Today's plan:

AI help with coding

Announcements: status report

Announcements: Material returns

Relays

Serial data transmission

Power supplias and batteries.

Capacitance measurements

Comparators

AI help with coding

Always ask for shortest possible code with minimum use of libraries and even functions. If you have some constants to use just use them in formulas directly rather than setting them as variables. Naming numbers is a waste of time if you are going to use them once or twice.

AI will remember your previous codes or example codes and follow your style of programming.

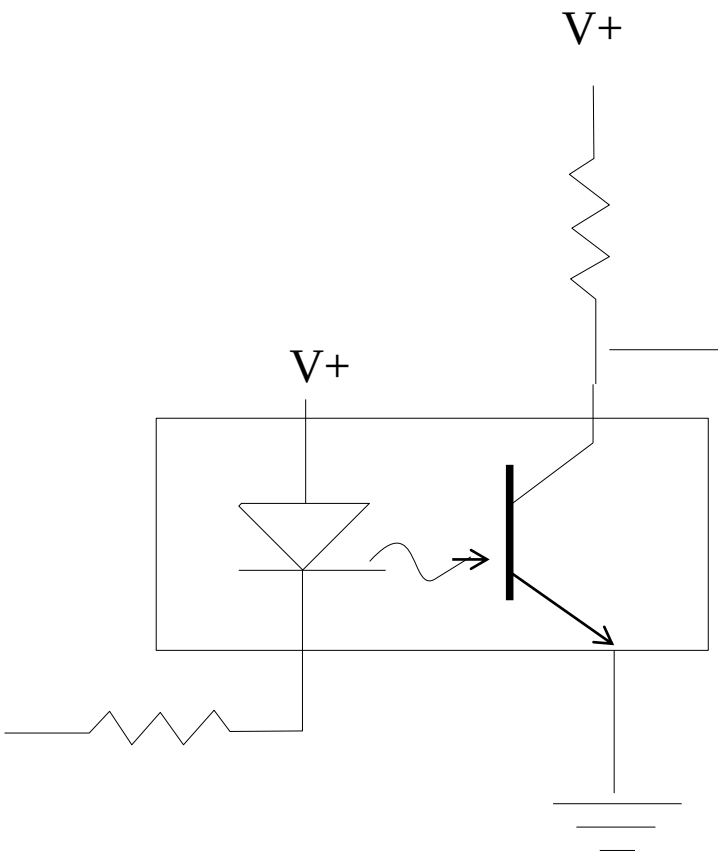
Announcements: Status Report

I would like a short written status report from everyone turned in at start of the lab during the week of March 23th.

The report should discuss your progress so far: what has been accomplished, what remains to be done. If you have encountered problems, discuss them, and your plans to move forward. If you need help to make progress, please mention it.

These reports need not be long, just a few sentences or points are fine.

Driving loads: Optoisolators

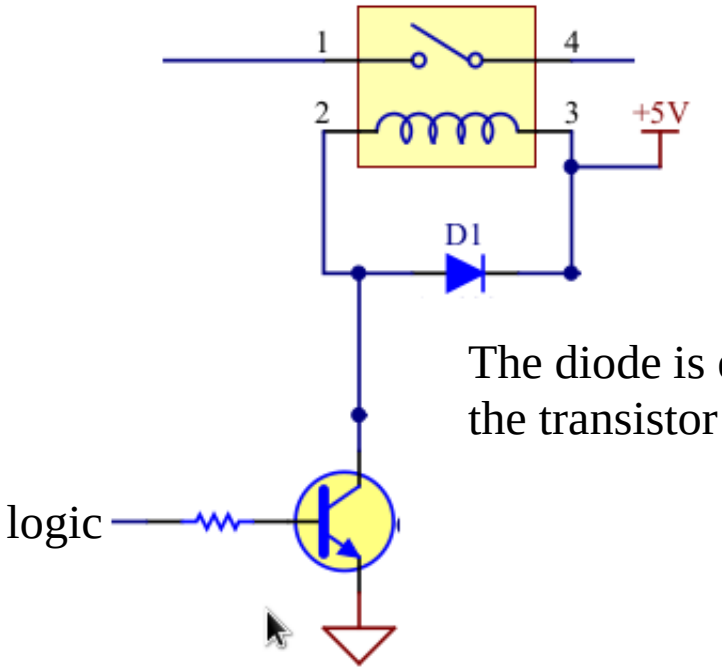


Logic input

4N36, low current, but good isolation

From microprocessor

Driving loads: Relays



The diode is essential to prevent destroying the transistor on turn-off!

There are some small low-current relays that can be driven directly by logic chips, again, a diode is essential to protect the logic circuit from the inductive spike on turn-off!

Driving loads: Solid-state Relays

good for AC, large loads, fast, repeated switching
(expensive, may need a heat sink), Often will synchronize to line voltage.

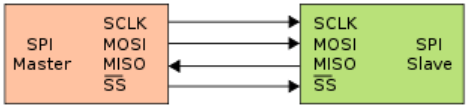
eg Crydom D2425: 280VAC, 25A !

Serial interfaces

Many sensors use standard protocols such as I^2C (inter-integrated circuit), SPI (serial peripheral interface) or UART (Universal Asynchronous Receiver/Transmitter) to talk to the microcontroller.

The MSP430 has a module USCI (Universal Serial Communication Interface) that can be configured for using these protocols.

SPI: Serial Peripheral Interface

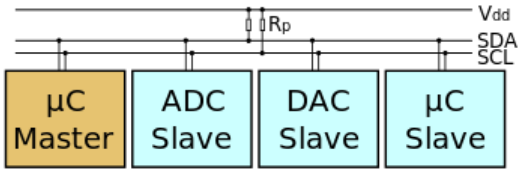


SCLK: clock from master
MOSI: Master out, slave in
MISO: Master in, slave out.
Slave Select

On every toggle of the clock, bits are transmitted in both directions, though not always useful. Communications controlled completely by the master.

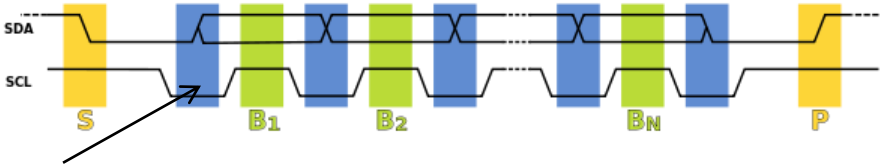
point-to-point, one master, one slave.

I2C: Inter-integrated Circuit



SDA – serial data
SCL – serial clock

Both lines are open-drain, pulled up with pull-up resistors



data line changes when clock is held low.

I2C is a bus: can be multiple masters, multiple slaves on the bus.

A word about data sheets

- Beware of sections entitled “Absolute Maximum Ratings”
- These sections tell you about the most extreme conditions the component can be subjected to without being destroyed. These conditions are usually very far away from the optimal operating conditions! To find suitable operating conditions, there is often a table of Electrical Parameters – look for the conditions under which other parameters are measured.

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LED1200-series

TECHNICAL DATA

Infrared LED — InGaAsP

LED1200-series are InGaAsP LEDs mounted on a lead frame and encapsulated in various types of epoxy lens, which offers different design settings.
On forward bias, it emits a high power radiation of typical 5 mW at a peak wavelength at 1200 nm.

Specifications

- Structure: InGaAsP
- Peak Wavelength: typ. 1200 nm
- Optical Ouput Power: typ. 5 mW
- Resin Material: Epoxy resin
- Solder: Lead free

Absolute Maximum Ratings (T_a=25°C)

Type	Symbol	Value	Unit
Power Dissipation	P_D	140	mW
Forward Current	I_F	100	mA
Pulse Forward Current	I_{FP}	1000	mA
Reverse Voltage	V_R	5	V
Operating Temperature	T_{OP}	-40 … +85	°C
Storage Temperature	T_{STG}	-40 … +100	°C
Soldering Temperature (for 5 sec.)	T_{SOL}	265	°C

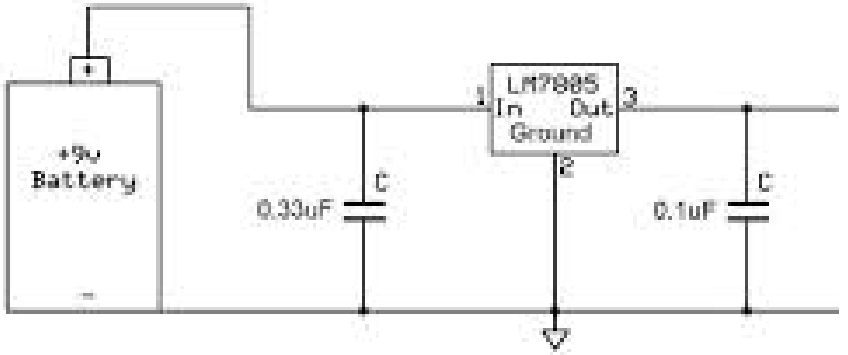
Electro-Optical Characteristics (T_a=25°C)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Forward Voltage	V_F	I_F = 50 mA	-	1.1	1.5	V
Reverse Current	I_R	V_R = 5 V	-	-	10	µA
Radiated Power	P_O	I_F = 50 mA	3	5	-	mW
Peak Wavelength	λ_P	I_F = 50 mA	1150	1200	1250	nm
Half Width	$\Delta\lambda$	I_F = 50 mA	-	80	-	nm
Rise Time	t_r	I_F = 50 mA	-	10	-	ns
Fall Time	t_f	I_F = 50 mA	-	10	-	ns

Voltage Regulation

- To power the Launchpad and most other circuitry, you'll want to use a regulated voltage. 3.3 V for the Launchpad, maybe 3.3V or 5V or 15V for other components. (one can run MSP430 off of 2 AA or AAA batteries directly).
- These voltages are most easily made with a 3 pin voltage regulator.
- eg LM7805, LM7815, UA78M33

- These can supply up to 1A, but may need a heatsink
- Notice that the values of the 2 capacitors are indicating just an order of magnitude! 1μF will work for both.

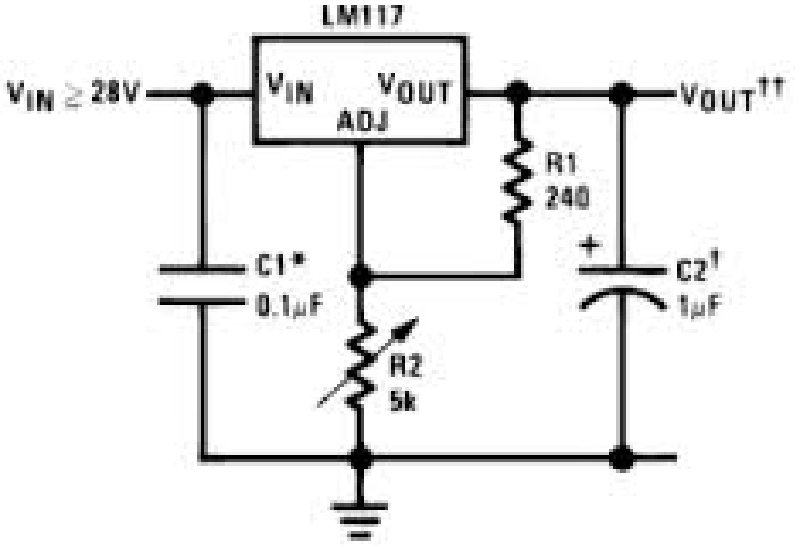


To 5V pin on Launchpad

To ground pin on Launchpad

Voltage Regulation

For 'non-standard' voltage, LM317 is a three-terminal, adjustable regulator



The regulator attempts to maintain:
$V_O - V_{ADJ} = 1.25$ V (Vref)

So V_{out} is set by the ratio of R_1/R_2

$V_O = V_{REF} (1 + R_2/R_1) + I_{ADJ} R_2$
I_{ADJ} = ~50uA.

Choose R_1, R_2 so that I_{ADJ} x R_2 is small, but also so V_O x (R_1+R_2) is not big.
R_1 = 240 Ω is recommended.

Power dissipation

- Three pin regulators can get very hot, and may need a heatsink. They tend to draw exactly the same current from the supply as they output, and they dissipate the power difference.

For example, a 5V regulator operating from a 12V supply, supplying 1A has to dissipate (12V-5V)x1A = 7W. Without a heatsink, this would get very hot, very fast!

Dropout

- Many 3 pin regulators have a fairly high (1.5 – 2 V) “dropout” voltage. This means that for a 5V regulator, the input needs to stay above 6.5-7V. It will not work from 4 AA batteries!
- There exist “low-dropout” regulators, some of which are also low-power. LP2950 is a nice family.

Powering your project

Easiest, if it works:

- Launchpad from your computer
- the board/external circuitry with the wall wart we've provided.
- any higher current devices (eg big motors) from the batteries or a power supply available in the lab.

Wall Warts

Wall warts can be DC or AC, and regulated or not. Often we have to test them to find out.

Newer wall warts with USB connections are regulated at 5V

Batteries

Many sizes/shapes/chemistries:

Lead-acid - commonly available in 6V/12V. High power. Heavy, rechargeable.

Lithium. Rechargeable or not. Rechargeables are a little tricky to use – must not overcharge or undercharge. Light weight.

alkaline (AA and friends)

Ni-MH/NiCd – easiest rechargeables to use but rare now. Memory issue

coin cells/specialty (eg PX28L 6V camera battery)

Batteries

For most battery chemistries, the voltage changes as the battery is discharged. Eg alkalines start off ~ 1.5V, but discharge to ~ 1.0V.

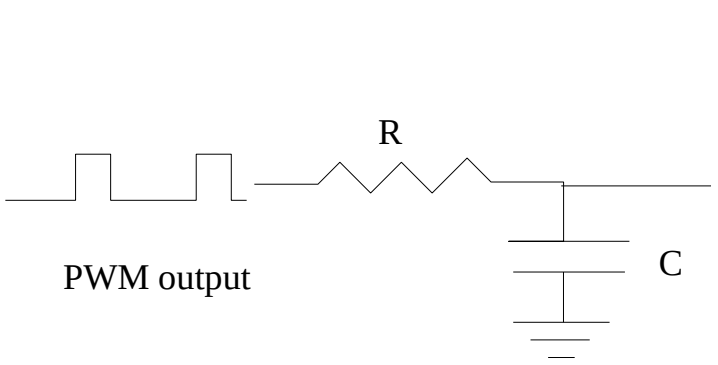
Many batteries can supply very high peak current – A fresh D battery can supply ~ 10A for a short period! Lead acid batteries can supply 100's of A. Due respect is required. Short circuit protection and possibly reverse connection protection should be considered.

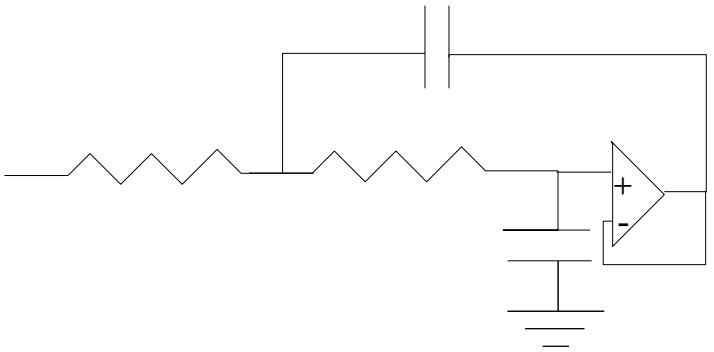
Like most other electronic components, batteries have data sheets with lots of useful information on them!

Analog Output:

The MSP430F5529 doesn't have a DAC. If you want an adjustable analog output, there are a couple of options:

- Add an external DAC (serial or parallel)
- low-pass filter and PWM output.





2nd order Low-pass filter

Analog Output:

Parallel DAC: eg TLC7528, Dual 8bit multiplying digital to analog converter.

TLC7528C, TLC7528E, TLC7528I
DUAL 8-BIT MULTIPLYING
DIGITAL-TO-ANALOG CONVERTERS

SLAS062E – JANUARY 1987 – REVISED NOVEMBER 2008

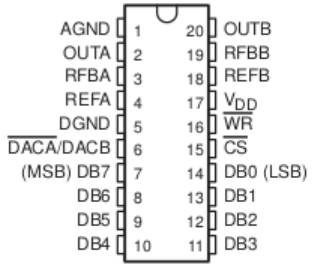
- **Easily Interfaced to Microprocessors**
- **On-Chip Data Latches**
- **Monotonic Over the Entire A/D Conversion Range**
- **Interchangeable With Analog Devices AD7528 and PMI PM-7528**
- **Fast Control Signaling for Digital Signal Processor (DSP) Applications Including Interface With TMS320**
- **Voltage-Mode Operation**
- **CMOS Technology**

KEY PERFORMANCE SPECIFICATIONS	
Resolution	8 bits
Linearity Error	1/2LSB
Power Dissipation at V_{DD} = 5V	20mW
Settling Time at V_{DD} = 5V	100ns
Propagation Delay Time at V_{DD} = 5V	80ns

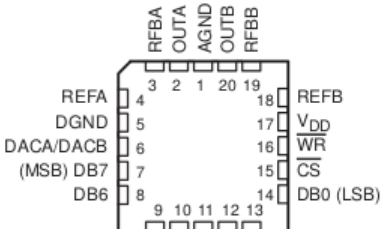
description

The TLC7528C, TLC7528E, and TLC7528I are dual, 8-bit, digital-to-analog converters (DACs) designed with separate on-chip data latches and feature exceptionally close DAC-to-DAC match-

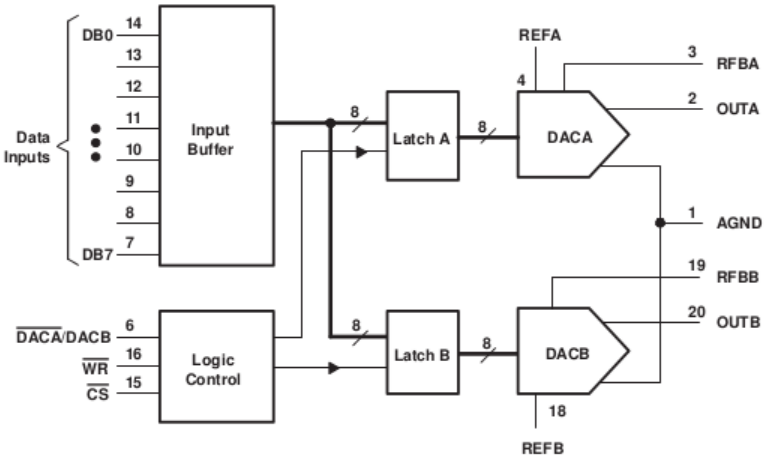
DW, N OR PW PACKAGE
(TOP VIEW)



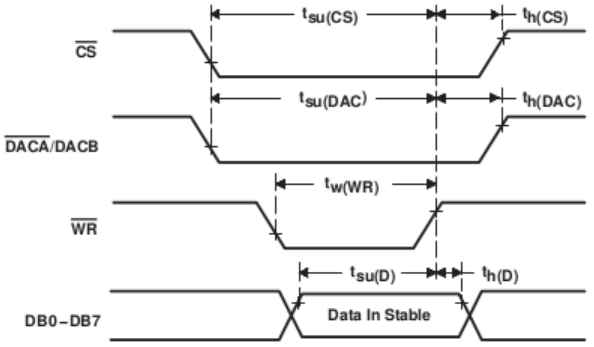
FN PACKAGE
(TOP VIEW)



DAC: TLC7528

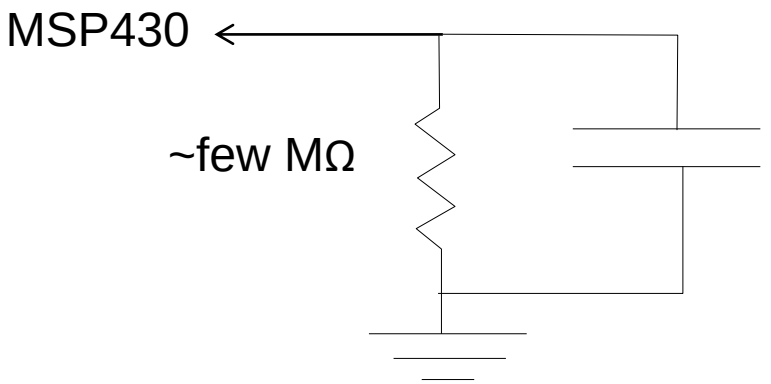


operating sequence



Capacitance Measurements

Simplest:



- set the pin as an output, and set it to high
- then set as input, and time how long it takes to discharge to read as low.

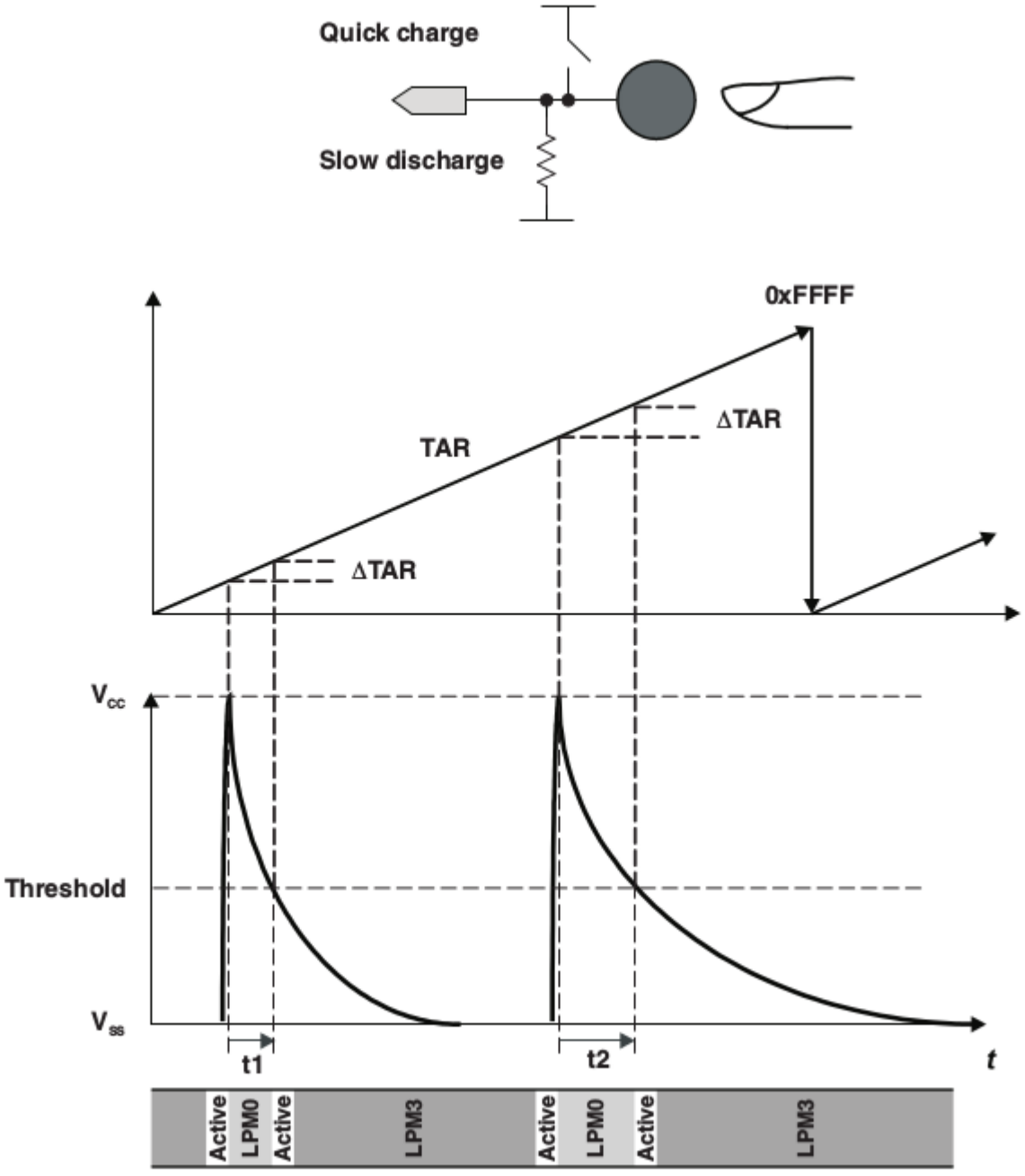
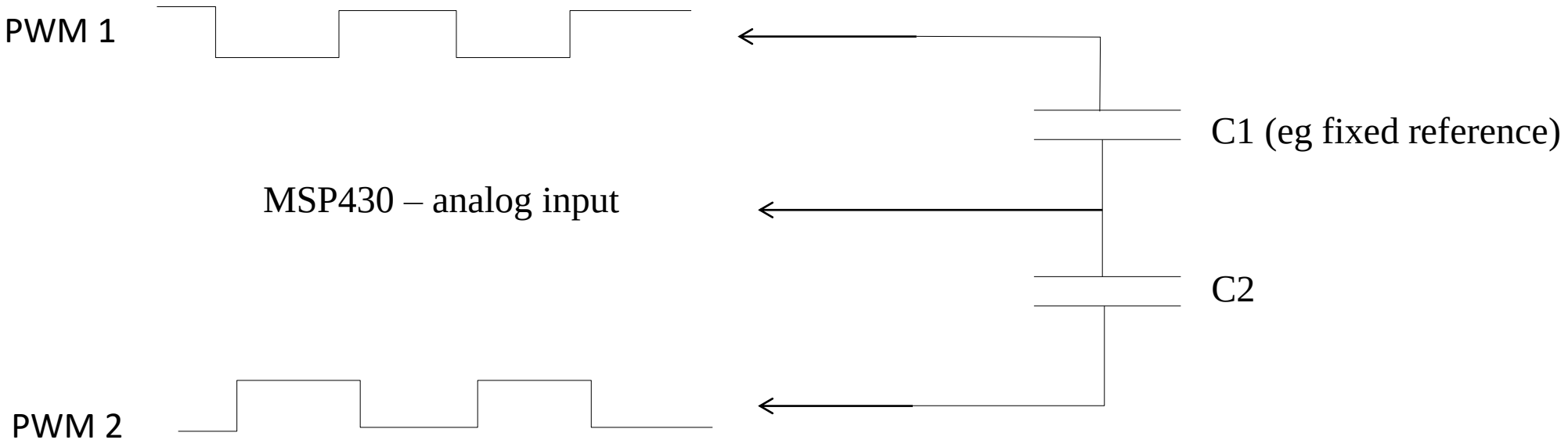


Figure 2. Charge-Discharge Sequence

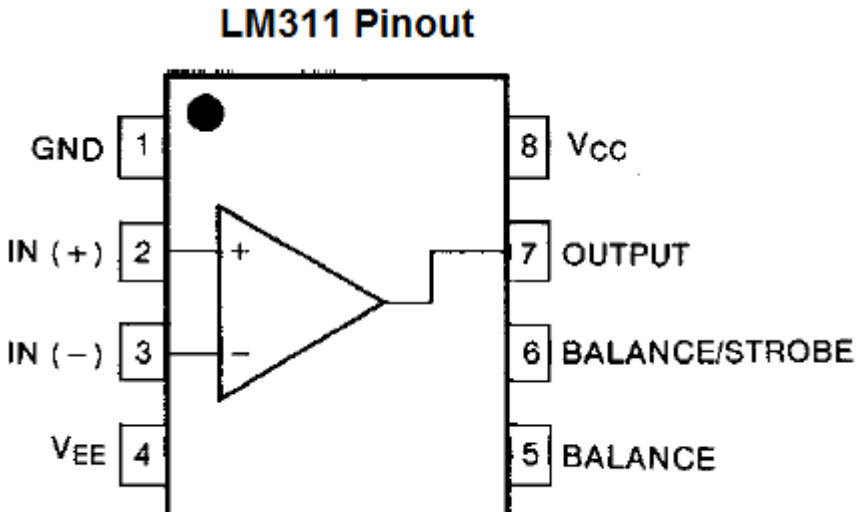
Differential capacitance measurement:



Comparators

Basic device function: compare two voltages, indicate which is greater by a state of a digital output.

But also useful for:
- logic level shifting,
- threshold detection/ generating square waves
- driving the P-channel mosfet or pnp transistor on H-bridges



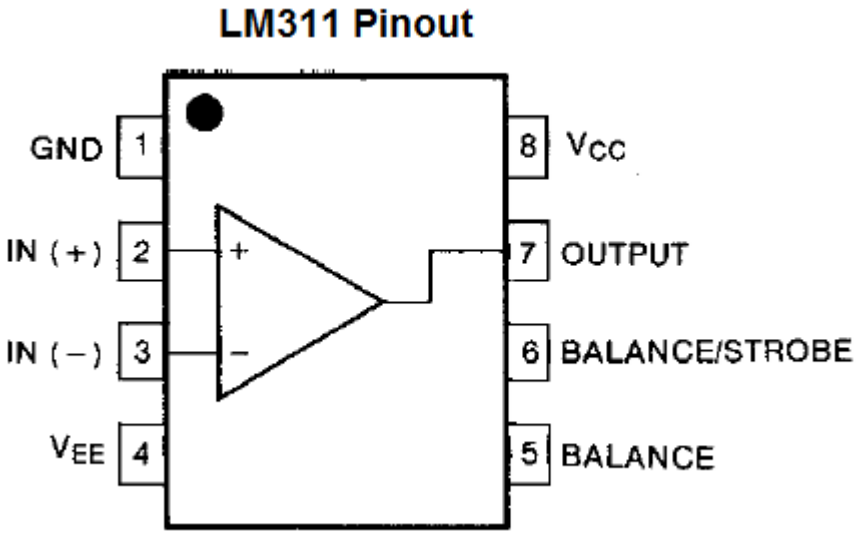
Notice: The output is an open collector – it needs a pull up resistor, which, if needed, can be connected to a different voltage. They need +-15V power supply

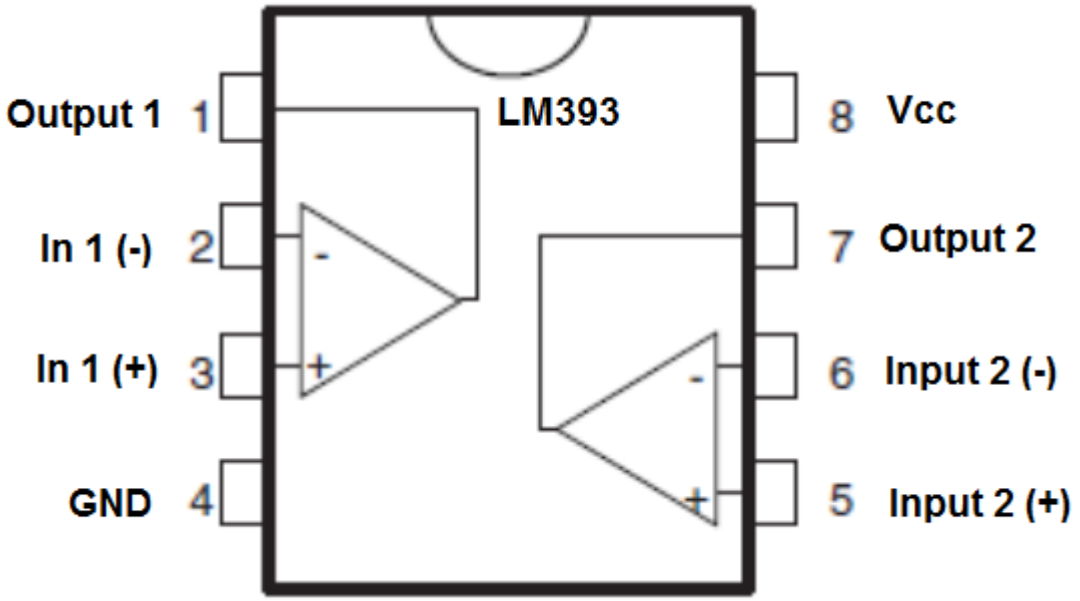
Comparators

V_{CC}, V_{EE} - +, - supplies. The inputs must stay between the supply voltages. Can be +/-15V or +5/0.

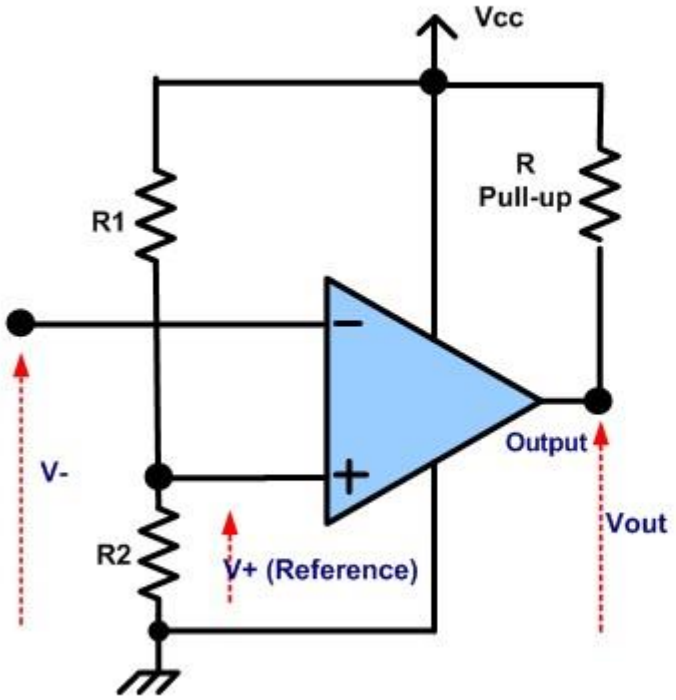
When V- > V+, then the output is connected to GND. When V+ > V-, the output floats.

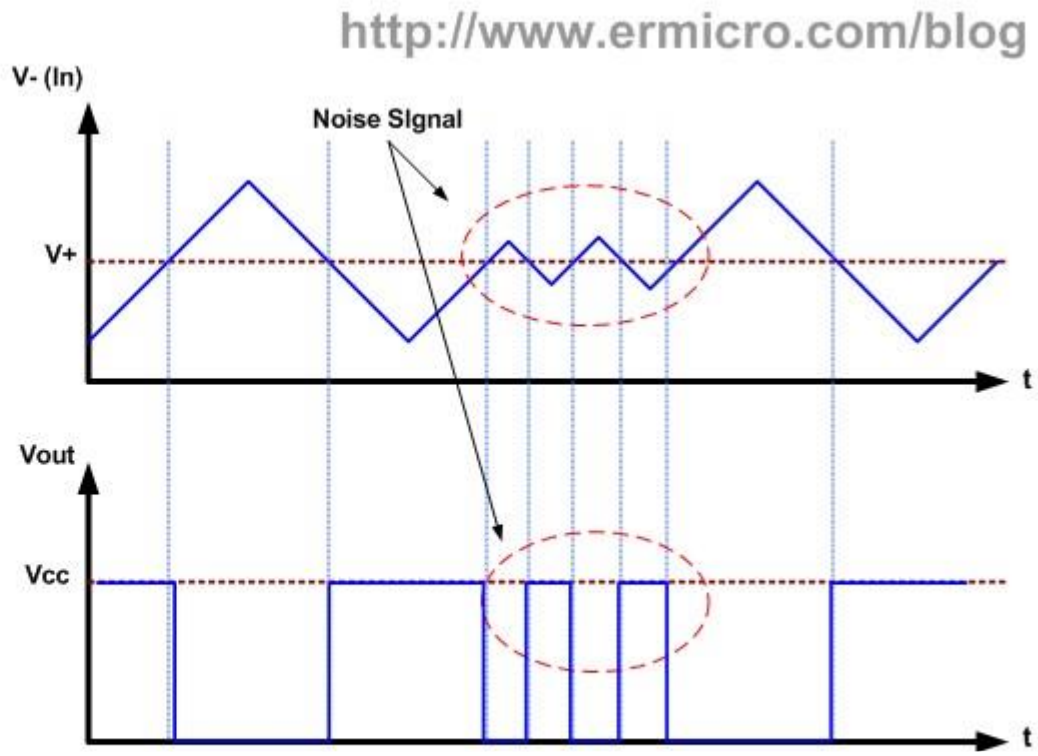
Balance: used to trim internal V+ vs V- offsets. Not usually needed.
Strobe: pull to ground to disable comparator.





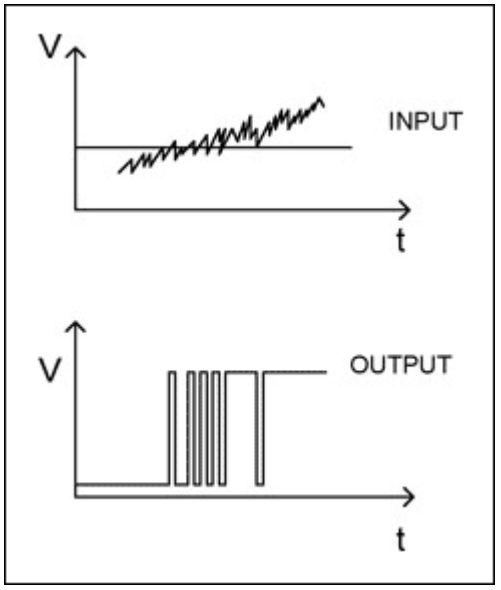
Comparators: single power use





Comparators

Noisy signals:



http://hades.mech.northwestern.edu/index.php/Comparators

Comparators

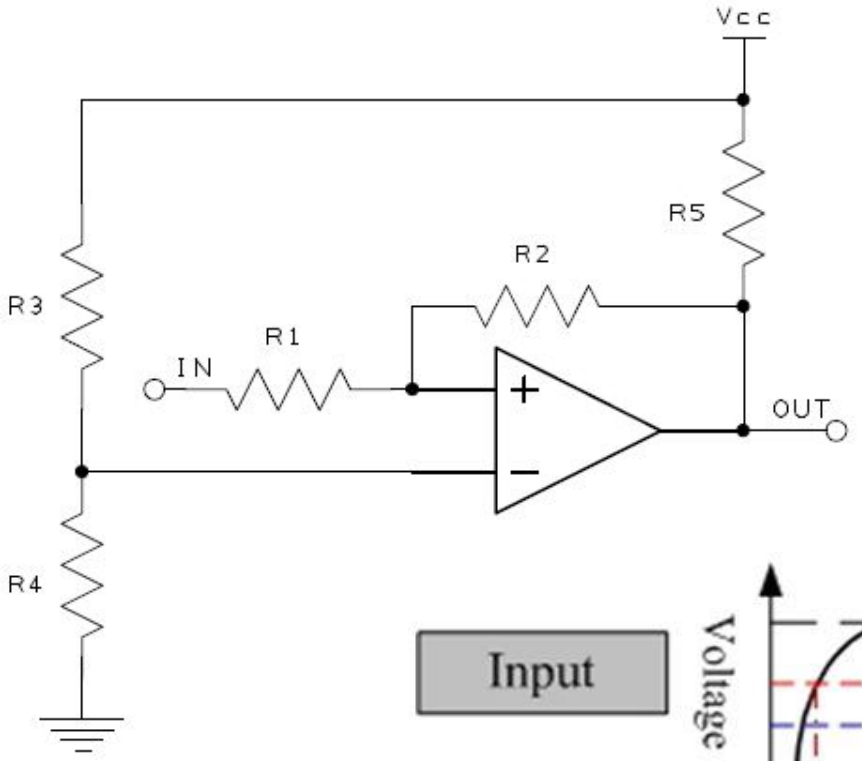
Hysteresis for noise immunity: add positive feedback.

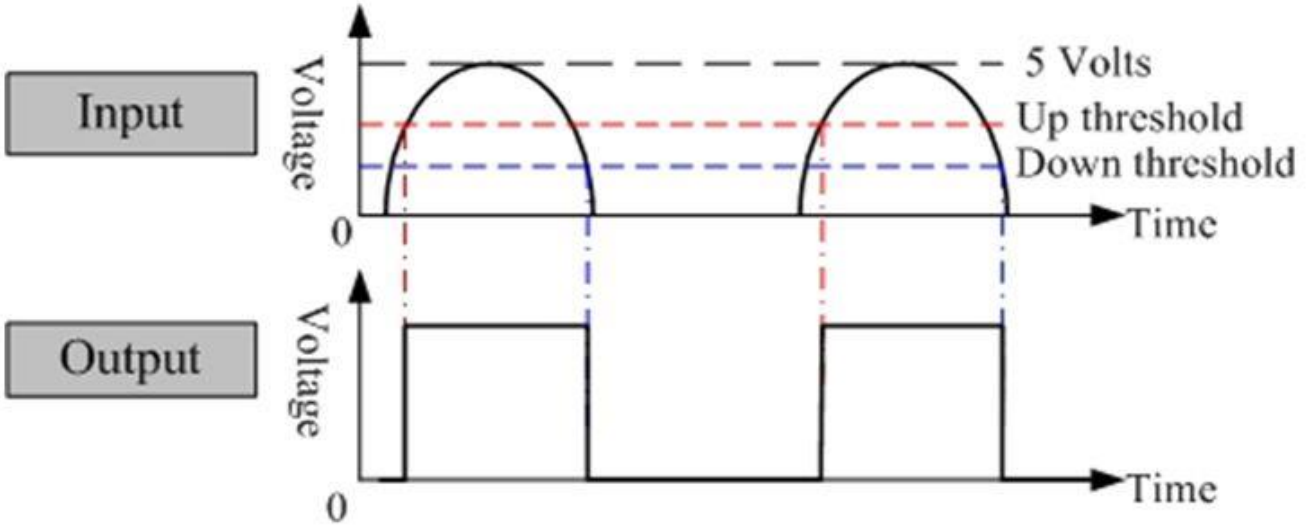
$$V_{ref} = V_{cc}\left(\frac{R4}{R4+R3}\right)$$

$$V_U = V_{ref}\left(\frac{R1+R2}{R2}\right)$$

$$V_L = \frac{V_{ref}\,(R1+R2) - V_{cc}\,(R1)}{R2}$$

(Assumes $R_5 << R_2$)





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