Output Interfacing Circuit

The AVR microcontroller and embedded systems
using assembly and c

Topics

- AVR Fan-out
- Transistor
- MOSFET
- ULN2003
- Relay
- Opto-isolator
- H-Bridge Motor Driver

AVR Fan-out

- Each I/O port can sink 20 mA at VCC = 5V and 10 mA at VCC = 3V

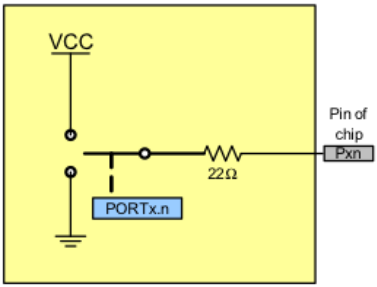
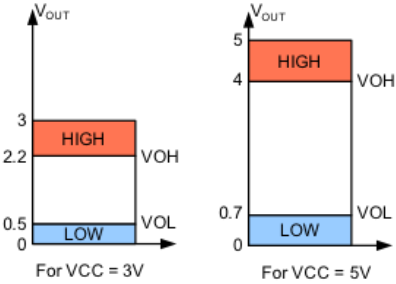


Table C-5: Fan-out for AVR Ports

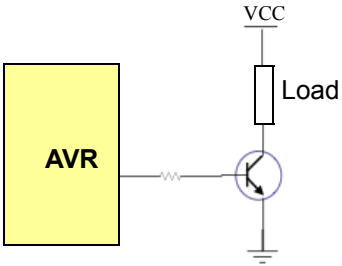
Pin	Fan-out
IOL	20 mA
IOH	–20 mA
IIL	–1 μA
IIH	1 μA

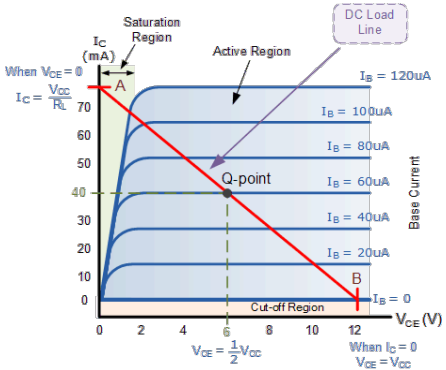
Note: Negative current is defined as current sourced by the pin.



Transistor

- We can switch devices using transistors.
- Transistor amplifies signals.





2N3903, 2N3904

General Purpose Transistors

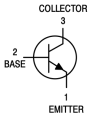
NPN Silicon

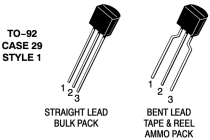
Features

- Pb–Free Packages are Available*

ON Semiconductor®

http://onsemi.com





MAXIMUM RATINGS

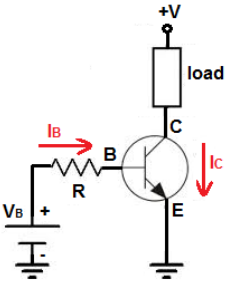
Rating	Symbol	Value	Unit
Collector – Emitter Voltage	V_{CEO}	40	Vdc
Collector – Base Voltage	V_{CBO}	60	Vdc
Emitter – Base Voltage	V_{EBO}	6.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	W mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS (Note 1)

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	200	°C/W

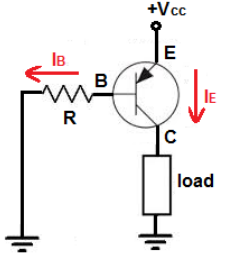
ON CHARACTERISTICS

DC Current Gain (Note 2) (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904	h_{FE}	20 40	– –	–
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904		35 70	– –	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904		30 60	– –	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3903 2N3904		15 30	– –	
Collector – Emitter Saturation Voltage (Note 2) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	– –	0.2 0.3	Vdc
Base – Emitter Saturation Voltage (Note 2) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	0.65 –	0.85 0.95	Vdc



NPN

In an NPN transistor, positive voltage is given to the collector terminal and current flows from the collector to the emitter, given there is sufficient base current

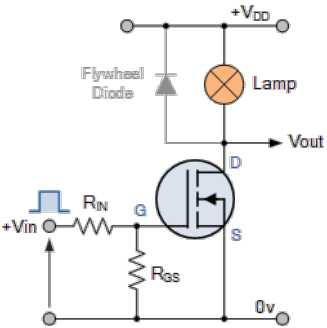


PNP

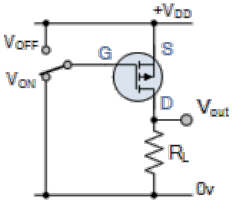
In a PNP transistor, positive voltage is given to the emitter terminal and current flows from the emitter to the collector, given there is sufficient negative current flow from the base

MOSFET

- We can switch devices using MOSFET like the transistor (voltage-controlled vs current controlled)



N-channel



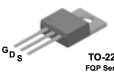
P-channel

MOSFET Type	$V_{GS} \ll 0$	$V_{GS} = 0$	$V_{GS} \gg 0$
N-channel Enhancement	OFF	OFF	ON
N-channel Depletion	OFF	ON	ON
P-channel Enhancement	ON	OFF	OFF
P-channel Depletion	ON	ON	OFF

FAIRCHILD
SEMICONDUCTOR®

FQP30N06L

60V LOGIC N-Channel MOSFET



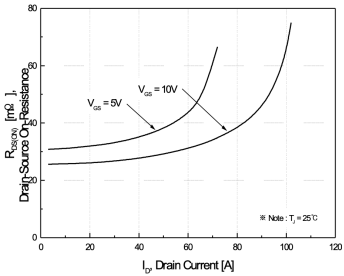


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

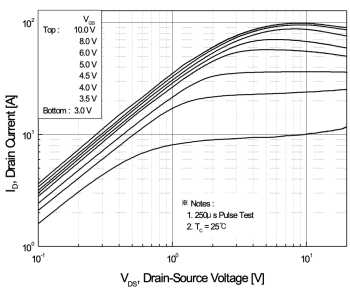


Figure 1. On-Region Characteristics

Absolute Maximum Ratings

T_C = 25°C unless otherwise noted

Symbol	Parameter		FQP30N06L	Units
V_{DSS}	Drain-Source Voltage		60	V
I_D	Drain Current - Continuous (T_C = 25°C)		32	A
	- Continuous (T_C = 100°C)		22.6	A
I_{DM}	Drain Current - Pulsed	(Note 1)	128	A
V_{GSS}	Gate-Source Voltage		± 20	V
E_{AS}	Single Pulsed Avalanche Energy	(Note 2)	350	mJ
I_{AR}	Avalanche Current	(Note 1)	32	A
E_{AR}	Repetitive Avalanche Energy	(Note 1)	7.9	mJ
dv/dt	Peak Diode Recovery dv/dt	(Note 3)	7.0	V/ns
P_D	Power Dissipation (T_C = 25°C)		79	W
	- Derate above 25°C		0.53	W/°C
T_J, T_{STG}	Operating and Storage Temperature Range		-55 to +175	°C
T_L	Maximum lead temperature for soldering purposes, 1/8" from case for 5 seconds		300	°C

On Characteristics

$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS}, I_D = 250 μA	1.0	--	2.5	V
$R_{DS(on)}$	Static Drain-Source On-Resistance	V_{GS} = 10 V, I_D = 16 A	--	0.027	0.035	Ω
		V_{GS} = 5 V, I_D = 16 A	--	0.035	0.045	
g_{FS}	Forward Transconductance	V_{DS} = 25 V, I_D = 16 A (Note 4)	--	24	--	S

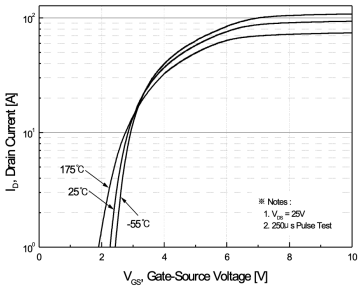
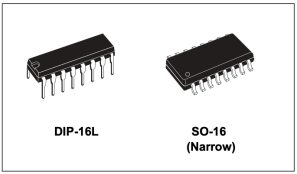


Figure 2. Transfer Characteristics

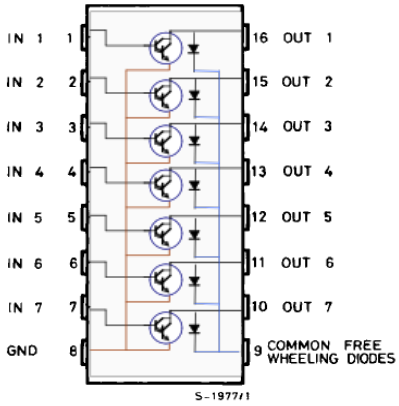
ULN2003

- There are 7 Darlington transistors in a ULN2003.



Features

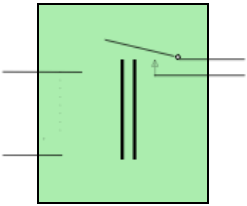
- Seven Darlingtons per package
- Output current 500 mA per driver (600 mA peak)
- Output voltage 50 V
- Integrated suppression diodes for inductive loads
- Outputs can be paralleled for higher current
- TTL/CMOS/PMOS/DTL compatible inputs
- Input pins placed opposite to output pins to simplify layout

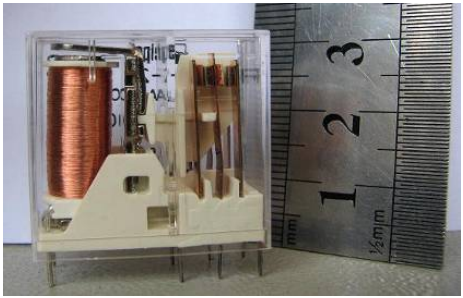


ULN2003 (each driver)

Relay

- Relay is an electronic controlled switch.
- It isolates two parts of a circuit from each other.
- A small amount of current and voltage causes to switch a large amount of voltage and current.





Relay DPDT

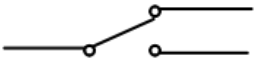
Maximum output: 250V 8A ~AC

Input: 24V DC

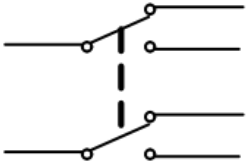
Contacts

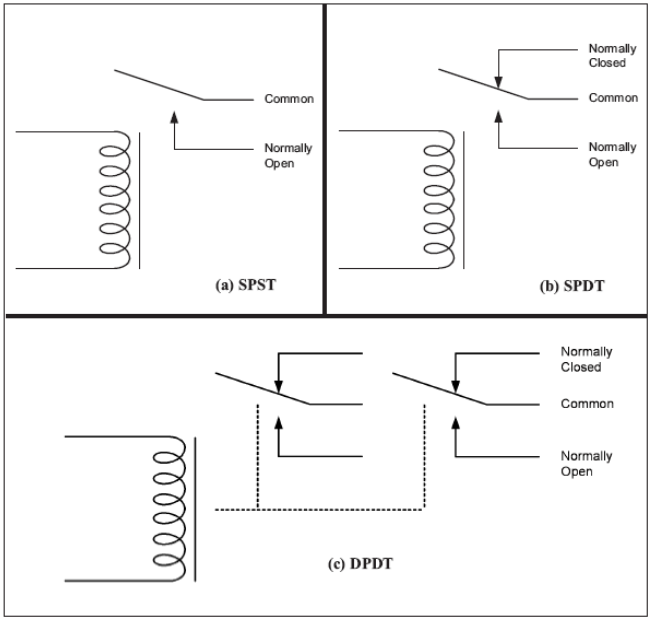
- SPST

- SPDT

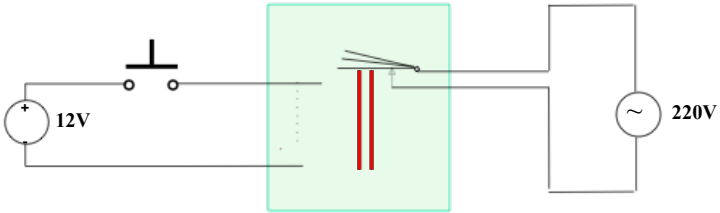


- DPDT

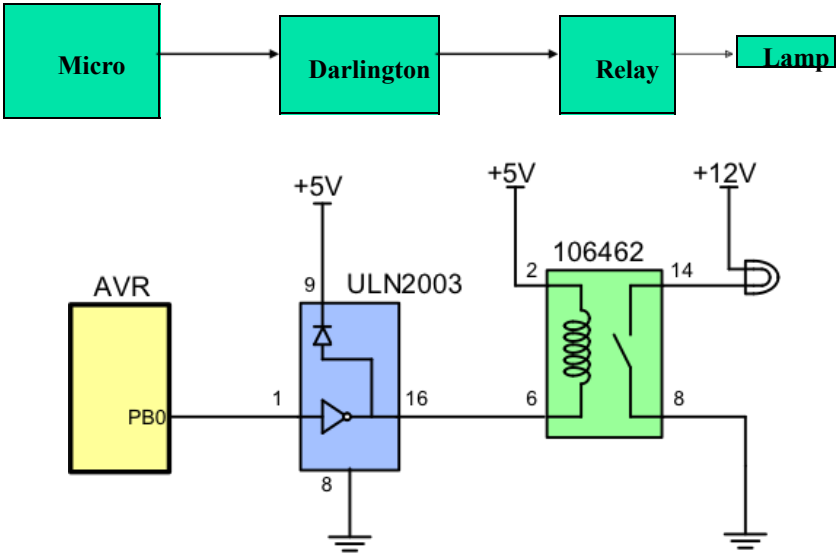




Relay

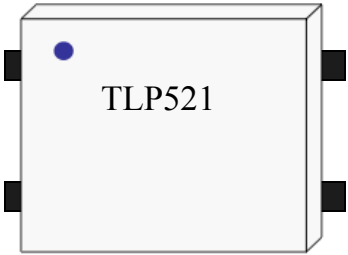


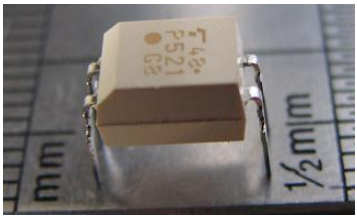
AVR connection to relay



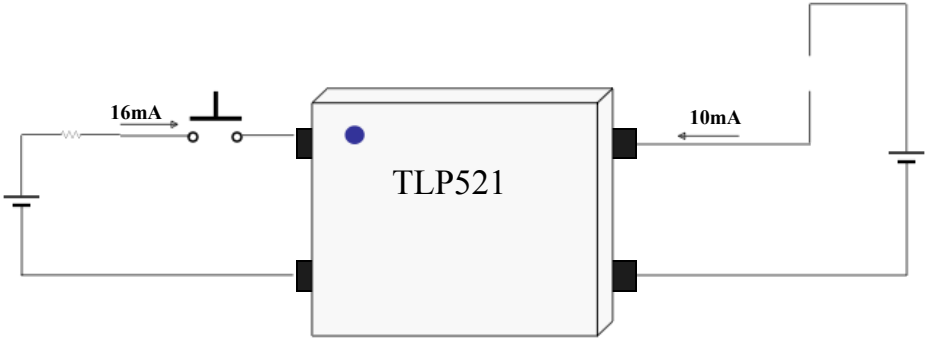
Optoisolator

- Opto-isolator isolates two parts of a circuit from each other.
- There is an LED in the input, and a photo-transistor in the output. When the LED lights up, the photo-transistor, senses the light and becomes conductor, and passes the current.
- can be used in input or output circuits.

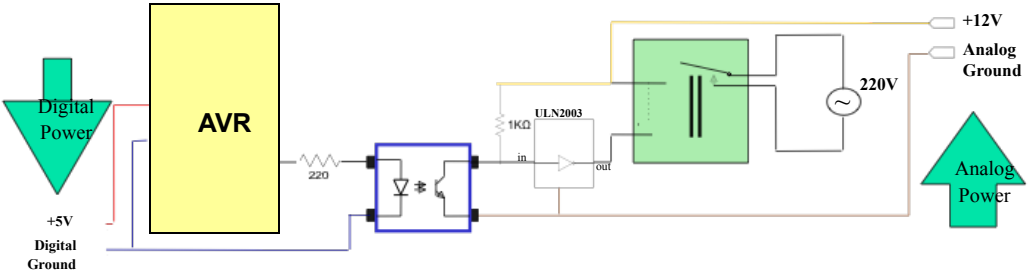




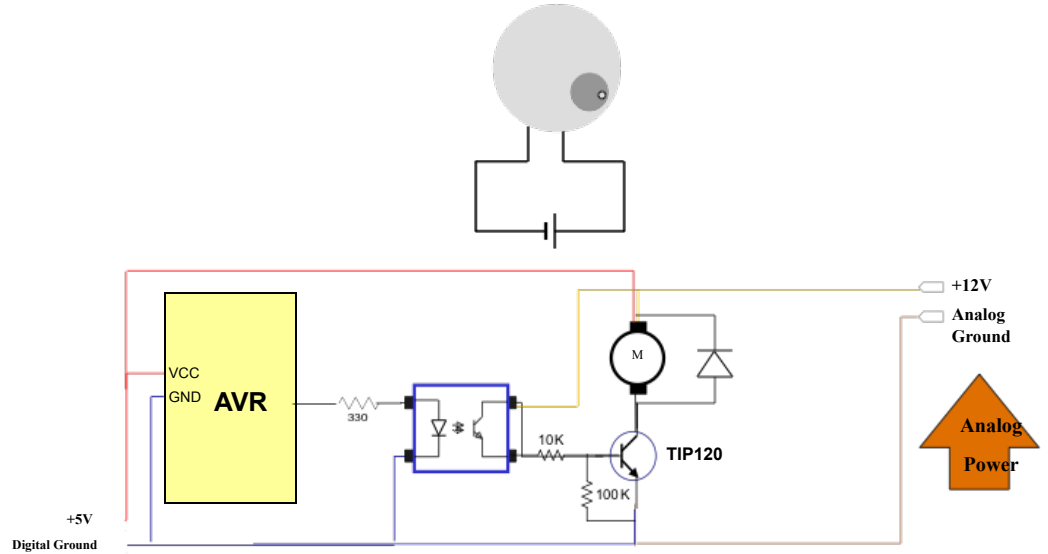
Opto-isolator



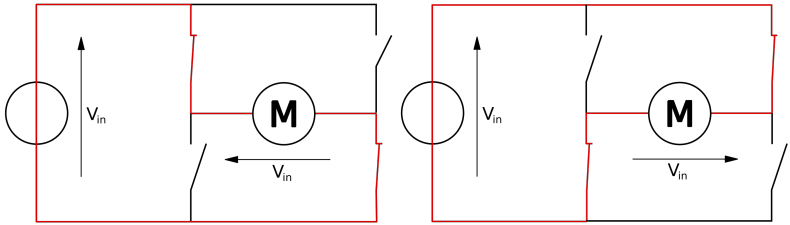
Controlling 220V devices

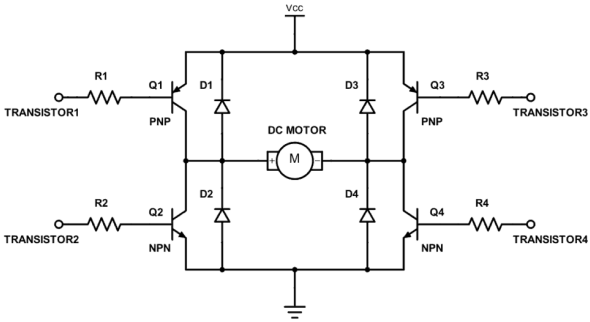


Unidirectional Motor control



H-Bridge Motor Drive





Using L298N