset Switch

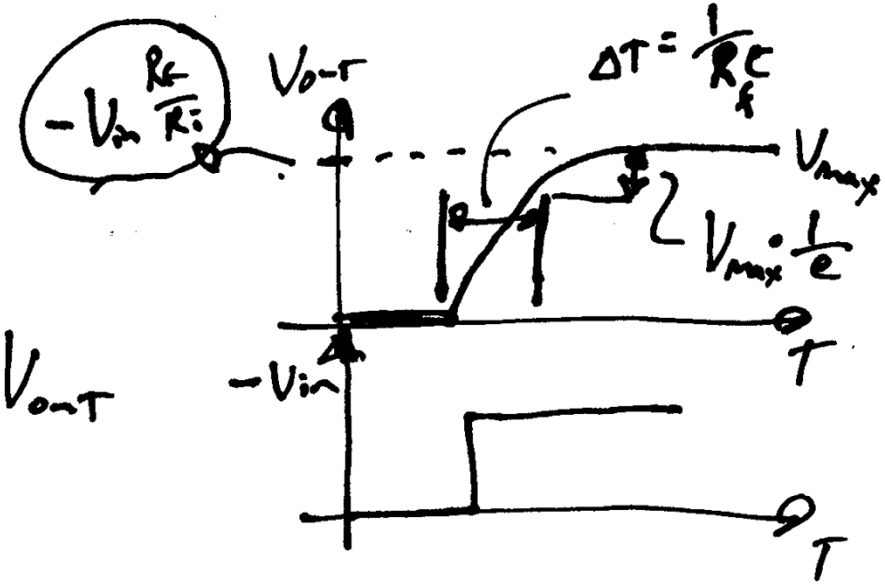


- Electronic switch in feedback forces output to ground when closed
  - Discharges capacitor
    - Resets Integrator!

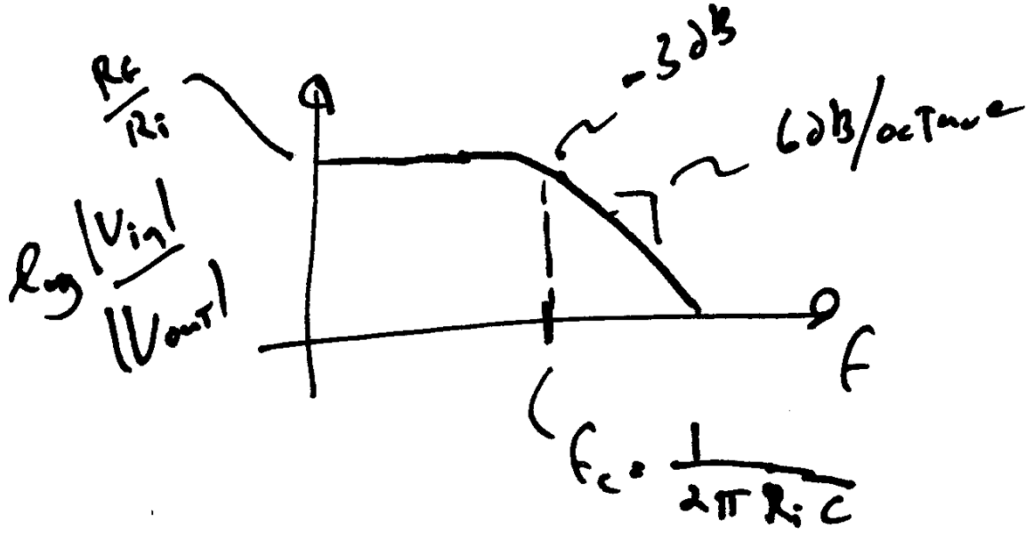
The First-Order Active Low Pass Filter

The Leaky Integrator ⟹ Low Pass Filter

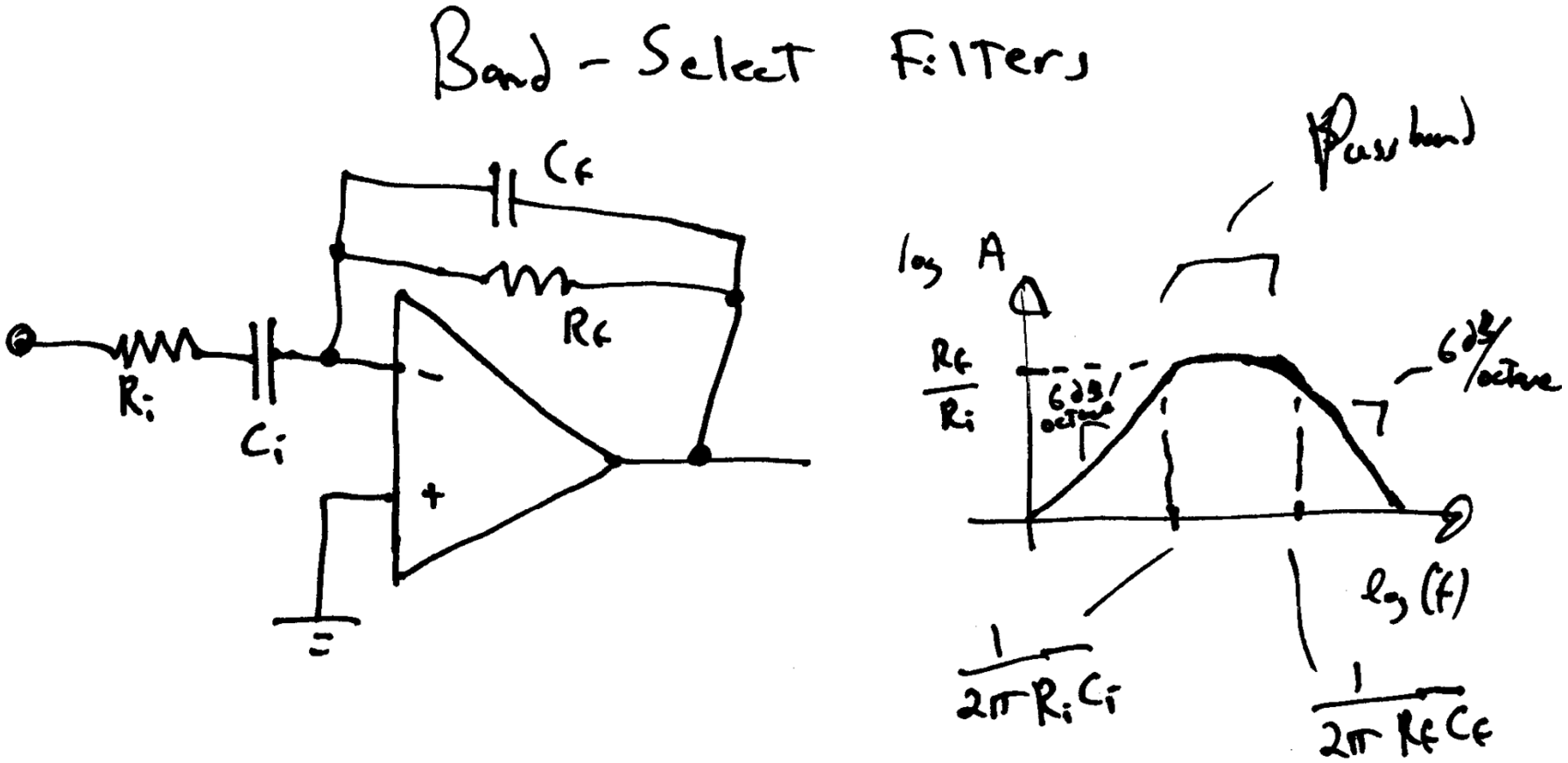




[Low impedance output !!
Voltage gain !!]

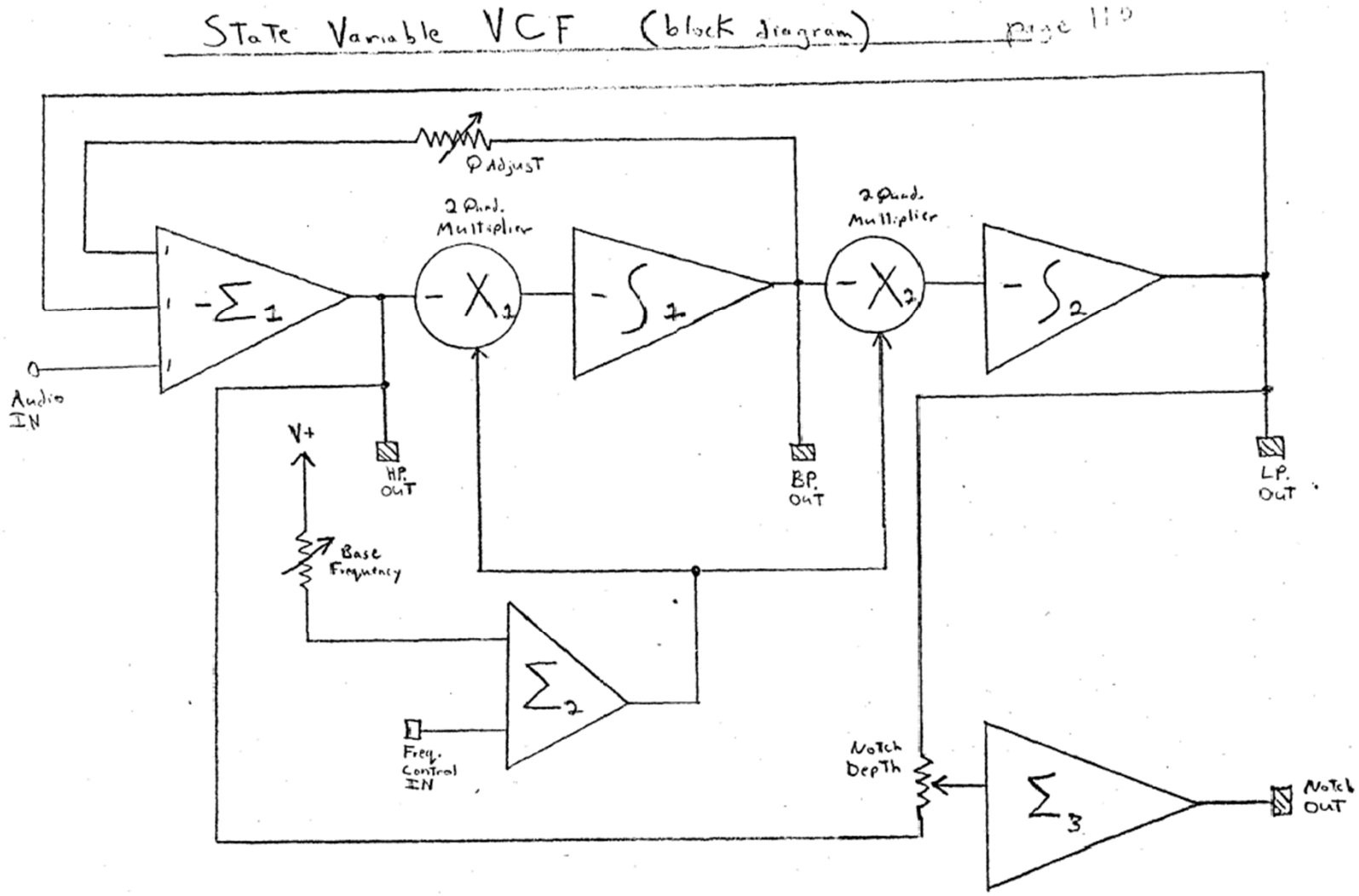


The Band-Select Filter



- Cascaded high and low pass filters
  - Always follow high-pass with low-pass (noise)
    - Low-Pass cutoff needs to be below high-pass cutoff!
  - No Q, first-order rolloffs

The State Variable Filter



- Analog Computer set up to solve a general Second-Order Differential Equation
  - Exhibits rolloff, damping, and resonance
  - Simultaneous low-pass, bandpass, high-pass, and notch outputs available

Modulars are Analog Computers?

Photo of a Compumedic Analog Computer from 1971 removed due to copyright restrictions. See: Old-Computers.com Museum.

Compumedic Analog Computer from 1971

Limitations on Filter Performance

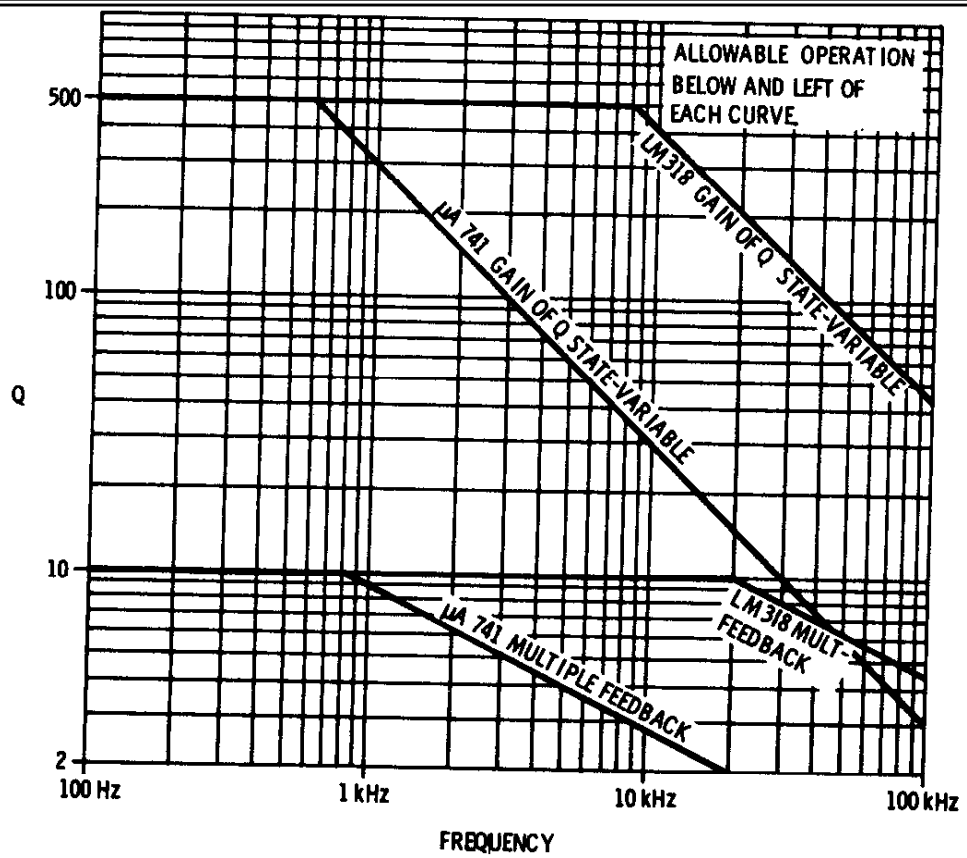
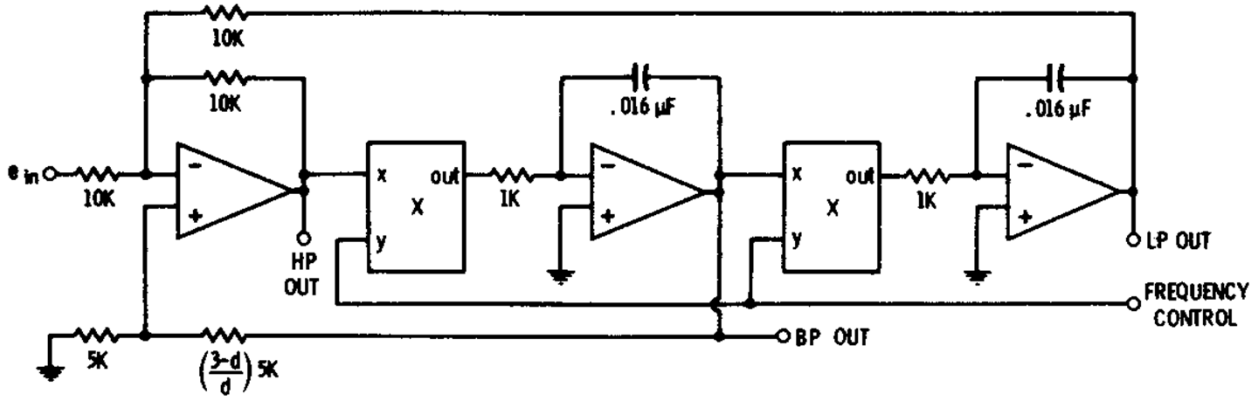


Fig. 7-14. Q and frequency limits for active bandpass filters, small output swings.

- The choice of OpAmp affects how well a given filter will perform
  - Multiple-OpAmp filters can attain higher Q's than single-OpAmp filters
  - Faster OpAmp's work better too
    - Accumulated Phase Shifts can cause oscillation!

Voltage-Controlled Filter



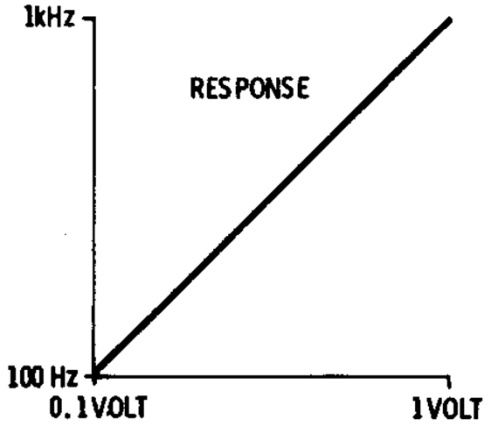
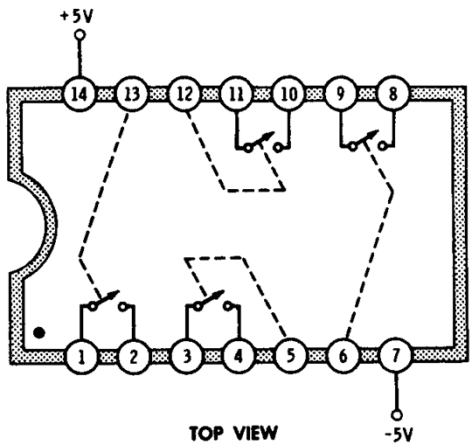


Fig. 9-5. Voltage-controlled filter using IC four-quadrant multipliers.

- Replace integrator input resistors with 2-quadrant multipliers (voltage-controlled amplifiers, or VCA's)
  - Need to tune both VCA's together
    - Results in a wide-range tunable filter!
      - Multiplier can be used to tune Q as well

Switched-Capacitor Tunable Filters

CMOS QUAD BILATERAL SWITCH **4016**



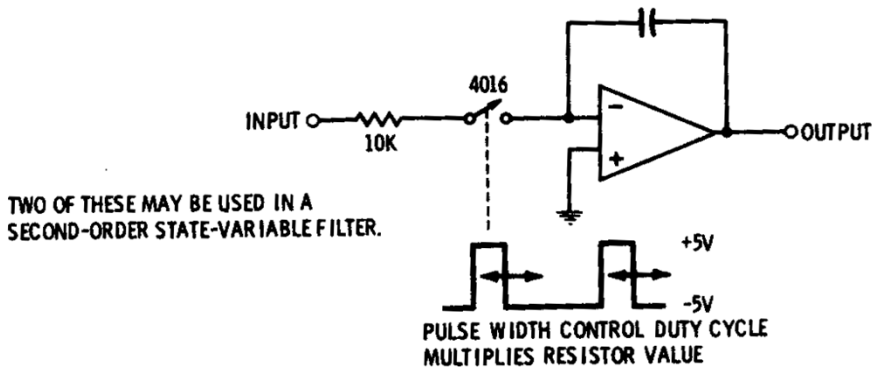
This circuit contains four independent switches that may be used for off-on control of digital or analog signals. Signals to be controlled must be less than +5 and more than −5 volts.

+5 volts applied to pin 13 turns ON the connection between pins 1 and 2. −5 volts applied to pin 13 turns OFF the connection between pins 1 and 2. The other three switches are similarly controlled.

Input impedance to pin 13 is essentially an open circuit. The OFF resistance of pins 1 and 2 is many megohms; the ON resistance is 300 ohms. A lower-impedance, improved version is available as the 4066.

Many types of analog switches are available (e.g., ADG from Analog Devices, etc.)

(B) Selecting resistors under digital command (D/A conversion).



(C) Duty-cycle modulator provides variable resistance. Switching rate must be much faster than signal frequencies.

Fig. 9-7. Using the 4016 switch.

- R is effectively varied proportionally to the On/Off duty cycle
  - Beware of aliasing (max input frequency is under half the switching frequency)
  - Not for High Pass filters!
- Tend to work best for lower-frequencies

Filters from Hong

Linear has come out with a couple really nice switched cap filters that really cuts down on the design time:

LTC1564 Tunable low pass filter 10kHz to 150kHz in steps of 10kHz, 8 pole roll-off, programmable 1-16 gain, 3-10V operation.

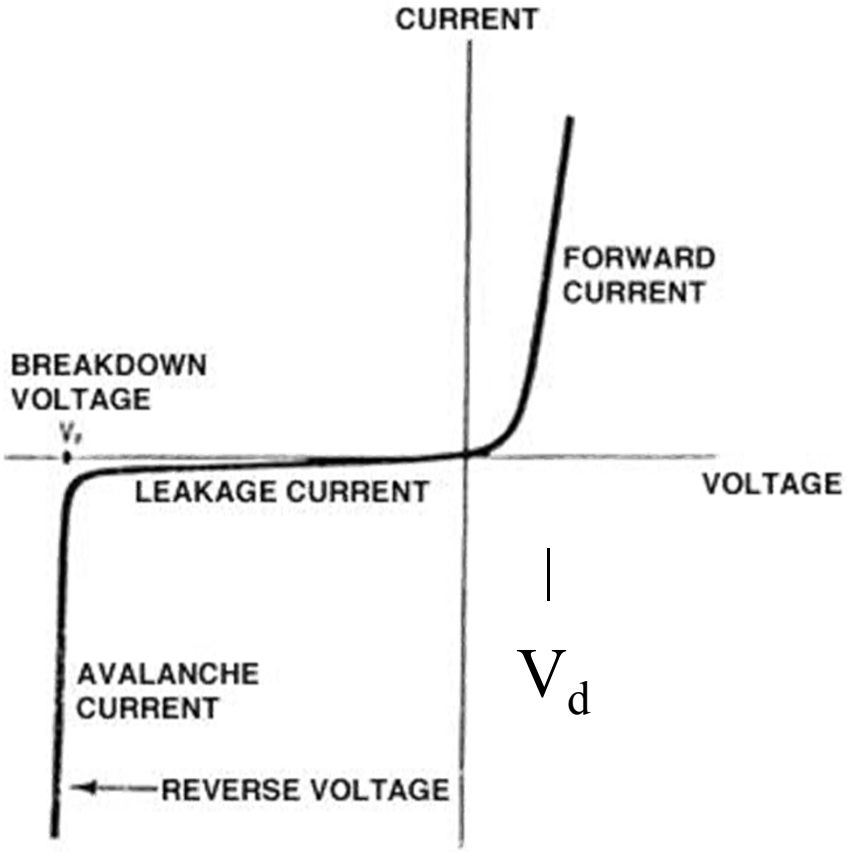
LTC1062 parallel 5-pole tunable low pass filter. Absolutely zero DC error because the input and output are connected directly with a wire and the filter damps out the high frequencies.

Biasing

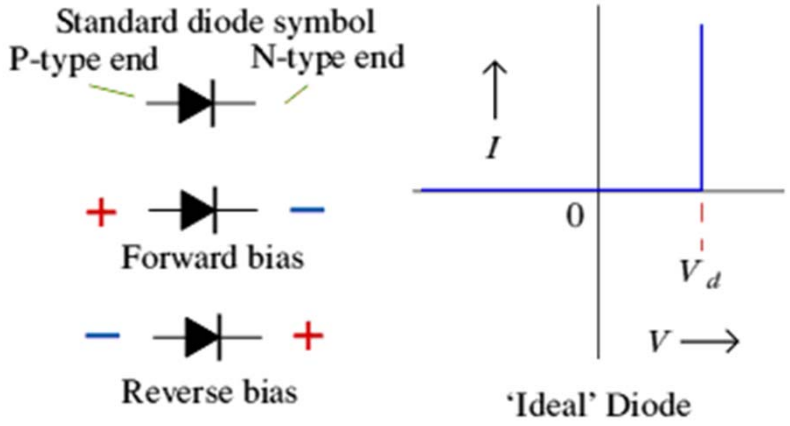
- AC Coupling
- Biasing noninverting input
- Biasing at inverting input

Diodes

- The Diode
  - I/V characteristic, ideal diode, forward drop, zeners

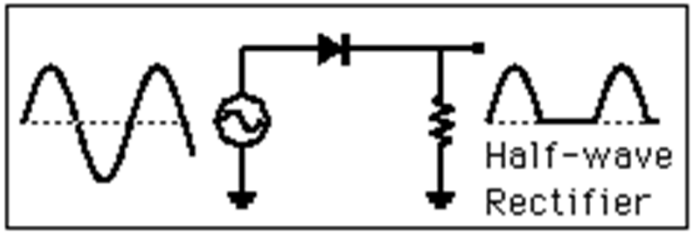


Drops (V_d):
Si = 0.6 V
Ge = 0.3 V
LED = 2.4-3.5 V
Schottky = .1-.3 V

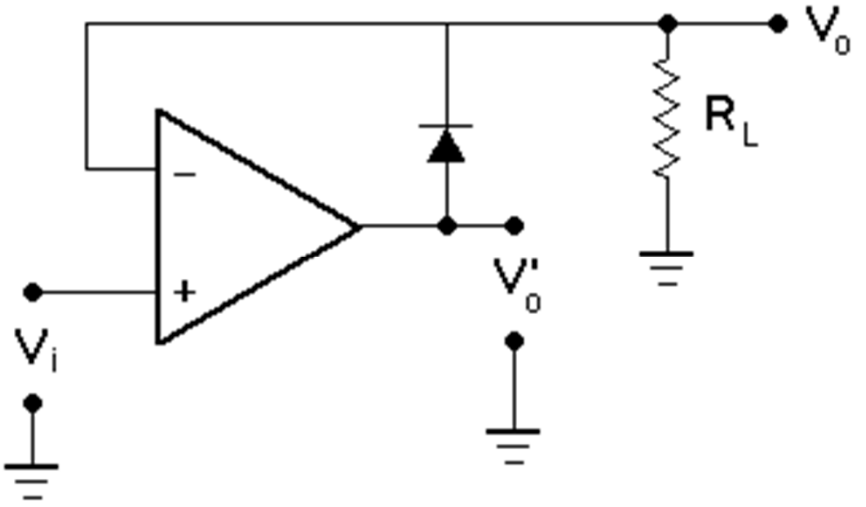


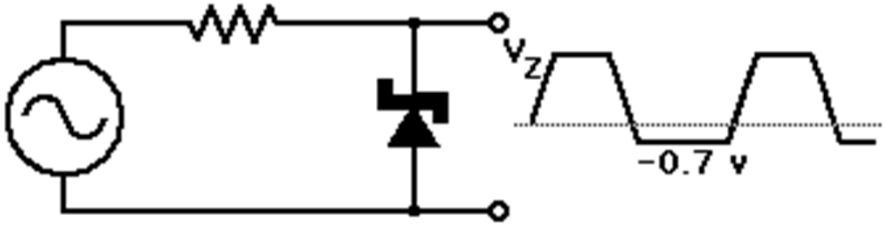
Basic Diode Circuits

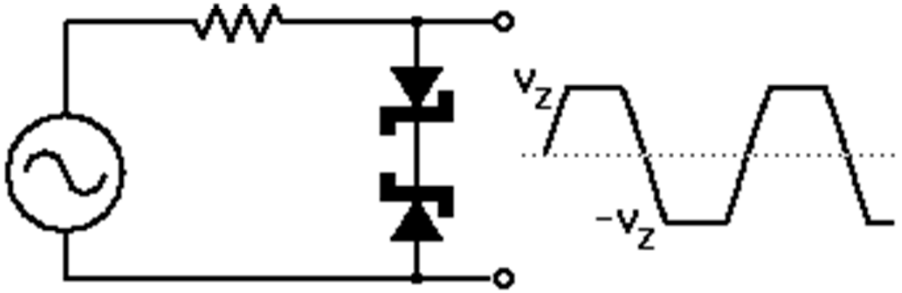
- Limiters/Clampers
  - –Passive Limiter - normal and zener
  - –Precision Zener



Positive Clamper

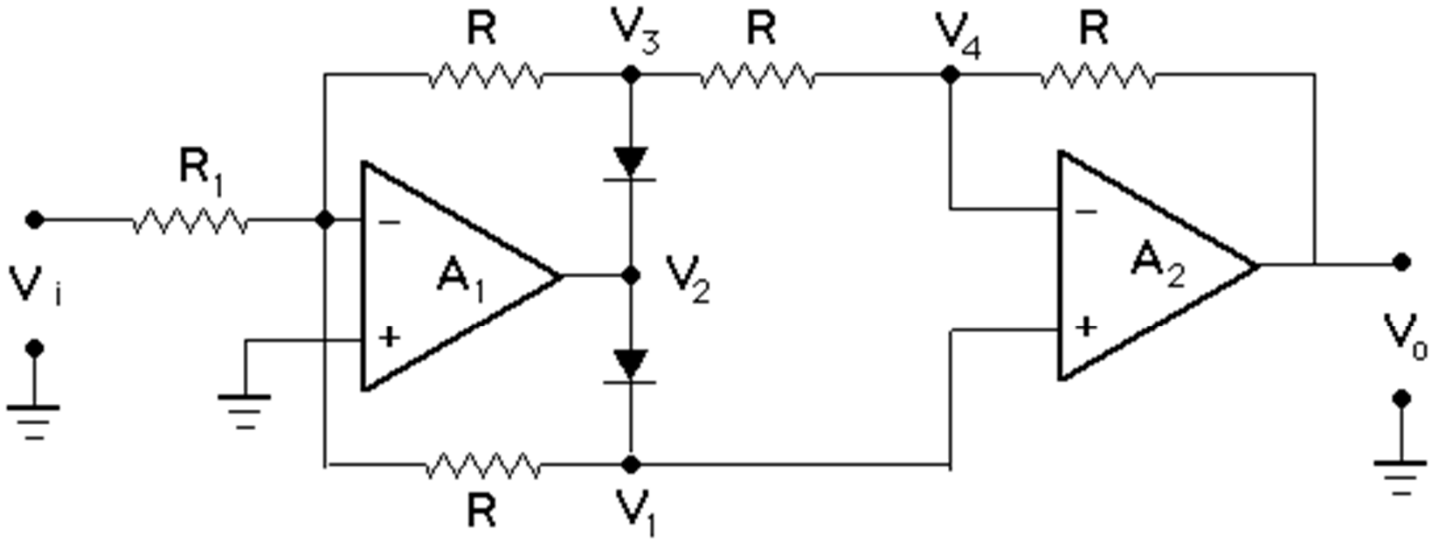




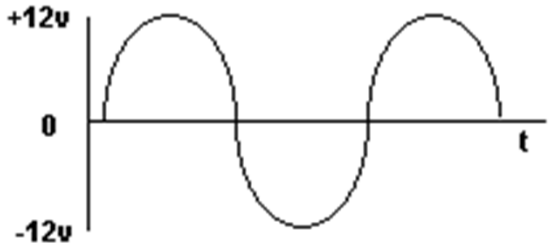


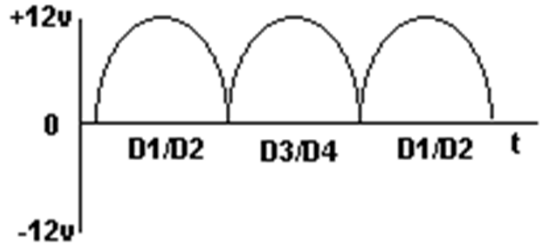
Zener Limiters

Absolute Value Circuits



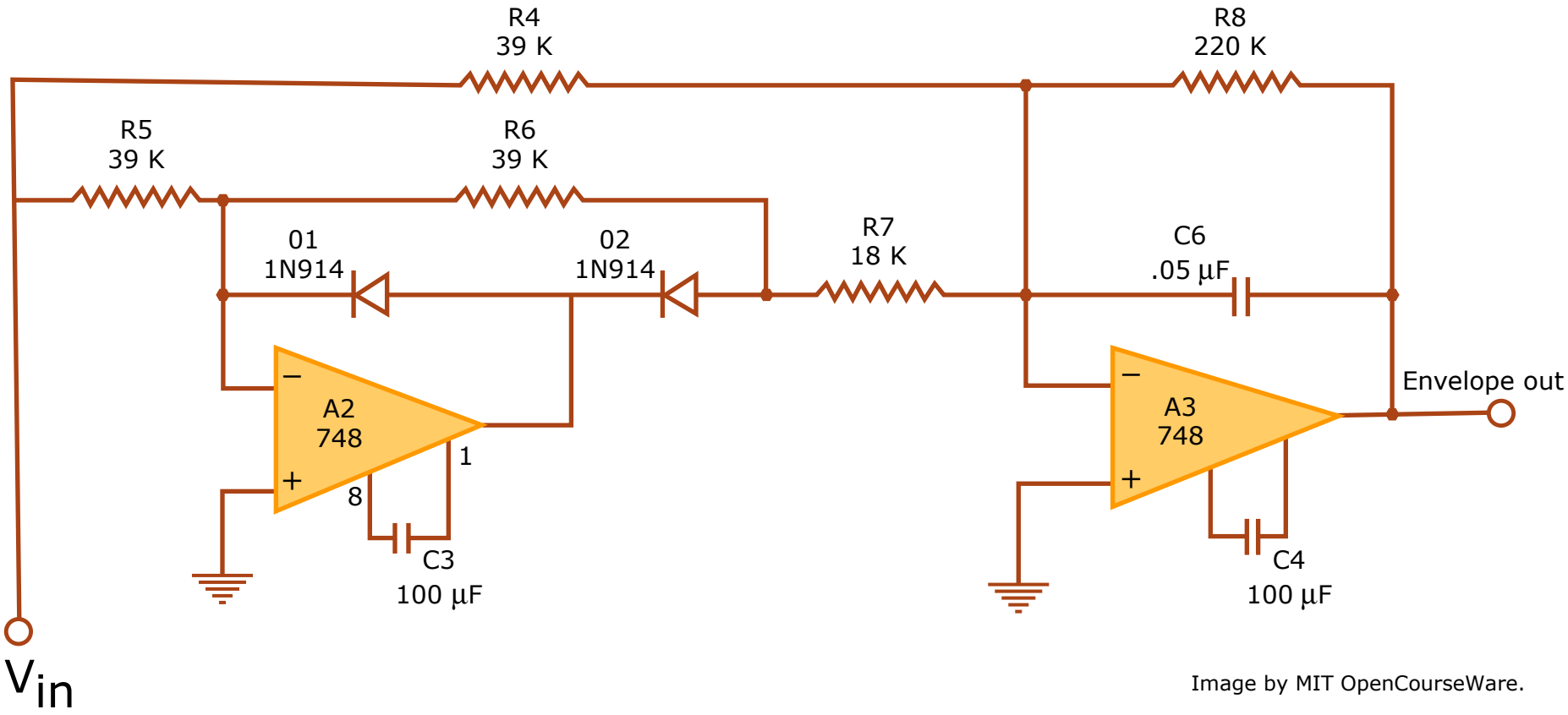
Full Wave Rectifier Circuit





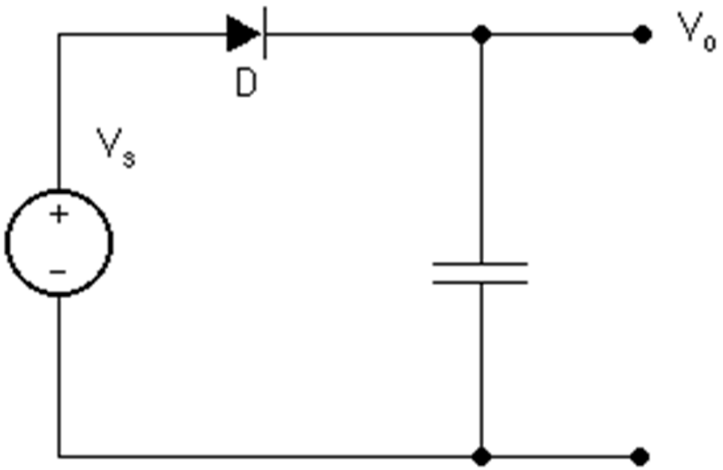
Bottom R is 2/3 top R in A_1?

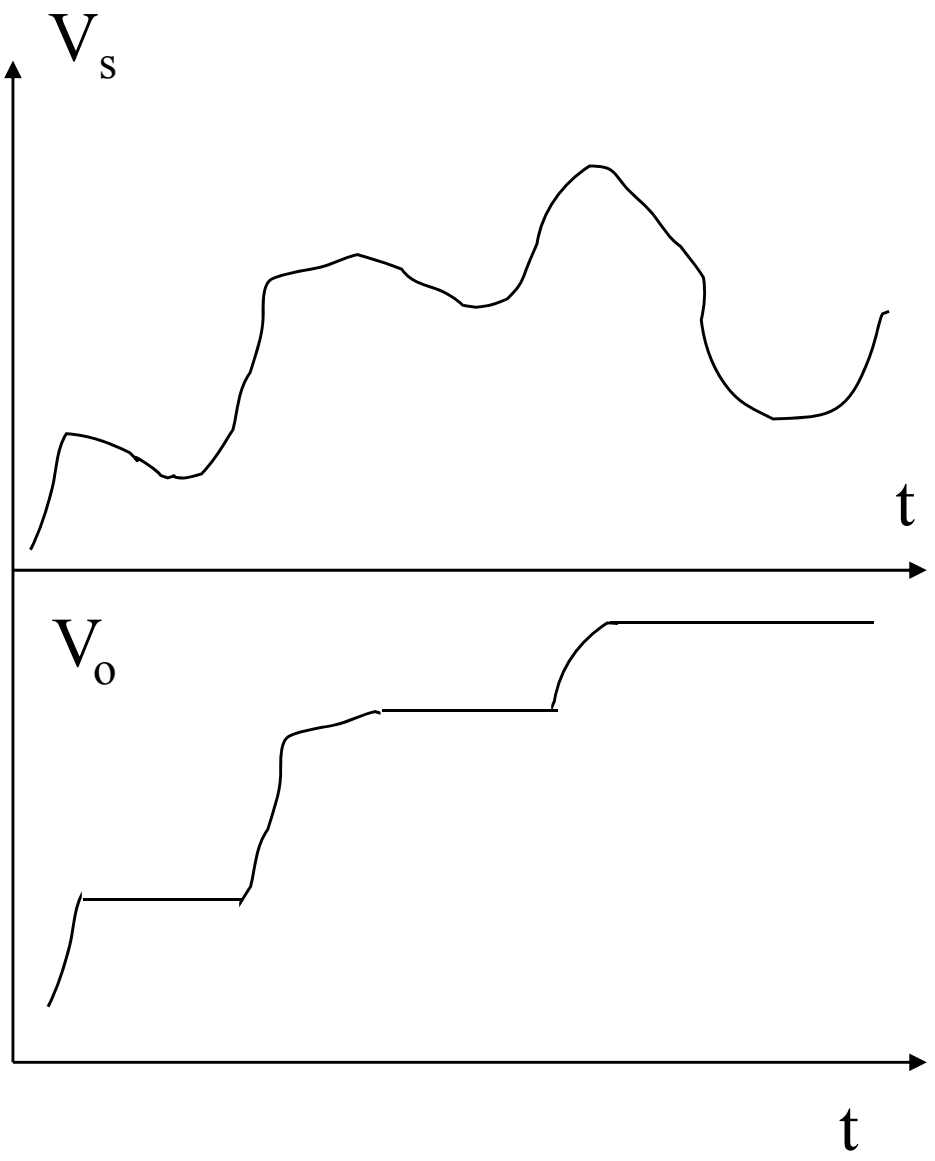
Absolute Value Circuit (envelope follower)



- A1 and A2 form an absolute value detector
- C6 integrates the absolute value to give the envelope
- Note that the 748 (and its compensation cap) is long obsolete!

Peak Detector

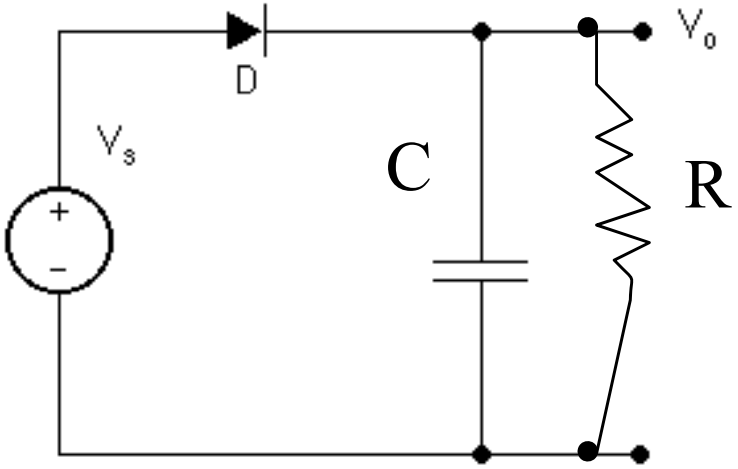


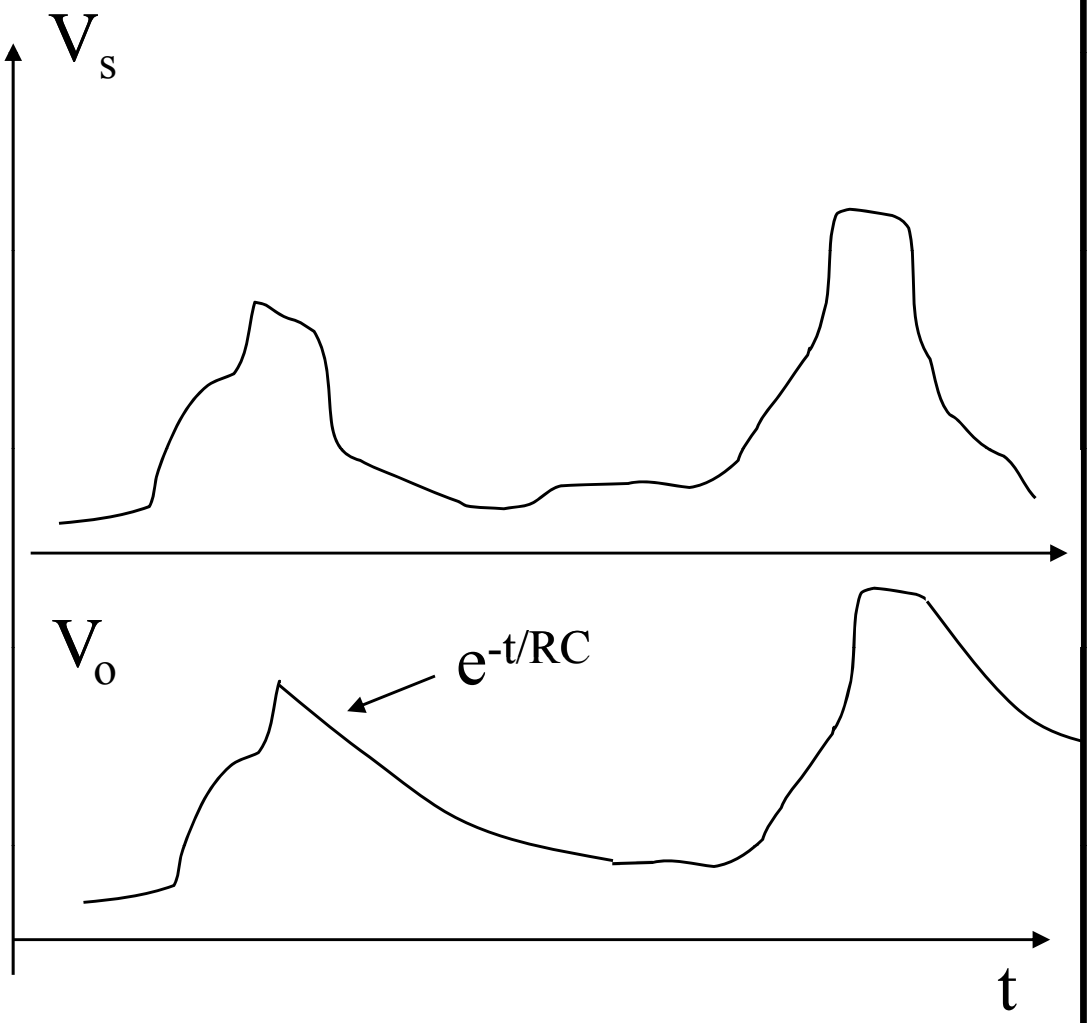


Capacitor holds peaks!

Need reset switch to continue tracking

Pulse Stretcher





-Resistor continually (and slowly) bleeds capacitor charge

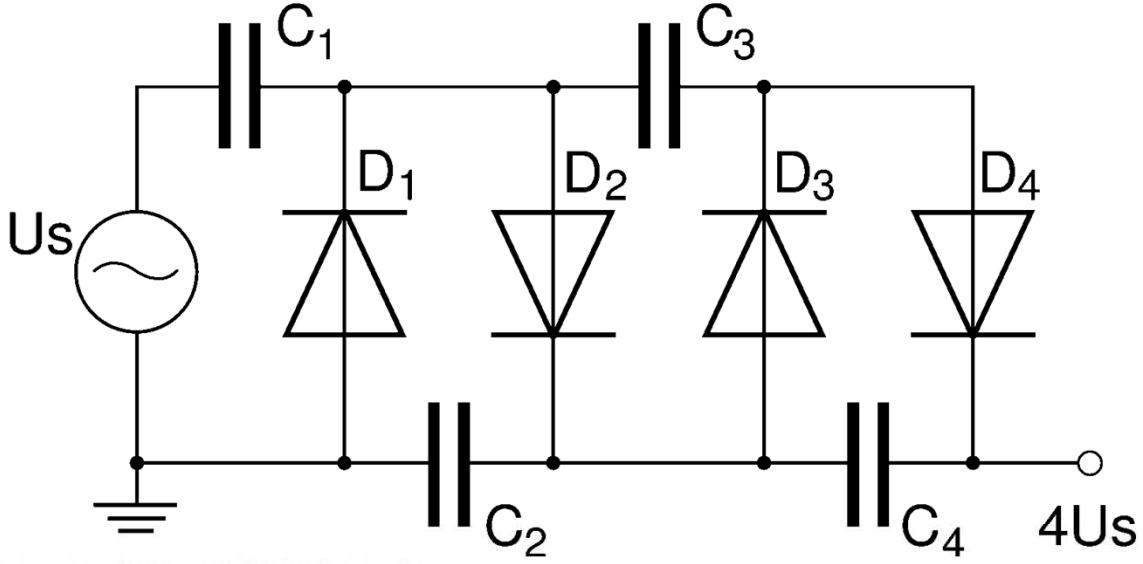
-Automatic "reset"

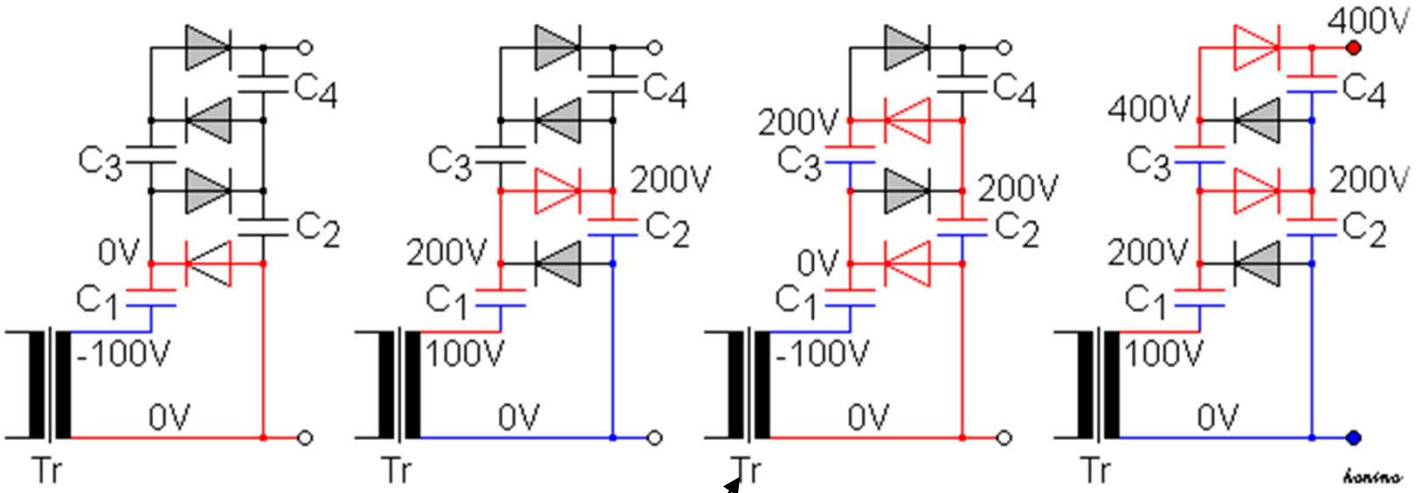
-Tune time constant to match signal dynamics (so peaks are always followed)

-Enables "lazy" sampling to catch transients

Voltage Multipliers, etc.

Cascaded Villard doubler





- Diodes don't let capacitors discharge onto source
- AC coupling lets each peak sit atop capacitor voltage
-Each AC peak increments voltage by half-wave height
- Voltage drop at given current increases rapidly (cube) with no. stages, inversely with C, freq

Ref: Wikipedia…

Transformer for isolation

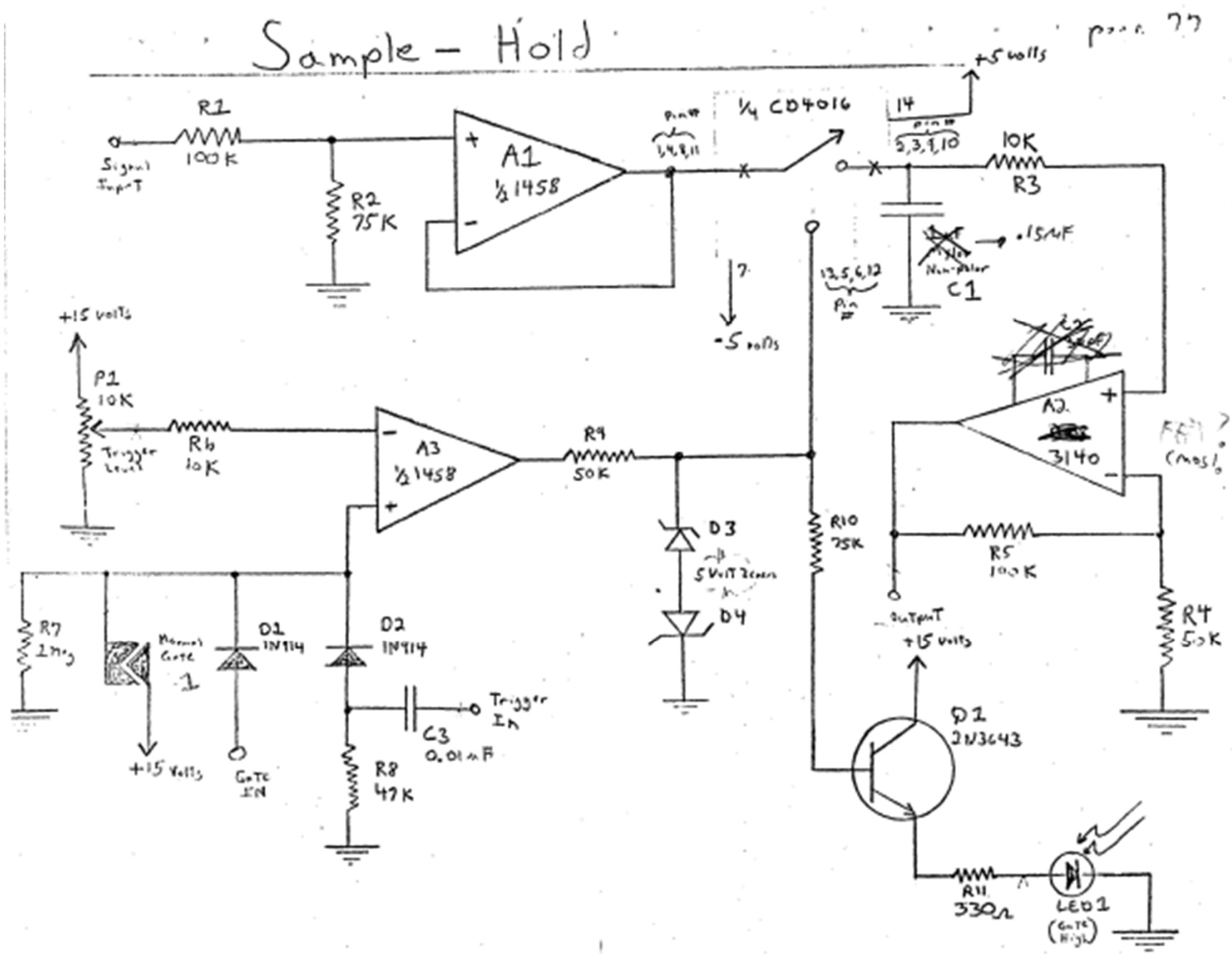
Sampling

- Nyquist: $f_{in} < f_s/2$
- Bandlimited (demodulation) sampling
  - $\Delta f_{in} < f_s/2$
  - Loose absolute phase information
    - Don't know whether phase moves forward or backward
  - Quadrature sampling
    - Bandlimited sampling at t and a quarter-period later

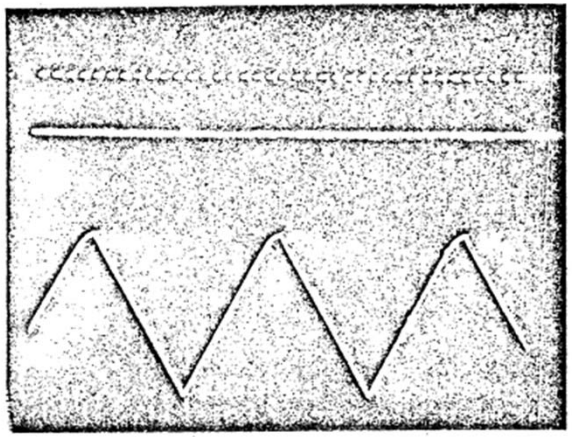
Sampling Aids

- Aliasing for nonperiodic signals??
  - Can miss or miss-sample trasients!
  - The Pulse-stretcher to the rescue!
- Sample/Holds
- Analog Multiplexers
- Programmable Gain Amplifiers (PGA's)
- Voltage-Controlled Amplifiers (VCA's)

The Basic Sample-Hold Circuit



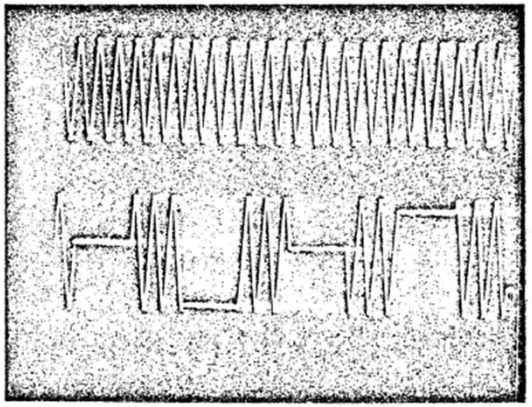
The Sample-Hold (and Track-Hold)



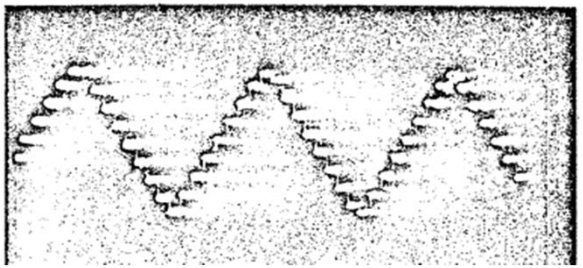
Pulse input to trigger on S/H

Triangle wave at the sampled input of S/H

Part B:
Square wave applied to the gate input of S/H to yield Photo#27



Waveform at S/H's sample input



Part A:
Output of S/H when waveforms in photo#25 are input

Output of S/H with above wave at input and the square wave in Part B of Photo#26 at the gate input

- Sample-Hold grabs input signal and holds it upon receipt of a pulse edge
- Track-Hold follows the input signal when the gate is high, but holds (latches) it when the gate is low.
- Sample hold acquires quickly – can use slow ADC.

Analog Multiplexers

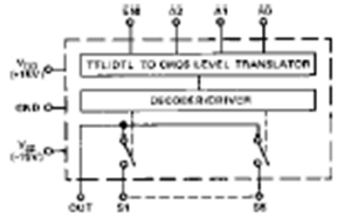
ANALOG DEVICES

CMOS
4-/8-Channel Analog Multiplexers

AD7501/AD7502/AD7503

FEATURES
DTL/TTL/CMOS Direct Interface
Power Dissipation: 30 μW
R_{ON}: 170 Ω
Standard 16-Lead DIPs and 20-Terminal Surface Mount Packages

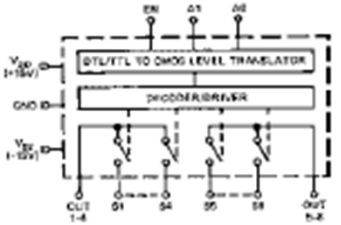
FUNCTIONAL BLOCK DIAGRAM
AD7501/AD7503



GENERAL DESCRIPTION
The AD7501 and AD7503 are monolithic CMOS, 8-channel analog multiplexers which switch one of eight inputs to a common output, depending on the state of three binary address lines and an "enable" input. The AD7503 is identical to the AD7501 except its "enable" logic is inverted. All digital inputs are TTL/DTL and CMOS logic compatible.

The AD7502 is a monolithic CMOS dual 4-channel analog multiplexer. Depending on the state of two binary address inputs and an "enable," it switches two output buses to two of eight inputs.

AD7502



Truth Tables

AD7501

A_2	A_1	A_0	EN	"ON"
0	0	0	1	1
0	0	1	1	2
0	1	0	1	3
0	1	1	1	4
1	0	0	1	5
1	0	1	1	6
1	1	0	1	7
1	1	1	1	8
X	X	X	0	None

AD7503

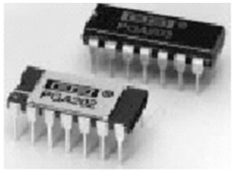
A_2	A_1	A_0	EN	"ON"
0	0	0	0	1
0	0	1	0	2
0	1	0	0	3
0	1	1	0	4
1	0	0	0	5
1	0	1	0	6
1	1	0	0	7
1	1	1	0	8
X	X	X	1	None

AD7502

A_1	A_0	EN	"ON"
0	0	1	1 & 5
0	1	1	2 & 6
1	0	1	3 & 7
1	1	1	4 & 8
X	X	0	None

Programmable Gain Amplifiers

BURR-BROWN®



PGA202/203

Digitally Controlled Programmable-Gain INSTRUMENTATION AMPLIFIER

FEATURES

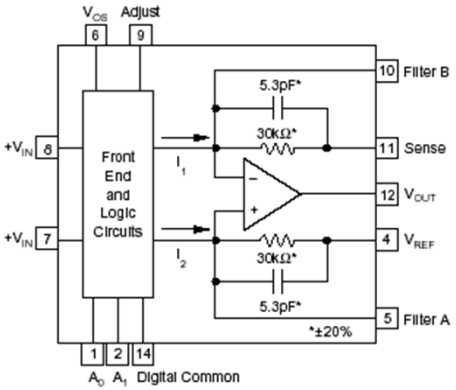
- DIGITALLY PROGRAMMABLE GAINS:
  DECADE MODEL—PGA202
  GAINS OF 1, 10, 100, 1000
  BINARY MODEL—PGA203
  GAINS OF 1, 2, 4, 8
- LOW BIAS CURRENT: 50pA max
- FAST SETTLING: 2µs to 0.01%
- LOW NON-LINEARITY: 0.012% max
- HIGH CMRR: 80dB min
- NEW TRANSCONDUCTANCE CIRCUITRY
- LOW COST

APPLICATIONS

- DATA ACQUISITION SYSTEMS
- AUTO-RANGING CIRCUITS
- DYNAMIC RANGE EXPANSION
- REMOTE INSTRUMENTATION
- TEST EQUIPMENT

DESCRIPTION

The PGA202 is a monolithic instrumentation amplifier with digitally controlled gains of 1, 10, 100, and 1000. The PGA203 provides gains of 1, 2, 4, and 8. Both have TTL or CMOS-compatible inputs for easy microprocessor interface. Both have FET inputs and a new transconductance circuitry that keeps the bandwidth nearly constant with gain. Gain and offsets are laser trimmed to allow use without any external components. Both amplifiers are available in ceramic or plastic packages. The ceramic package is specified over the full industrial temperature range while the plastic package covers the commercial range.



BURR-BROWN®

PGA206 PGA207

High-Speed Programmable Gain INSTRUMENTATION AMPLIFIER

FEATURES

- DIGITALLY PROGRAMMABLE GAINS:
  PGA206: G=1, 2, 4, 8V/V
  PGA207: G=1, 2, 5, 10V/V
- TRUE INSTRUMENTATION AMP INPUT
- FAST SETTLING: 3.5µs to 0.01%
- FET INPUT: I_B = 100pA max
- INPUT PROTECTION: ±40V
- LOW OFFSET VOLTAGE: 1.5mV max
- 16-PIN DIP, SOL-16 SOIC PACKAGES

APPLICATIONS

- MULTIPLE-CHANNEL DATA ACQUISITION
- MEDICAL, PHYSIOLOGICAL AMPLIFIER
- PC-CONTROLLED ANALOG INPUT BOARDS

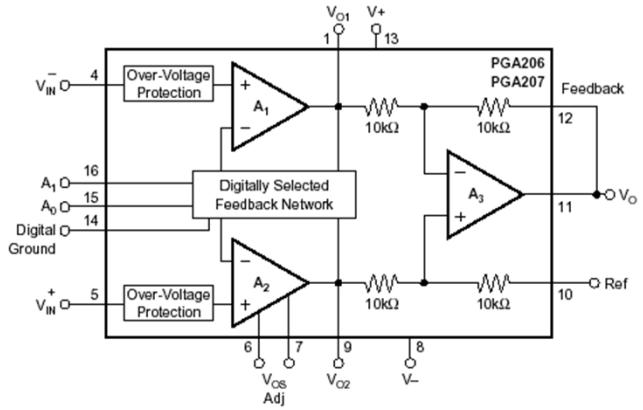
DESCRIPTION

The PGA206 and PGA207 are digitally programmable gain instrumentation amplifiers that are ideally suited for data acquisition systems.

The PGA206 and PGA207's fast settling time allows multiplexed input channels for excellent system efficiency. FET inputs eliminate I_B errors due to analog multiplexer series resistance.

Gains are selected by two CMOS/TTL-compatible address lines. Analog inputs are internally protected for overloads up to ±40V, even with the power supplies off. The PGA206 and PGA207 are laser-trimmed for low offset voltage and low drift.

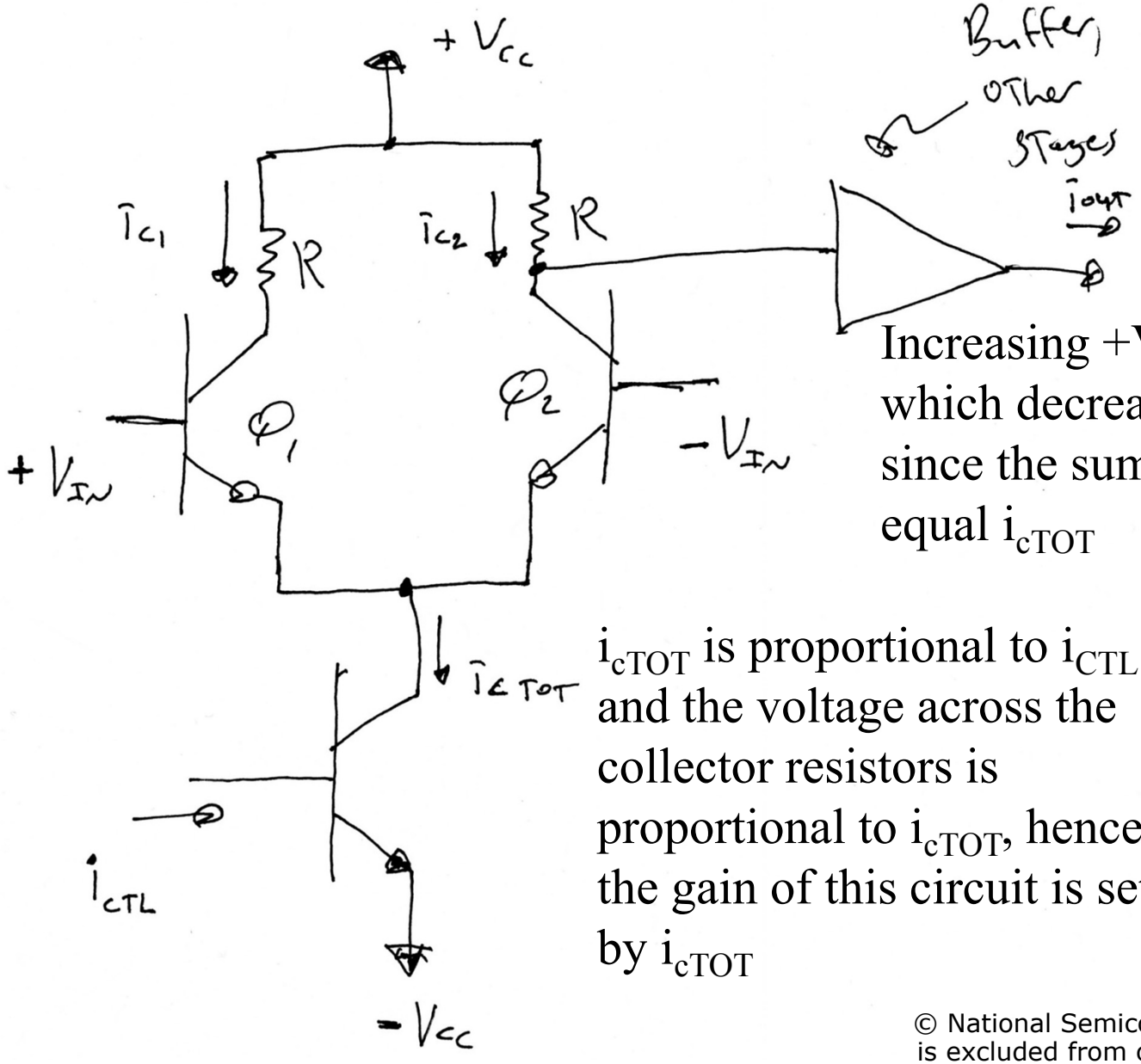
The PGA206 and PGA207 are available in 16-pin plastic DIP and SOL-16 surface-mount packages. Both are specified for –40°C to +85°C operation.

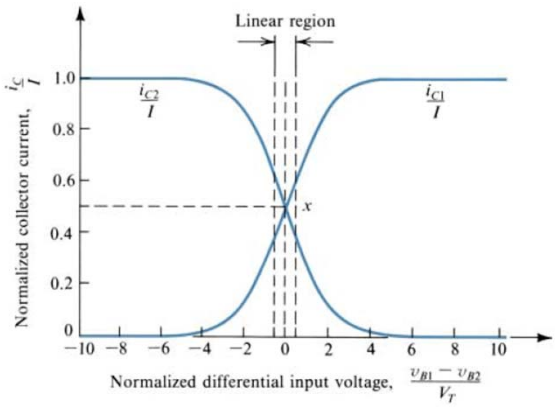


Front end of the OTA

$$I_{ctot} = i_{c1} + i_{c2} = \beta i_{CTL}$$

OTAs have current outputs

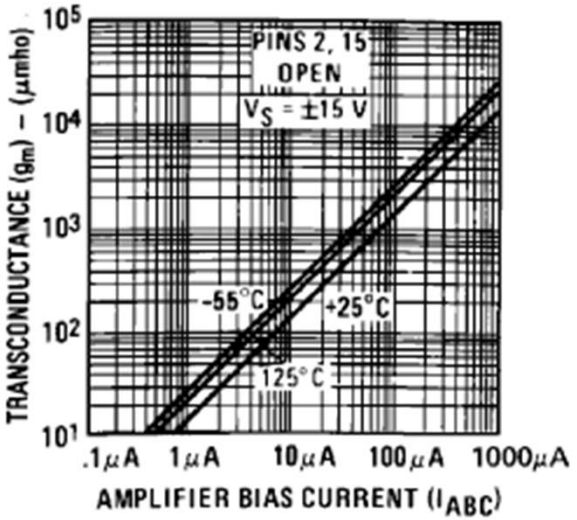




MTU ECE Diff Amp Notes

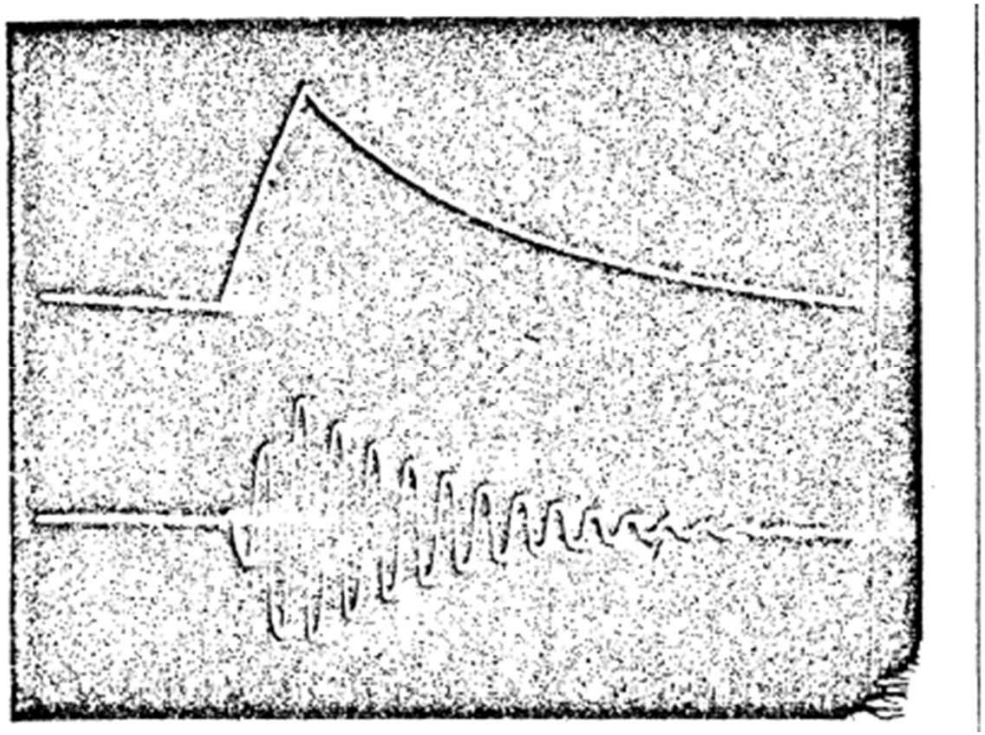
Increasing $+V_{IN}$ increases i_{c1}, which decreases i_{c2} (for fixed $-V_{IN}$) since the sum of i_{c1} and i_{c2} must equal i_{cTOT}

LM13700 Datasheet



i_{cTOT} is proportional to i_{CTL}, and the voltage across the collector resistors is proportional to i_{cTOT}, hence the gain of this circuit is set by i_{cTOT}

Voltage Controlled Amplifiers



VCA output for sinusoidal input and given control voltage

$$V_{out} = V_{in} * V_{ctl} \text{ (or 0 if } V_{ctl} < 0)$$

Voltage-Controlled Amplifiers (VCA)

Burr-Brown Products from Texas Instruments

VCA610

www.ti.com

WIDEBAND VOLTAGE CONTROLLED AMPLIFIER

FEATURES

- WIDE GAIN CONTROL RANGE: 77dB
- SMALL PACKAGE: SO-8
- WIDE SIGNAL BANDWIDTH: 30MHz
- LOW VOLTAGE NOISE: 2.2nV/√Hz
- FAST GAIN SLEW RATE: 300dB/µs

APPLICATIONS

- OPTICAL DISTANCE MEASUREMENT
- AGC AMPLIFIERS
- ULTRASOUND
- SONAR
- ACTIVE FILTERS
- LOG AMPLIFIERS
- IF CIRCUITS
- CCD CAMERAS

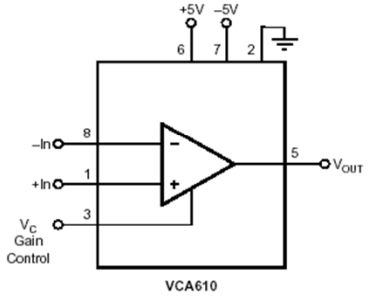
DESCRIPTION

The VCA610 is a wideband, continuously variable, voltage-controlled gain amplifier. It provides linear-dB gain control with high impedance inputs. It is designed to be used as a flexible gain-control element in a variety of electronic systems.

The VCA610 has a gain-control range of 77dB (–38.5dB to +38.5dB) providing both gain and attenuation for maximum flexibility in a small SO-8. The broad attenuation range can be used for gradual or controlled channel turn-on and turn-off for applications in which abrupt gain changes can create artifacts or other errors. In addition, the output can be disabled to provide –77dB of attenuation. Group delay variation with gain is typically less than ±2ns across a bandwidth of 1MHz to 15MHz.

The VCA610 has a noise figure of 3.5dB (with an R_S of 200Ω) including the effects of both current and voltage noise. Instantaneous output dynamic range is 70dB for gains of 0dB to +38.5dB with 1MHz noise bandwidth. The output is capable of driving 100Ω. The high-speed, 300dB/µs, gain-control signal is a unipolar (0V to –2V) voltage that varies the gain linearly in dB/V over a –38.5dB to +38.5dB range.

The VCA610 is designed with a very fast overload recovery time of only 200ns. This allows a large signal transient to overload the output at high gain, without obscuring low-level signals following closely behind. The excellent overload recovery time and distortion specifications optimize this device for low-level doppler measurements.



VCA610

TEXAS INSTRUMENTS

ANALOG DEVICES

Dual, Low Noise, Wideband Variable Gain Amplifiers

AD600/AD602*

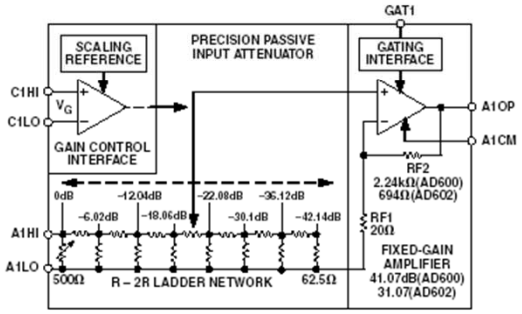
FEATURES

Two Channels with Independent Gain Control
"Linear in dB" Gain Response
Two Gain Ranges:
AD600: 0 dB to 40 dB
AD602: –10 dB to +30 dB
Accurate Absolute Gain: ±0.3 dB
Low Input Noise: 1.4 nV/√Hz
Low Distortion: –60 dBc THD at ±1 V Output
High Bandwidth: DC to 35 MHz (–3 dB)
Stable Group Delay: ±2 ns
Low Power: 125 mW (Max) per Amplifier
Signal Gating Function for Each Amplifier
Drives High-Speed A/D Converters
MIL-STD-883-Compliant and DESC Versions Available

APPLICATIONS

Ultrasound and Sonar Time-Gain Control
High-Performance Audio and RF AGC Systems
Signal Measurement

FUNCTIONAL BLOCK DIAGRAM



PRODUCT DESCRIPTION

The AD600 and AD602 dual channel, low noise variable gain amplifiers are optimized for use in ultrasound imaging systems, but are applicable to any application requiring very precise gain, low noise and distortion, and wide bandwidth. Each independent channel provides a gain of 0 dB to +40 dB in the AD600 and –10 dB to +30 dB in the AD602. The lower gain of the AD602 results in an improved signal-to-noise ratio at the output. However, both products have the same 1.4 nV/√Hz input noise spectral density. The decibel gain is directly proportional to the control voltage, is accurately calibrated, and is supply- and temperature-stable.

To achieve the difficult performance objectives, a proprietary circuit form—the X-AMP®—has been developed. Each channel of the X-AMP comprises a variable attenuator of 0 dB to –42.14 dB followed by a high speed fixed gain amplifier. In this way, the amplifier never has to cope with large inputs, and can benefit from the use of negative feedback to precisely define the gain and dynamics. The attenuator is realized as a seven-stage R-2R ladder network having an input resistance of 100 Ω, laser-trimmed to ±2%. The attenuation between tap points is 6.02 dB; the gain-control circuit provides continuous interpolation between these taps. The resulting control function is linear in dB.

The gain-control interfaces are fully differential, providing an input resistance of ~15 MΩ and a scale factor of 32 dB/V (that is, 31.25 mV/dB) defined by an internal voltage reference. The response time of this interface is less than 1 µs. Each channel also has an independent gating facility that optionally blocks signal transmission and sets the dc output level to within a few millivolts of the output ground. The gating control input is TTL and CMOS compatible.

The maximum gain of the AD600 is 41.07 dB, and that of the AD602 is 31.07 dB; the –3 dB bandwidth of both models is nominally 35 MHz, essentially independent of the gain. The signal-to-noise ratio (SNR) for a 1 V rms output and a 1 MHz noise bandwidth is typically 76 dB for the AD600 and 86 dB for the AD602. The amplitude response is flat within ±0.5 dB from 100 kHz to 10 MHz; over this frequency range the group delay varies by less than ±2 ns at all gain settings.

Each amplifier channel can drive 100 Ω load impedances with low distortion. For example, the peak specified output is ±2.5 V minimum into a 500 Ω load, or ±1 V into a 100 Ω load. For a 200 Ω load in shunt with 5 pF, the total harmonic distortion for a ±1 V sinusoidal output at 10 MHz is typically –60 dBc.

The AD600J and AD602J are specified for operation from 0°C to 70°C, and are available in both 16-lead plastic DIP (N) and 16-lead SOIC (R). The AD600A and AD602A are specified for operation from –40°C to +85°C and are available in both 16-lead cerdip (Q) and 16-lead SOIC (R).

The AD600S and AD602S are specified for operation from –55°C to +125°C and are available in a 16-lead cerdip (Q) package and are MIL-STD-883 compliant. The AD600S and AD602S are also available under DESC SMD 5962-94572.

Courtesy of Burr-Brown. Used with permission.

Courtesy of Analog Devices. Used with permission.

VCA Arrays

ANALOG DEVICES

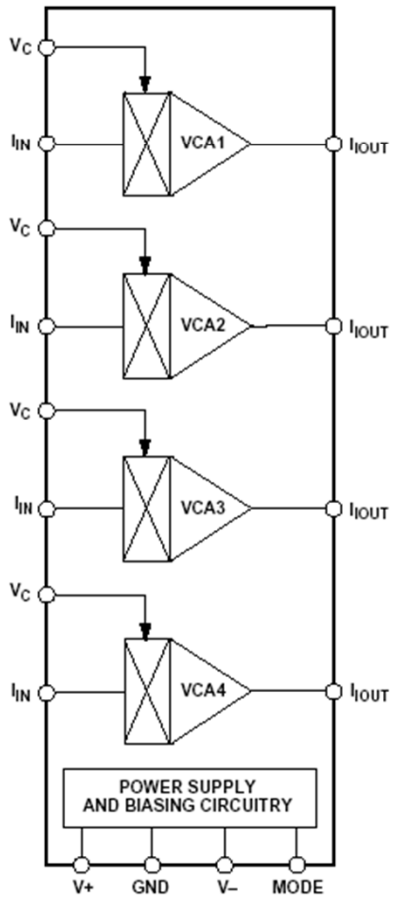
Low Cost Quad Voltage Controlled Amplifier

SSM2164

FEATURES
- Four High Performance VCAs in a Single Package
- 0.02% THD
- No External Trimming
- 120 dB Gain Range
- 0.07 dB Gain Matching (Unity Gain)
- Class A or AB Operation

APPLICATIONS
- Remote, Automatic, or Computer Volume Controls
- Automotive Volume/Balance/Faders
- Audio Mixers
- Compressor/Limiters/Compandors
- Noise Reduction Systems
- Automatic Gain Controls
- Voltage Controlled Filters
- Spatial Sound Processors
- Effects Processors

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The SSM2164 contains four independent voltage controlled amplifiers (VCAs) in a single package. High performance (100 dB dynamic range, 0.02% THD) is provided at a very low cost-per-VCA, resulting in excellent value for cost sensitive gain control applications. Each VCA offers current input and output for maximum design flexibility, and a ground referenced –33 mV/dB control port.

All channels are closely matched to within 0.07 dB at unity gain, and 0.24 dB at 40 dB of attenuation. A 120 dB gain range is possible.

A single resistor tailors operation between full Class A and AB modes. The pinout allows upgrading of SSM2024 designs with minimal additional circuitry.

The SSM2164 will operate over a wide supply voltage range of ±4 V to ±18 V. Available in 16-pin P-DIP and SOIC packages, the device is guaranteed for operation over the extended industrial temperature range of –40°C to +85°C.

Analog Multipliers (4-Quadrant)

ANALOG DEVICES

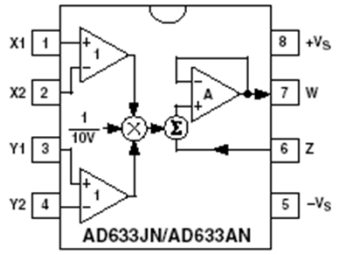
Low Cost Analog Multiplier

AD633

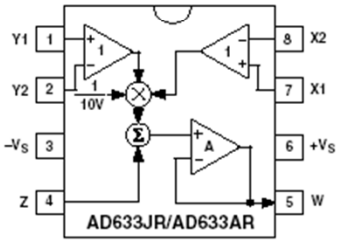
FEATURES
4-Quadrant Multiplication
Low Cost 8-Lead Package
Complete—No External Components Required
Laser-Trimmed Accuracy and Stability
Total Error within 2% of FS
Differential High Impedance X and Y Inputs
High Impedance Unity-Gain Summing Input
Laser-Trimmed 10 V Scaling Reference

APPLICATIONS
Multiplication, Division, Squaring
Modulation/Demodulation, Phase Detection
Voltage Controlled Amplifiers/Attenuators/Filters

CONNECTION DIAGRAMS
8-Lead Plastic DIP (N) Package



8-Lead Plastic SOIC (RN-8) Package



$$W = \frac{(X_1 - X_2)(Y_1 - Y_2)}{10V} + Z$$

PRODUCT DESCRIPTION

The AD633 is a functionally complete, four-quadrant, analog multiplier. It includes high impedance, differential X and Y inputs and a high impedance summing input (Z). The low impedance output voltage is a nominal 10 V full scale provided by a buried Zener. The AD633 is the first product to offer these features in modestly priced 8-lead plastic DIP and SOIC packages.

The AD633 is laser calibrated to a guaranteed total accuracy of 2% of full scale. Nonlinearity for the Y input is typically less than 0.1% and noise referred to the output is typically less than 100 µV rms in a 10 Hz to 10 kHz bandwidth. A 1 MHz bandwidth, 20 V/µs slew rate, and the ability to drive capacitive loads make the AD633 useful in a wide variety of applications where simplicity and cost are key concerns.

The AD633's versatility is not compromised by its simplicity. The Z-input provides access to the output buffer amplifier, enabling the user to sum the outputs of two or more multipliers, increase the multiplier gain, convert the output voltage to a current, and configure a variety of applications.

The AD633 is available in an 8-lead plastic DIP package (N) and 8-lead SOIC (R). It is specified to operate over the 0°C to 70°C commercial temperature range (J Grade) or the –40°C to +85°C industrial temperature range (A Grade).

PRODUCT HIGHLIGHTS

1. The AD633 is a complete four-quadrant multiplier offered in low cost 8-lead plastic packages. The result is a product that is cost effective and easy to apply.
2. No external components or expensive user calibration are required to apply the AD633.
3. Monolithic construction and laser calibration make the device stable and reliable.
4. High (10 MΩ) input resistances make signal source loading negligible.
5. Power supply voltages can range from ±8 V to ±18 V. The internal scaling voltage is generated by a stable Zener diode; multiplier accuracy is essentially supply insensitive.

4 Quadrant means: Multiplying by negative values (negative voltages) inverts the output. Either input can go negative.

VCA's are 2 Quadrant devices – the control input can't go negative, although the signal input can.

MAS.836 Sensor Technologies for Interactive Environments

Spring 2011