Noise Isolation

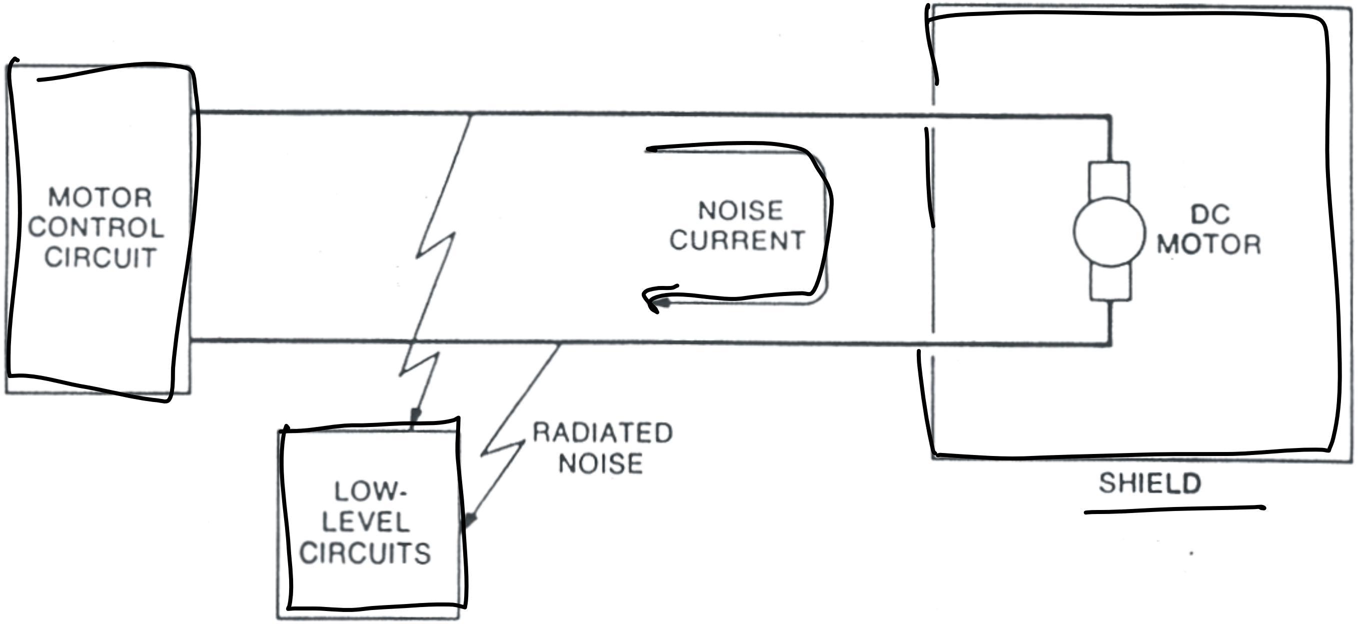
Keeping the Gremlins Out!

Cyrus Bazeghi

Winter 2010

How noise gets into your circuits

Figure 1-11. *Before noise can be a problem, there must be a noise source, a receptor that is susceptible to the noise, and a coupling channel that transmits the noise to the receptor.*



Key Characteristics of the noise source

kV 1000's Volts

- Voltage
  - High Voltage, electric field "capacitive coupling"
  - High dV/dt $I = \frac{dV}{dt} C$
- Current – High Current, magnetic field gives "inductive coupling"
- Frequency – High Freq – radiation – "radiation coupling"

0 < distance < wavelength "R.F. Coupling"

- Distance from the victim –

0 = distance direct contact "conductive coupling"

Make d infinite

① don't share the

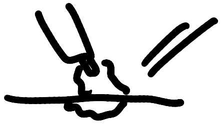
② +

What is the most likely coupling mechanism for:

- Florescent Light noise

high $\frac{dV}{dt}$ "capacitive coupling"

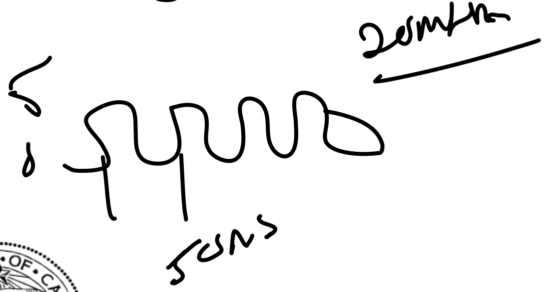
- Arc Welding Noise



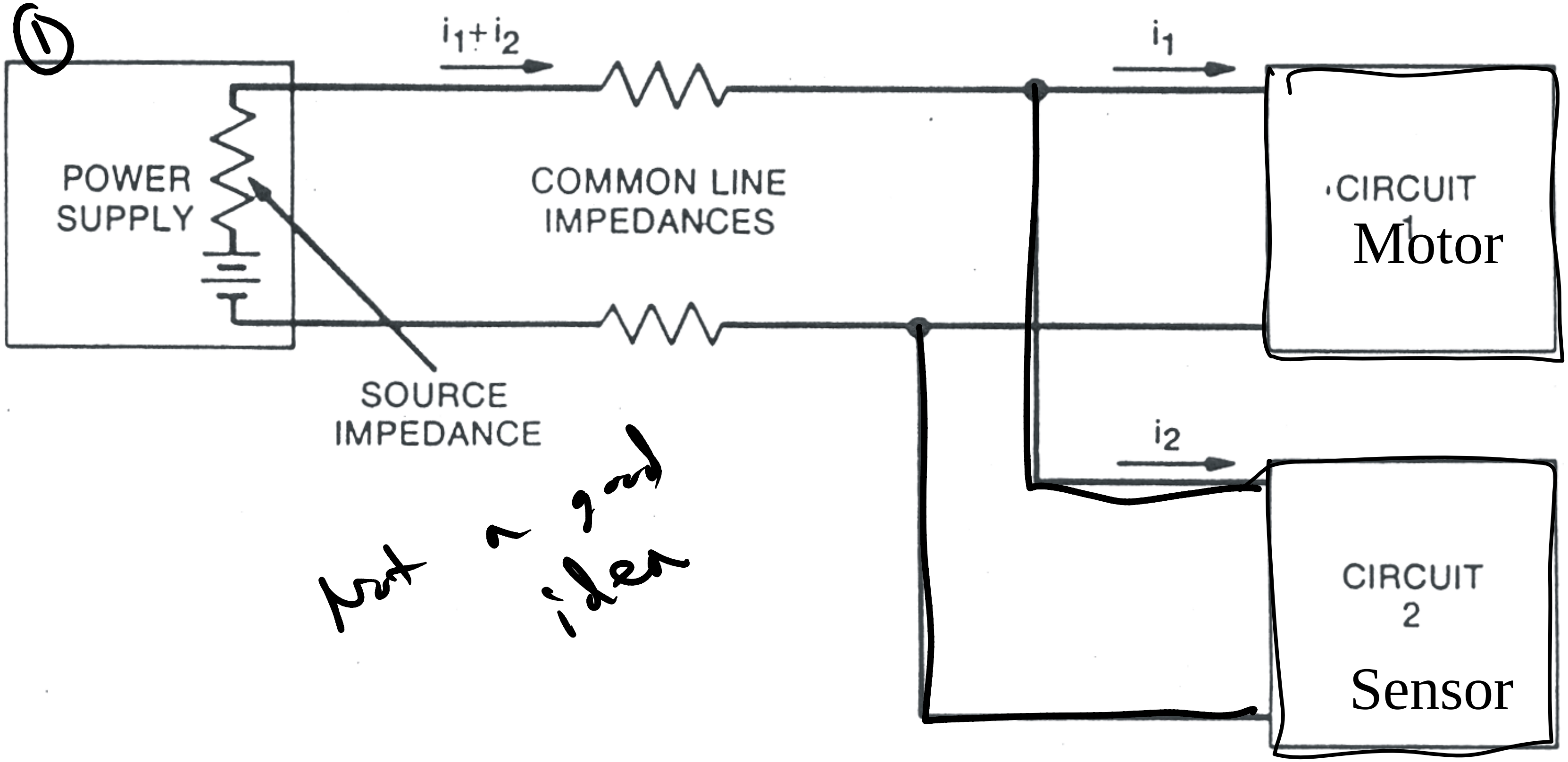
high current 100's of Amps "inductive coupling"

- Digital Clock Noise

$\frac{dV}{dt}$ High "capacitive coupling"

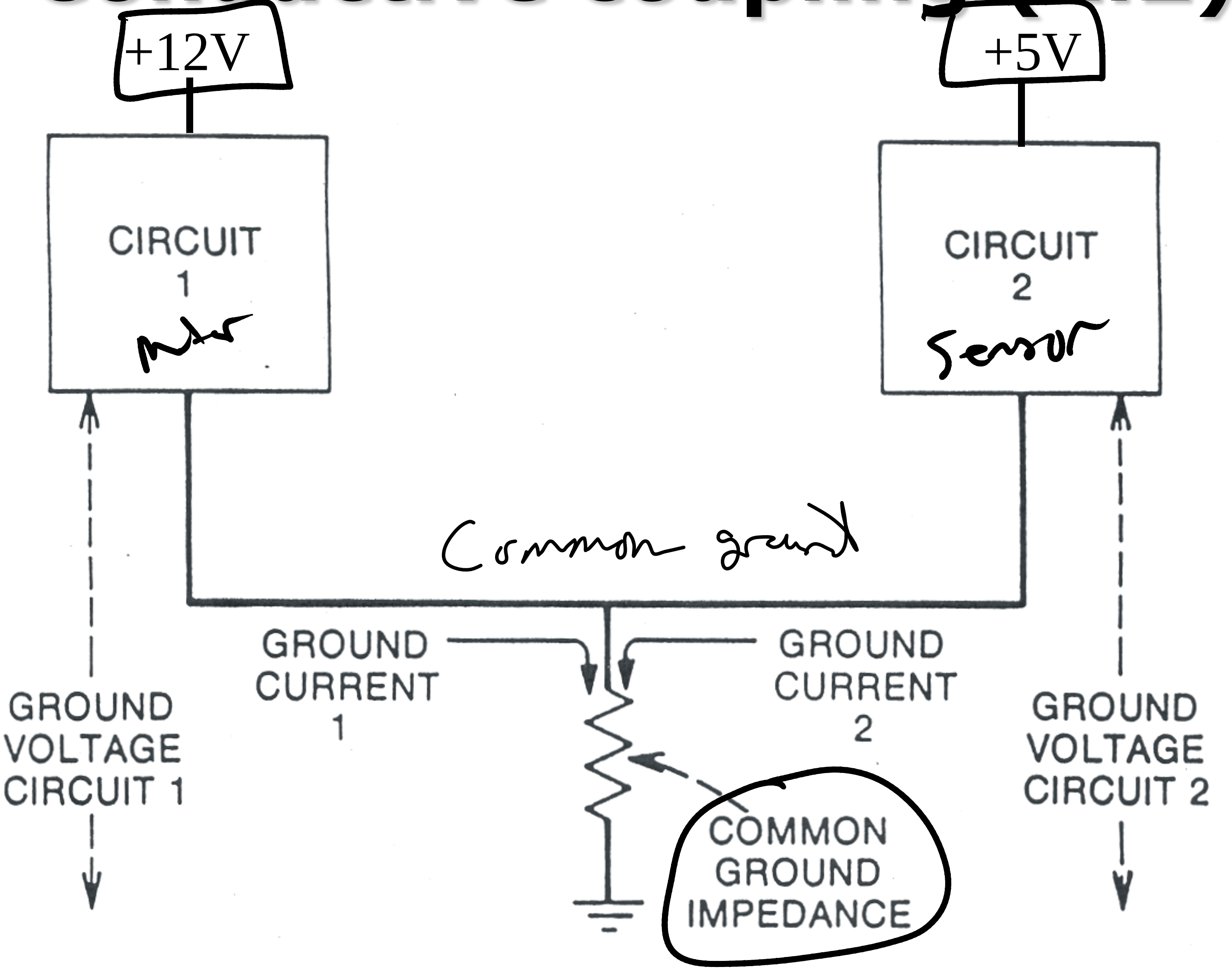


Conductive coupling (1.2)

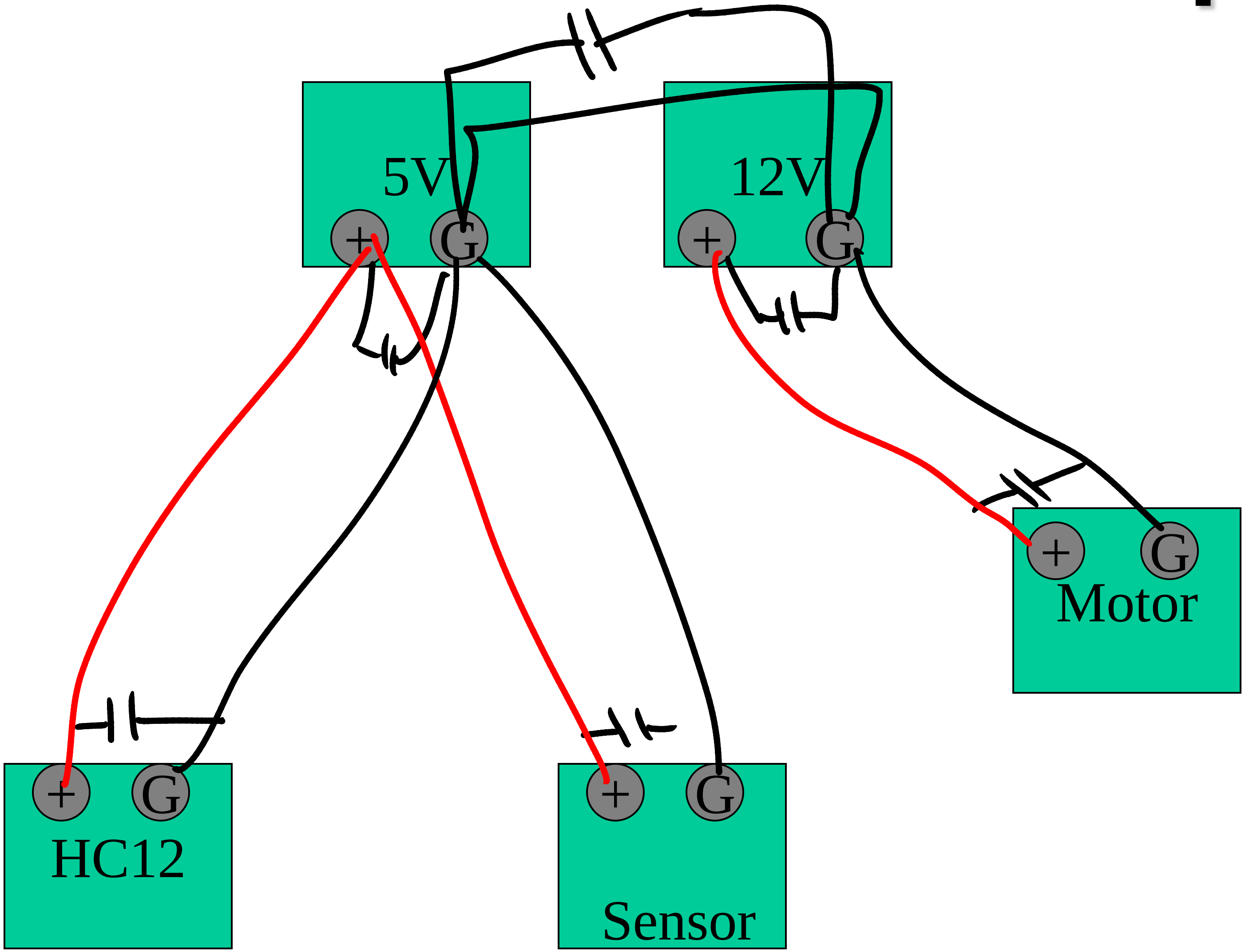


Not a good idea

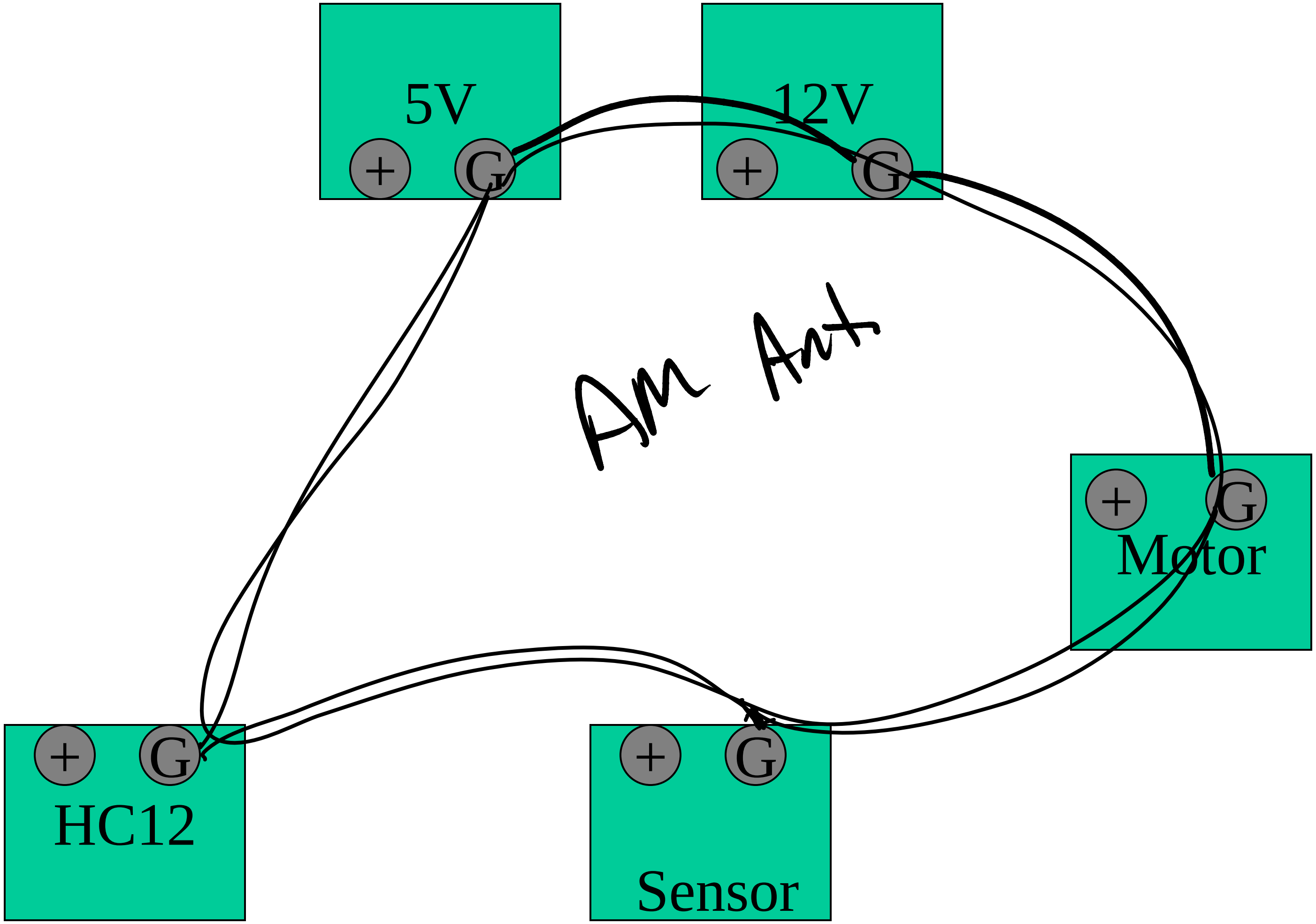
Conductive coupling (2.2)



How should I wire these up?

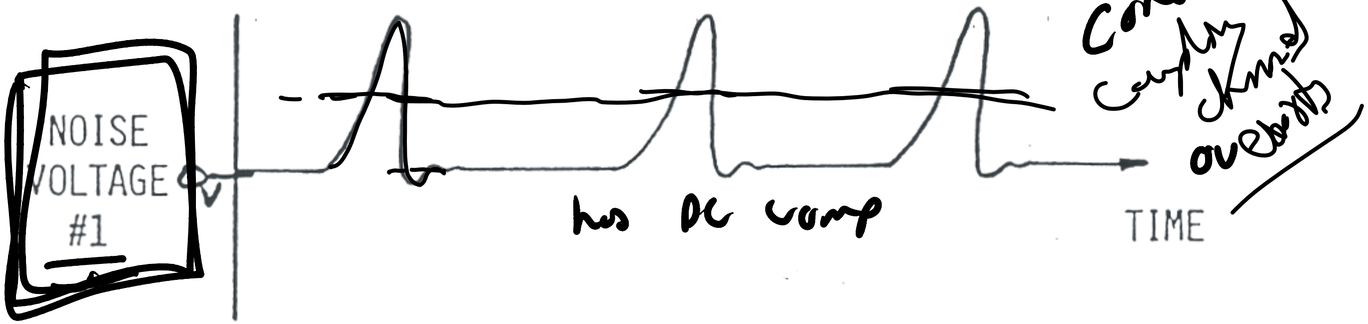


Avoid Ground Loops



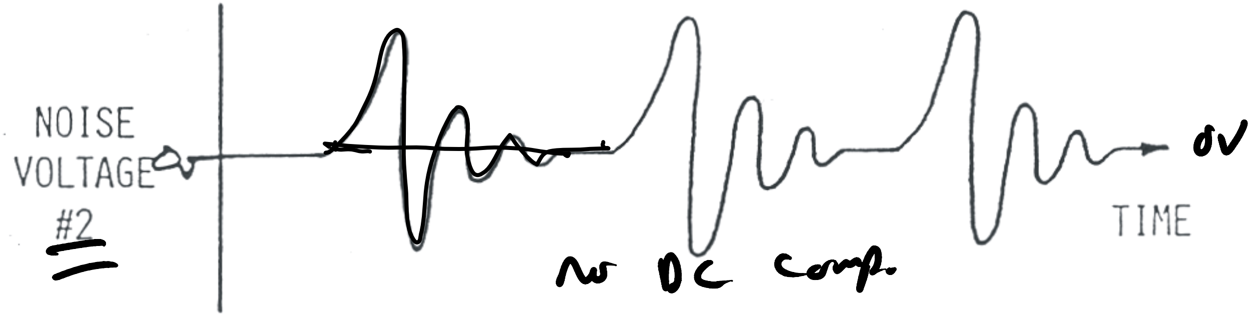
Which waveform ***must*** be conductively coupled?

Why?



has DC comp

Conductive coupling shared overlaps



No DC comp.

Identifying Characteristics of Conductive Coupling

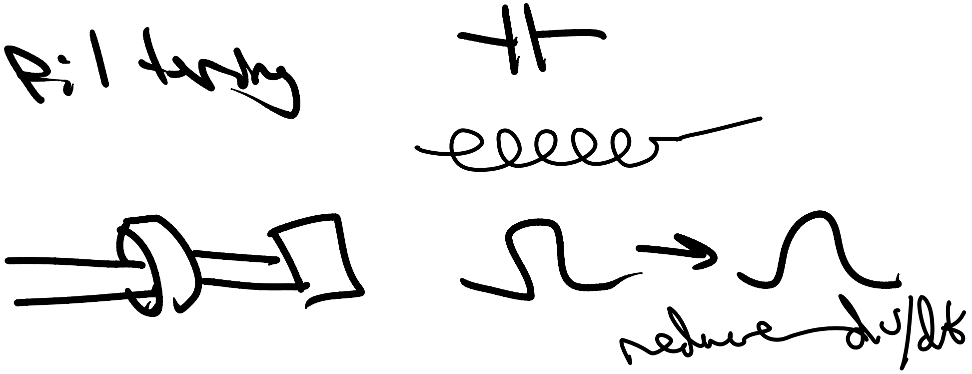
+ metallic contact is required

+ unaffected by people or cable movement

+ non-zero average value for waveform

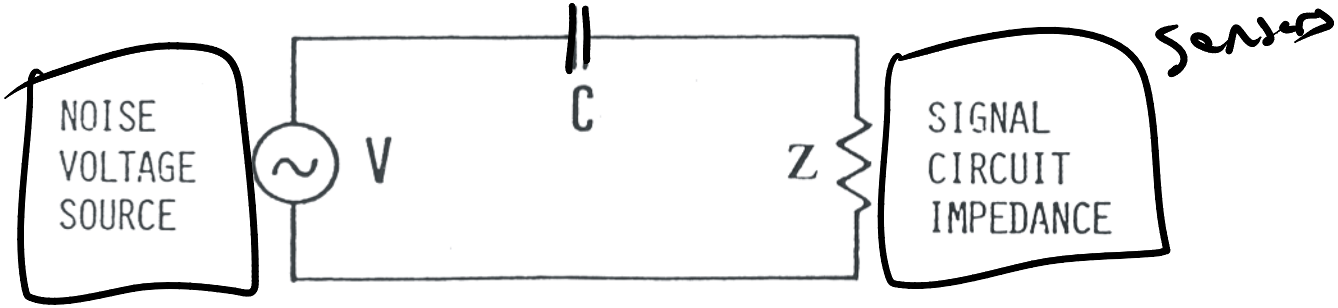
Break contact

- separate wires back to pwr supply
- use filtering



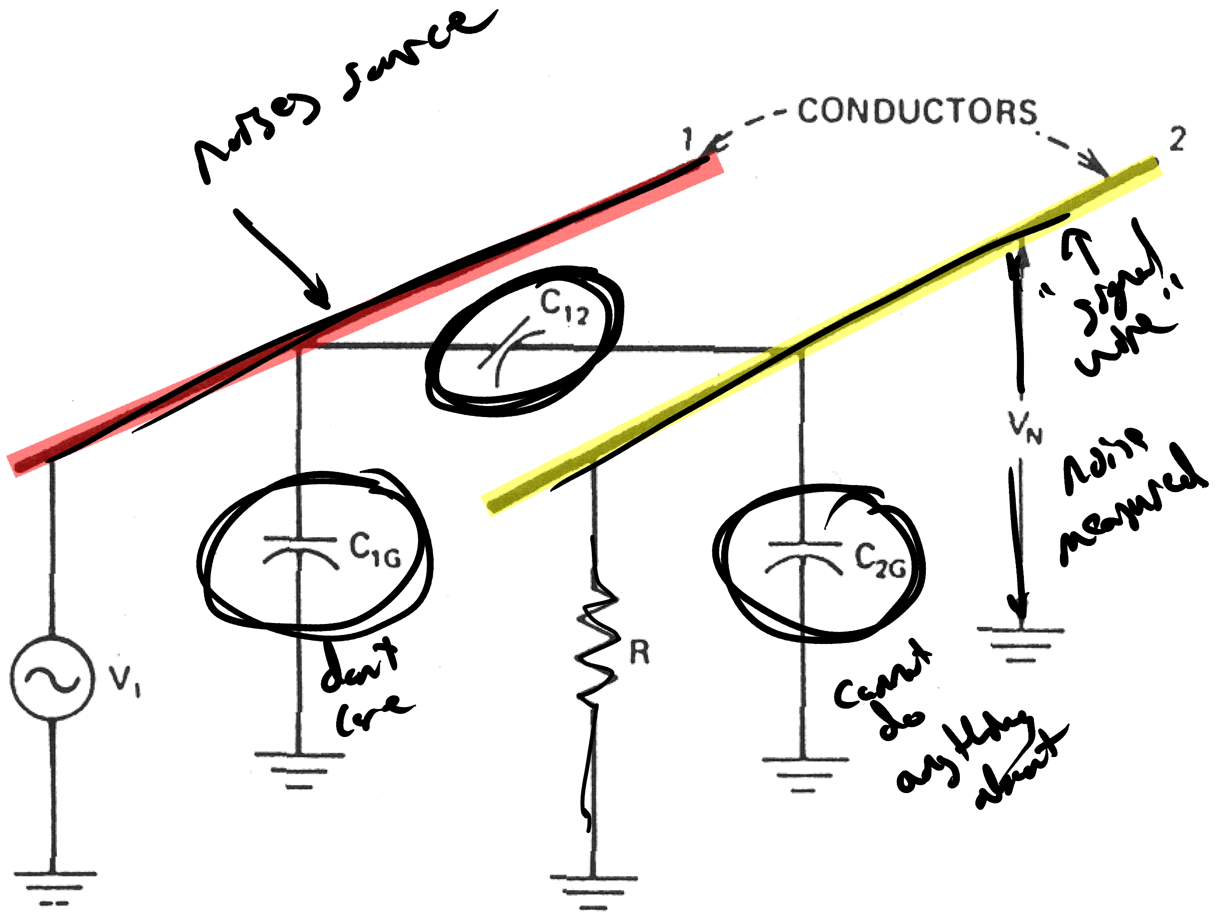
Capacitively coupled noise

Coupling capacitance



Simplified circuit

Physical Representation of capacitively coupled noise



PHYSICAL
REPRESENTATION

Equivalent circuit for capacitively coupled noise

$$V_N = \frac{j\omega[C_{12}/(C_{12}+C_{2G})]}{j\omega + 1/R(C_{12}+C_{2G})} V_1$$

$$\text{If} \quad R >> \frac{1}{j\omega(C_{12}+C_{2G})}$$

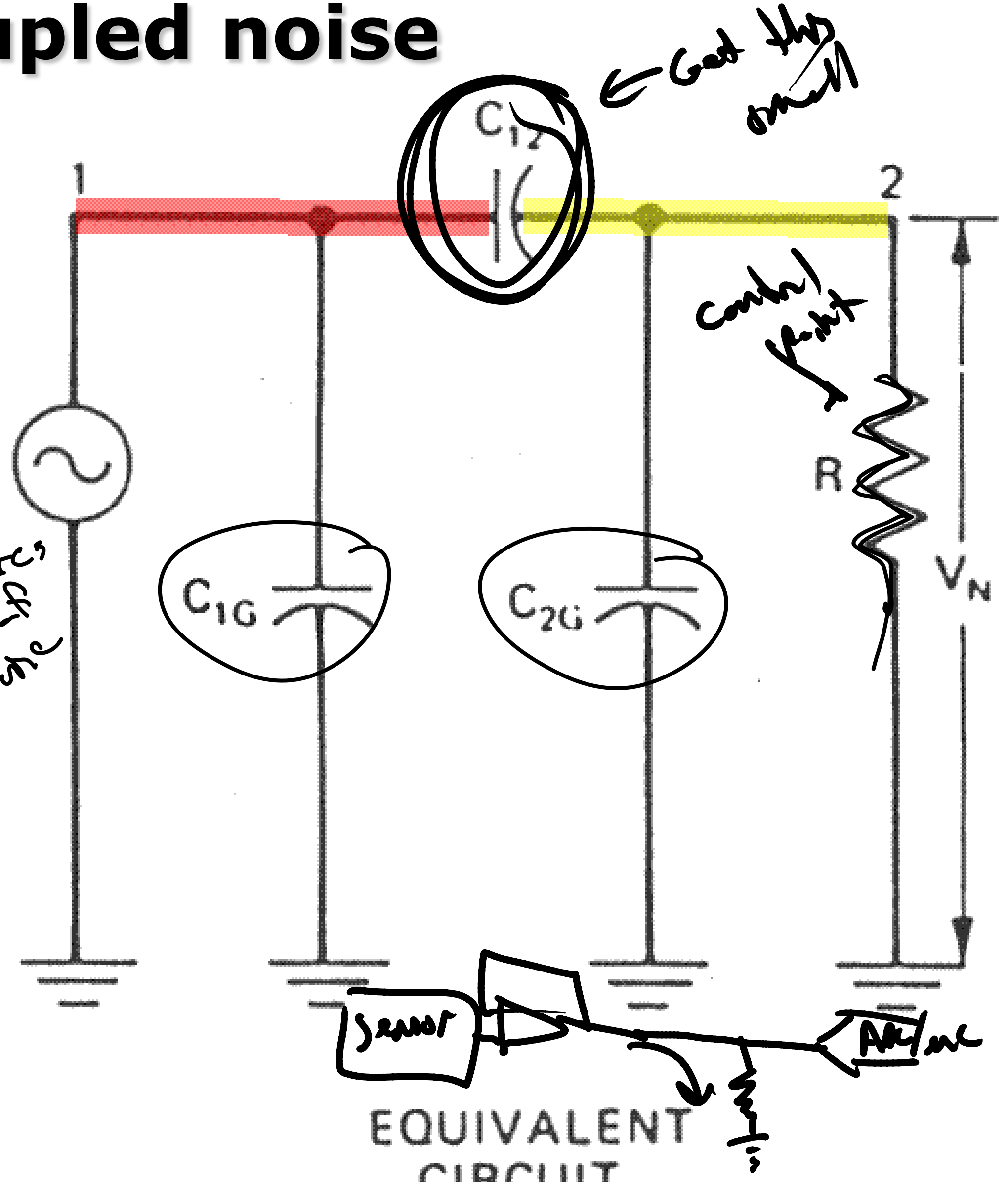
R is big

$$\boxed{V_N = \frac{C_{12}}{(C_{12}+C_{2G})} V_1}$$

$$\text{If} \quad R << \frac{1}{j\omega(C_{12}+C_{2G})}$$

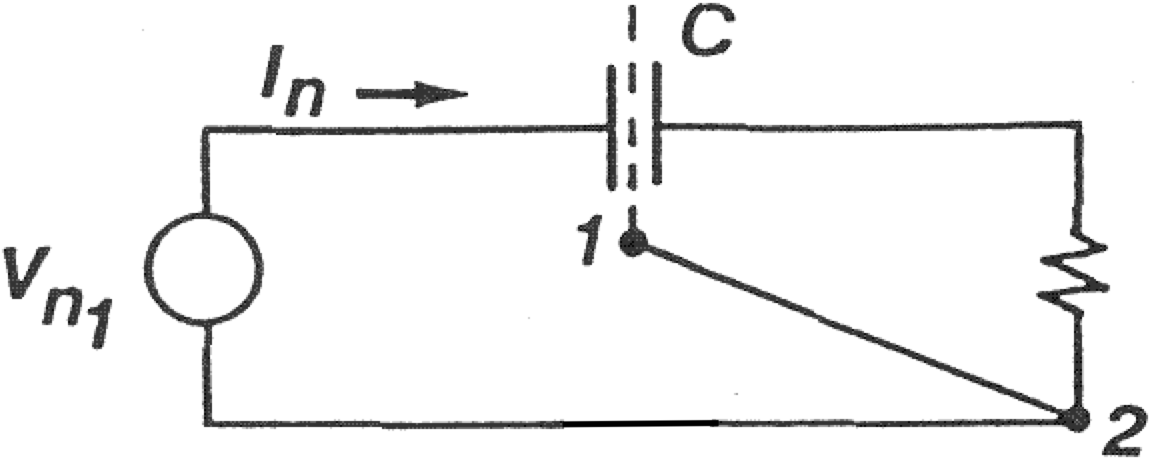
R is small

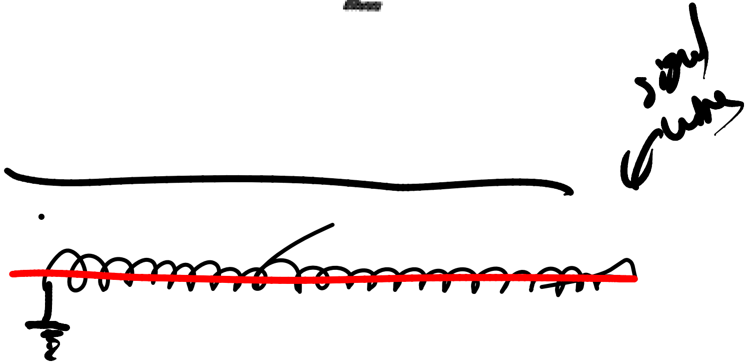
$$\boxed{V_N = j\omega R C_{12} V_1}$$



EQUIVALENT CIRCUIT

Reducing Capacitively Coupled Noise

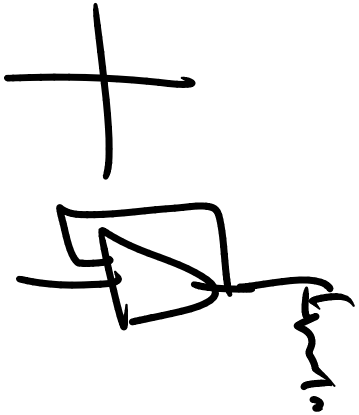




Summary of capacitive noise reduction techniques

to Reduce capacitive noise by:

1) reduce capacitive coupling
2) increase circuit impedance
3) use shielding
    - proper shield location
        - i.e. signals
    - connect shield to gnd in one place only



Isolation

Why do we need it?

- Conductive noise - have not paid attention to pwr
- large voltage differentials
- fault isolation
- min. leakage currents

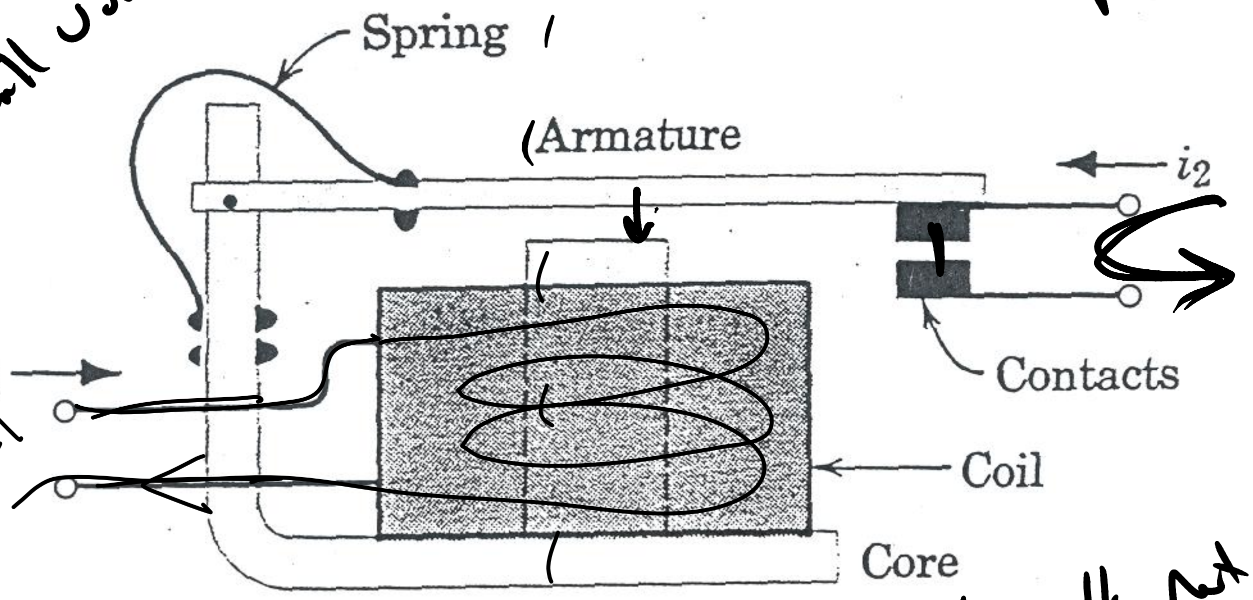
} critical in medical devices.

How do we do it?

- optical
- magnetic

} break the physical contact

Isolation via magnetic coupling



small voltage

Huge voltage

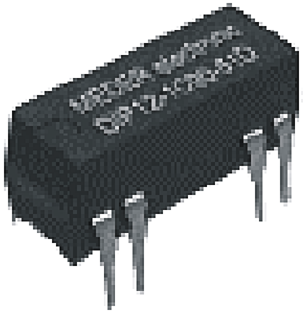
input control

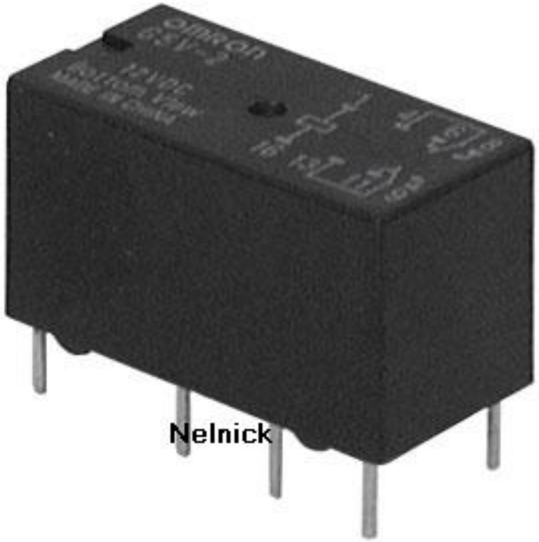
+ electrically not connected

+ like a mechanical transistor

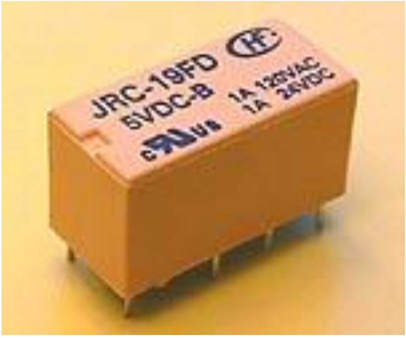
PCB mount miniature relays

Reed Relay

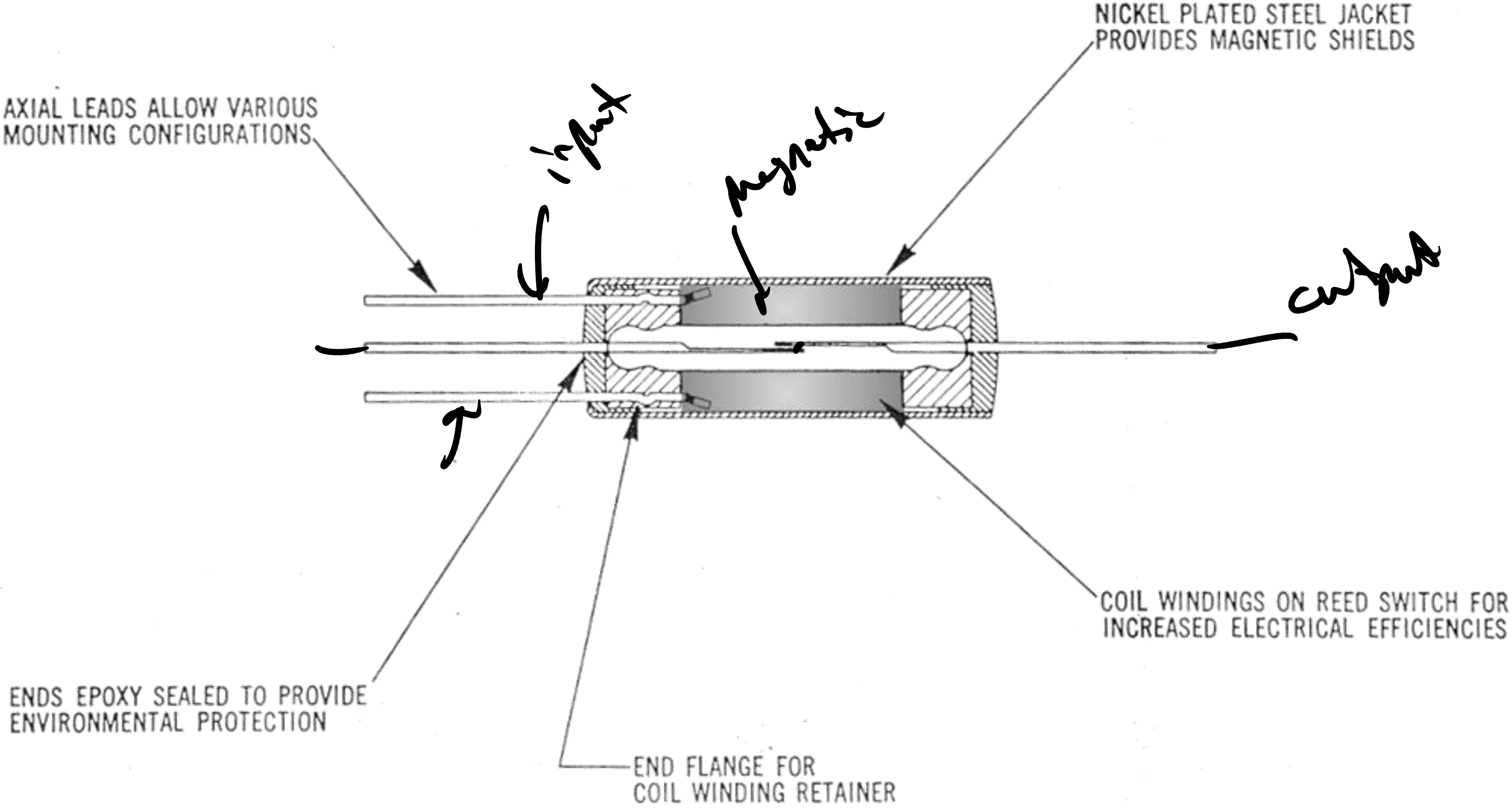




Nelnick



Reed Relay construction



NICKEL PLATED STEEL JACKET
PROVIDES MAGNETIC SHIELDS

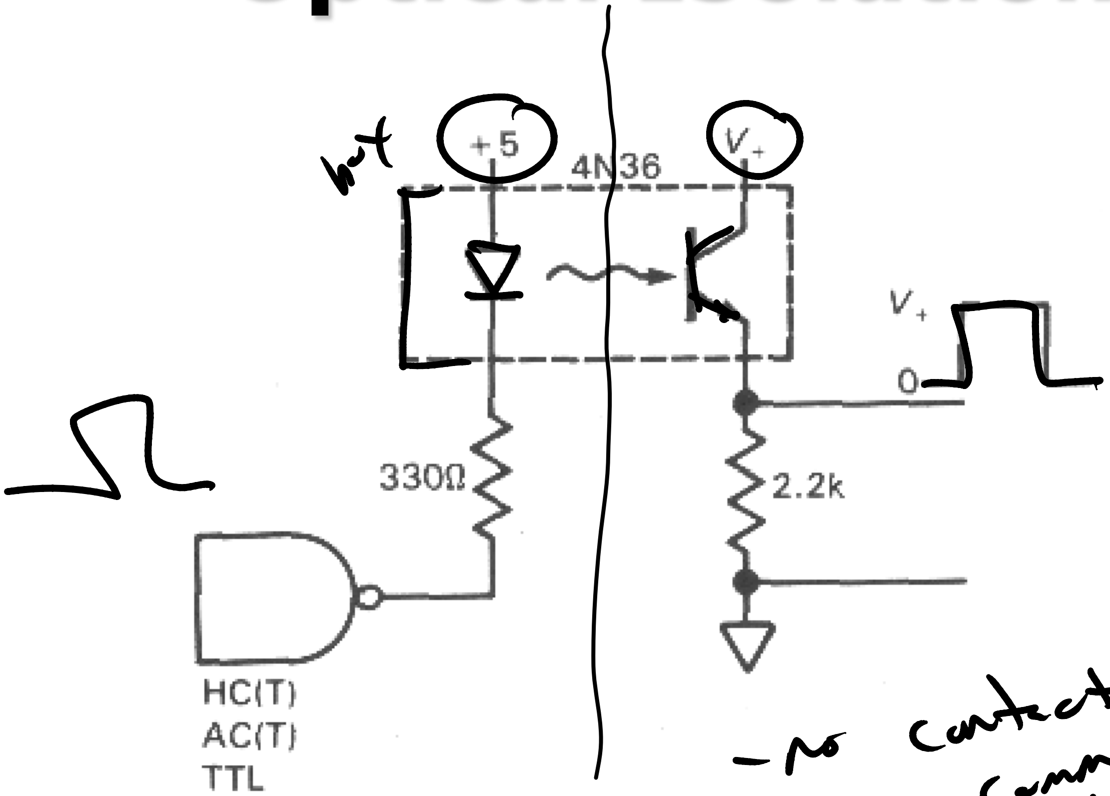
AXIAL LEADS ALLOW VARIOUS
MOUNTING CONFIGURATIONS

COIL WINDINGS ON REED SWITCH FOR
INCREASED ELECTRICAL EFFICIENCIES

ENDS EPOXY SEALED TO PROVIDE
ENVIRONMENTAL PROTECTION

END FLANGE FOR
COIL WINDING RETAINER

Optical Isolation



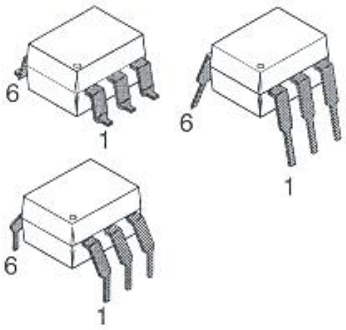
- no contact
- no common gnd
- KV level difference
- doesn't wear out

FAIRCHILD
SEMICONDUCTOR®

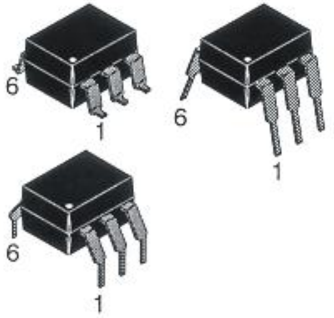
GENERAL PURPOSE 6-PIN PHOTOTRANSISTOR OPTOCOUPLERS

4N25	4N26	4N27	4N28	4N35	4N36
4N37	H11A1	H11A2	H11A3	H11A4	H11A5

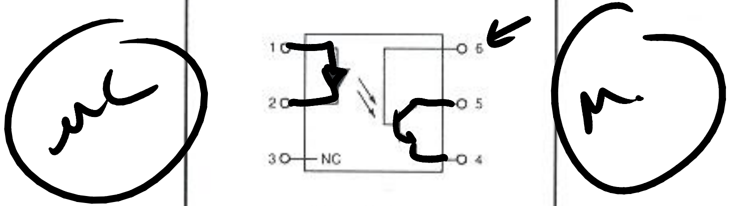
WHITE PACKAGE (-M SUFFIX)



BLACK PACKAGE (NO -M SUFFIX)



SCHEMATIC



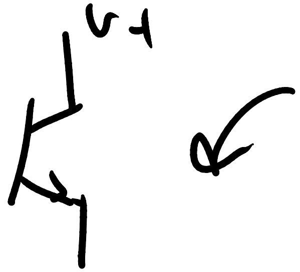
PIN 1. ANODE
2. CATHODE
3. NO CONNECTION
4. EMITTER
5. COLLECTOR
6. BASE

4N25	4N26	4N27	4N28	4N35	4N36
4N37	H11A1	H11A2	H11A3	H11A4	H11A5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

INDIVIDUAL COMPONENT CHARACTERISTICS

Parameter	Test Conditions	Symbol	Min	Typ*	Max	Unit
EMITTER						
Input Forward Voltage	(I_F = 10 mA)	V_F		1.18	1.50	V
Reverse Leakage Current	(V_R = 6.0 V)	I_R		0.001	10	μA
DETECTOR						
Collector-Emitter Breakdown Voltage	(I_C = 1.0 mA, I_F = 0)	BV_{CEO}	30	100		V
Collector-Base Breakdown Voltage	(I_C = 100 μA, I_F = 0)	BV_{CBO}	70	120		V
Emitter-Collector Breakdown Voltage	(I_E = 100 μA, I_F = 0)	BV_{ECO}	7	10		V
Collector-Emitter Dark Current	(V_{CE} = 10 V, I_F = 0)	I_{CEO}		1	50	nA
Collector-Base Dark Current	(V_{CB} = 10 V)	I_{CBO}			20	nA
Capacitance	(V_{CE} = 0 V, f = 1 MHz)	C_{CE}		8		pF

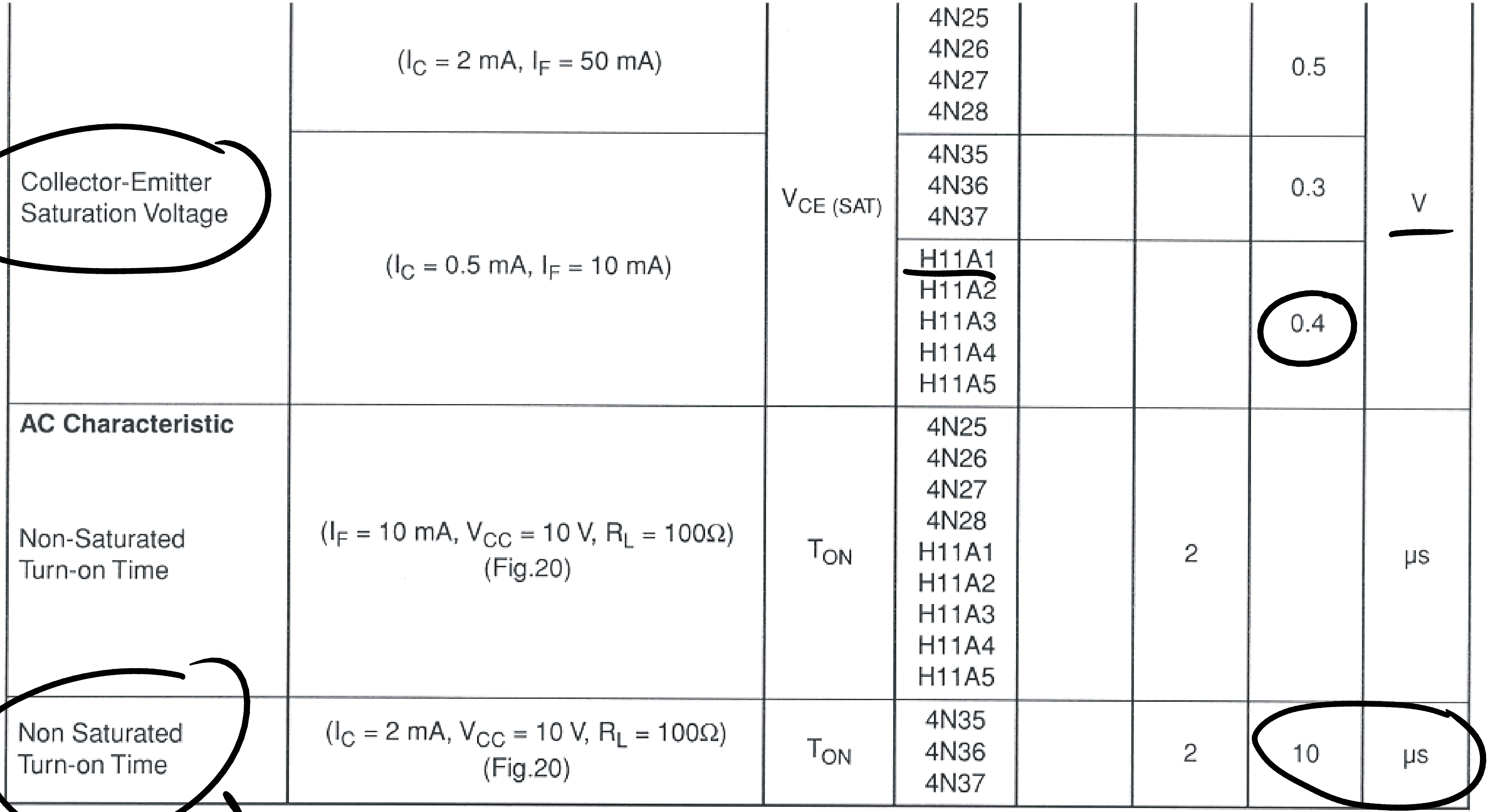


TRANSFER CHARACTERISTICS (T_A = 25°C Unless otherwise specified.)

I_c / I_F

LED → I_F

DC Characteristic	Test Conditions	Symbol	Device	Min	Typ*	Max	Unit
Current Transfer Ratio, Collector to Emitter	(I_F = 10 mA, V_{CE} = 10 V)	CTR	4N35 4N36 4N37	100			%
			H11A1	50			
			H11A5	30			
			4N25 4N26 H11A2 H11A3	20			
			4N27 4N28 H11A4	10			
	(I_F = 10 mA, V_{CE} = 10 V, T_A = -55°C)		4N35 4N36 4N37	40			
	(I_F = 10 mA, V_{CE} = 10 V, T_A = +100°C)		4N35 4N36 4N37	40			



					min	max	
Collector-Emitter Saturation Voltage	(I_C = 2 mA, I_F = 50 mA)	$V_{CE\ (SAT)}$	4N25 4N26 4N27 4N28			0.5	V
	(I_C = 0.5 mA, I_F = 10 mA)		4N35 4N36 4N37			0.3	
			H11A1 H11A2 H11A3 H11A4 H11A5			0.4	
AC Characteristic Non-Saturated Turn-on Time	(I_F = 10 mA, V_{CC} = 10 V, R_L = 100Ω) (Fig.20)	T_{ON}	4N25 4N26 4N27 4N28 H11A1 H11A2 H11A3 H11A4 H11A5		2		μs
Non Saturated Turn-on Time	(I_C = 2 mA, V_{CC} = 10 V, R_L = 100Ω) (Fig.20)	T_{ON}	4N35 4N36 4N37		2	10	μs

speed

switch in ~ 10 μs

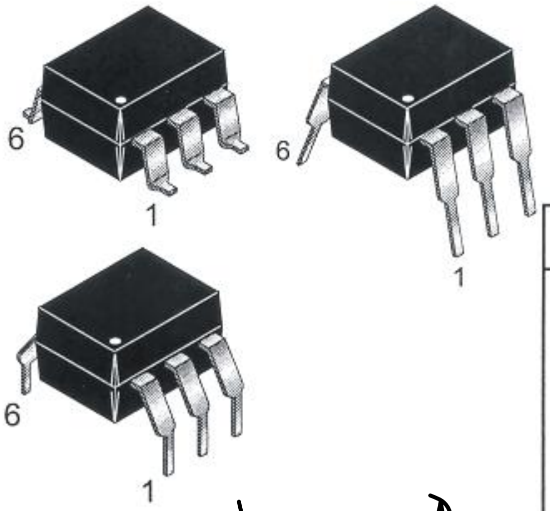
FAIRCHILD
SEMICONDUCTOR®

AC INPUT/PHOTOTRANSISTOR OPTOCOUPLERS

H11AA1 **H11AA3** **H11AA2** **H11AA4**

DESCRIPTION

The H11AAX series consists of two gallium-arsenide infrared emitting diodes connected in inverse parallel driving a single silicon phototransistor output.

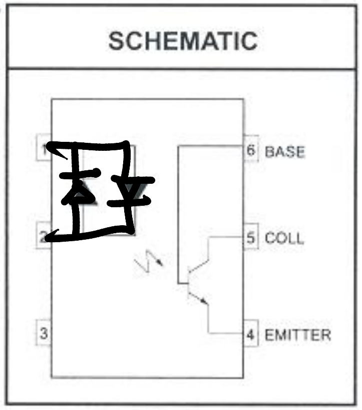


FEATURES

- Bi-polar emitter input
- Built-in reverse polarity input protection
- Underwriters Laboratory (UL) recognized — File #E90700
- VDE approved — File #E94766 (ordering option '300')

APPLICATIONS

- AC line monitor
- Unknown polarity DC sensor
- Telephone line interface



- switch replacement
- insensitivity to polarity

FAIRCHILD SEMICONDUCTOR™

PHOTODARLINGTON OPTOCOUPLERS

CNX48U H11B1 H11B2 H11B255 H11B3
MOC8080 TIL113

DESCRIPTION

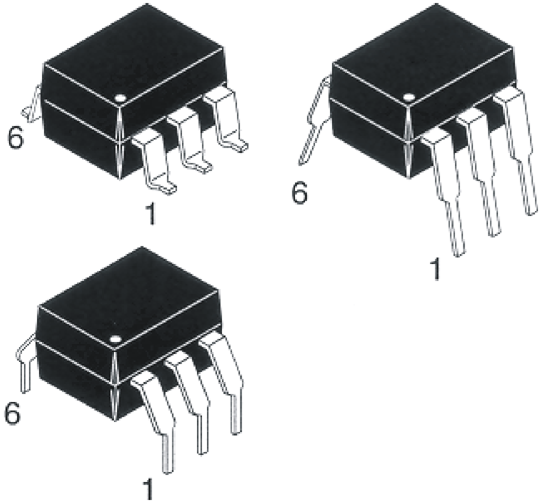
The CNX48U, H11BX, MOC8080 and TIL113 have a gallium arsenide infrared emitter optically coupled to a silicon planar photodarlington.

FEATURES

- High sensitivity to low input drive current
- Meets or exceeds all JEDEC Registered Specifications
- VDE 0884 approval available as a test option -add option .300. (e.g., H11B1.300)

APPLICATIONS

- Low power logic circuits
- Telecommunications equipment
- Portable electronics
- Solid state relays
- Interfacing coupling systems of different potentials and impedances.



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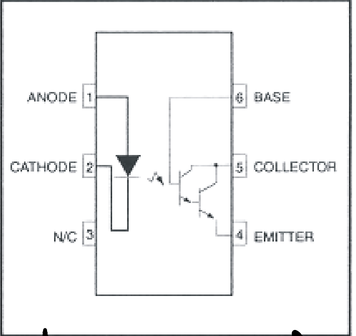
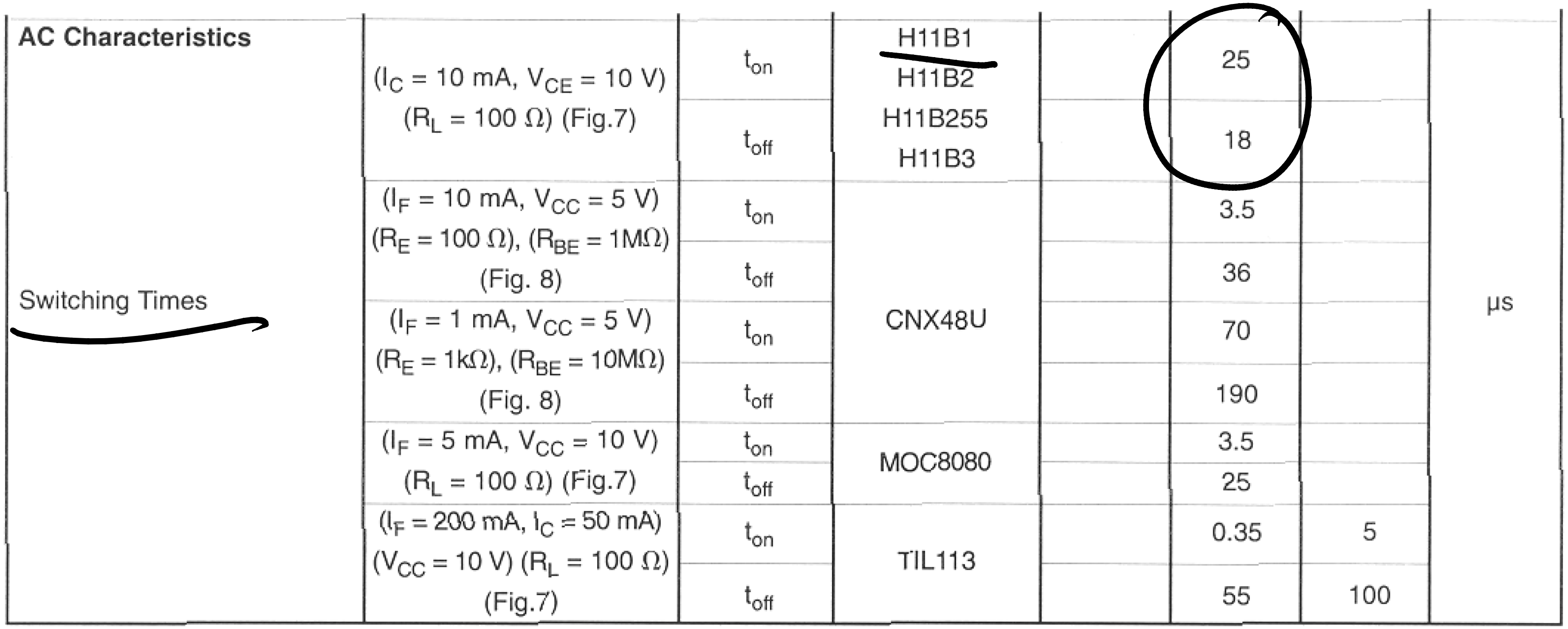
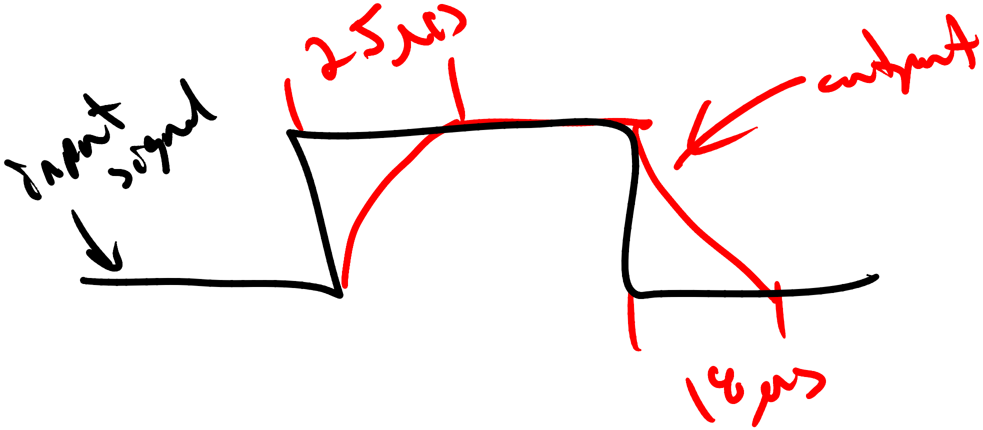


Higher current transfer Ratio (CTR)
~1000%



AC Characteristics	$(I_C = 10\text{ mA}, V_{CE} = 10\text{ V})$ $(R_L = 100\ \Omega)$ (Fig.7)	t_{on}	H11B1 H11B2 H11B255 H11B3		25		
		t_{off}			18		
	$(I_F = 10\text{ mA}, V_{CC} = 5\text{ V})$ $(R_E = 100\ \Omega)$, $(R_{BE} = 1\text{M}\Omega)$ (Fig. 8)	t_{on}	CNX48U		3.5		
		t_{off}			36		
Switching Times	$(I_F = 1\text{ mA}, V_{CC} = 5\text{ V})$ $(R_E = 1\text{k}\Omega)$, $(R_{BE} = 10\text{M}\Omega)$ (Fig. 8)	t_{on}			70		µs
		t_{off}			190		
	$(I_F = 5\text{ mA}, V_{CC} = 10\text{ V})$ $(R_L = 100\ \Omega)$ (Fig.7)	t_{on}	MOC8080		3.5		
		t_{off}			25		
	$(I_F = 200\text{ mA}, I_C = 50\text{ mA})$ $(V_{CC} = 10\text{ V})$ $(R_L = 100\ \Omega)$ (Fig.7)	t_{on}	TIL113		0.35	5	
		t_{off}			55	100	



GlobalOptoisolator™

VDE UL CSA SETI SEMKO DEMKO NEMKO BABT

6-Pin DIP Optoisolators Logic Output

H11L1*
[IF(on) = 1.6 mA Max]
H11L2
[IF(on) = 10 mA Max]

*Motorola Preferred Device

The H11L1 and H11L2 have a gallium arsenide IRED optically coupled to a high–speed integrated detector with Schmitt trigger output. Designed for applications requiring electrical isolation, fast response time, noise immunity and digital logic compatibility.

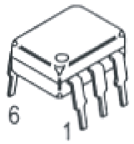
- Guaranteed Switching Times — t_{on}, $t_{off} < 4$ µs
- Built–In On/Off Threshold Hysteresis
- High Data Rate, 1 MHz Typical (NRZ)
- Wide Supply Voltage Capability
- Microprocessor Compatible Drive
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

- Interfacing Computer Terminals to Peripheral Equipment
- Digital Control of Power Supplies
- Line Receiver — Eliminates Noise
- Digital Control of Motors and Other Servo Machine Applications
- Logic to Logic Isolator
- Logic Level Shifter — Couples TTL to CMOS

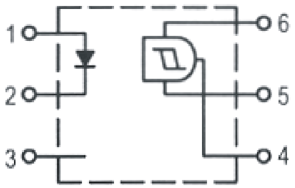
MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

STYLE 5 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



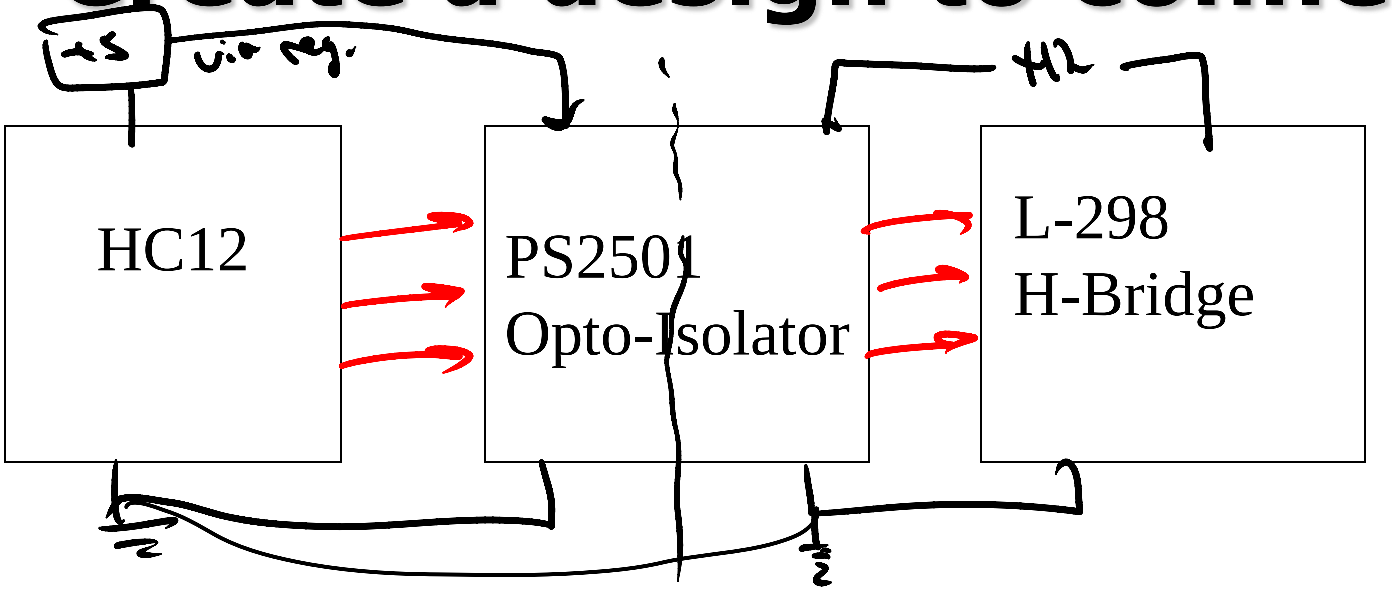
H11L1 H11L2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Reverse Leakage Current (V_R = 3 V, R_L = 1 MΩ)		I_R	—	0.05	10	µA
Forward Voltage (I_F = 10 mA) (I_F = 0.3 mA)		V_F	— 0.75	1.2 0.95	1.5 —	Volts
Capacitance (V_R = 0 V, f = 1 MHz)		C	—	18	—	pF
OUTPUT DETECTOR						
Operating Voltage		V_{CC}	3	—	15	Volts
Supply Current (I_F = 0, V_{CC} = 5 V)		$I_{CC(off)}$	—	1	5	mA
Output Current, High (I_F = 0, V_{CC} = V_o = 15 V)		I_{OH}	—	—	100	µA
COUPLED						
Supply Current (I_F = $I_{F(on)}$, V_{CC} = 5 V)		$I_{CC(on)}$	—	1.6	5	mA
Output Voltage, Low (R_L = 270 Ω, V_{CC} = 5 V, I_F = $I_{F(on)}$)		V_{OL}	—	0.2	0.4	Volts
Threshold Current, ON (R_L = 270 Ω, V_{CC} = 5 V)	H11L1 H11L2	$I_{F(on)}$	— —	1.2 —	1.6 10	mA
Threshold Current, OFF (R_L = 270 Ω, V_{CC} = 5 V)	H11L1 H11L2	$I_{F(off)}$	0.3 0.3	0.75 —	— —	mA
Hysteresis Ratio (R_L = 270 Ω, V_{CC} = 5 V)		$\frac{I_{F(off)}}{I_{F(on)}}$	0.5	0.75	0.9	
Isolation Voltage(2) 60 Hz, AC Peak, 1 second, T_A = 25°C		V_{ISO}	7500	—	—	Vac(pk)
Turn–On Time	R_L = 270 Ω(3) V_{CC} = 5 V, I_F = $I_{F(on)}$ T_A = 25°C	t_{on}	—	1.2	4	µs
Fall Time		t_f	—	0.1	—	
Turn–Off Time		t_{off}	—	1.2	4	
Rise Time		t_r	—	0.1	—	

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. For this test, IRED Pins 1 and 2 are common and Output Gate Pins 4, 5, 6 are common.
3. R_L value effect on switching time is negligible.

Create a design to connect



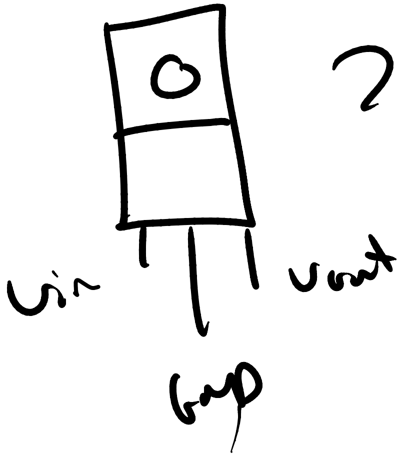
HC12

PS2501
Opto-Isolator

L-298
H-Bridge

Voltage Regulator

7805 5V Regulator

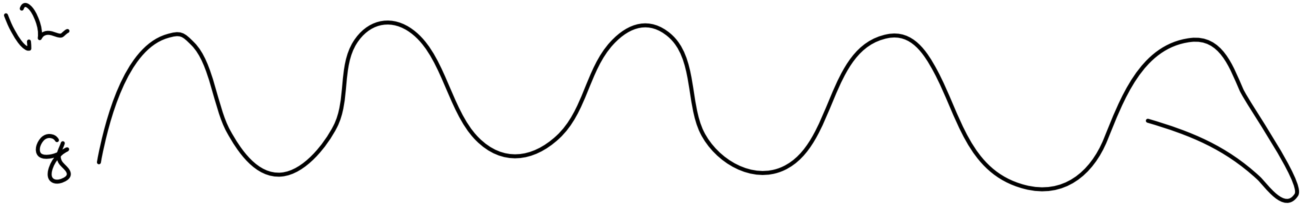


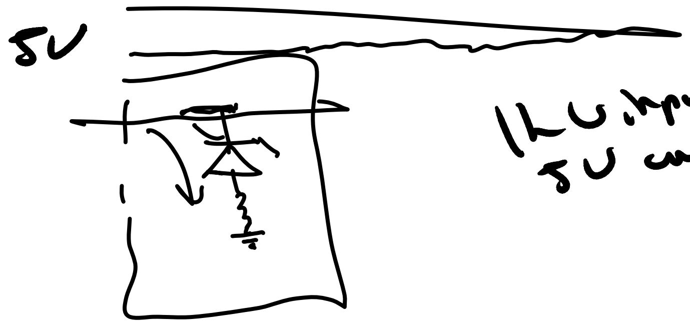
$V_{out} = 5V$

if $V_{in} > \cancel{8}.2V$ 7V

&

$V_{in} < V_{max}$





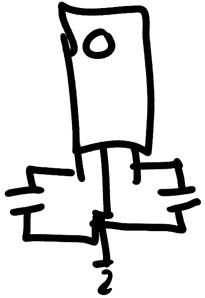
~5%

12V input

5V output

200mA

$P = (7 \times .2) = 1.4W$



Questions?