Lecture 9 : MOSFET Switches

0. Review
1. MOSFET Intro
2. MOSFET Switch Analysis
3. MOSFET Switch Design

- PreLab 4 due Thu
- HW4 due Fri (Oct 25)
- Exam 1 re-do (counts as HW) due next Tue (Oct 29)
- Lab3 report due Nov 4 (Mon)

Textbook Reading: 12-4 Enhancement Mode MOSFET
5 Ohmic region
8 Power FETs
9 High-side MOSFET load switches

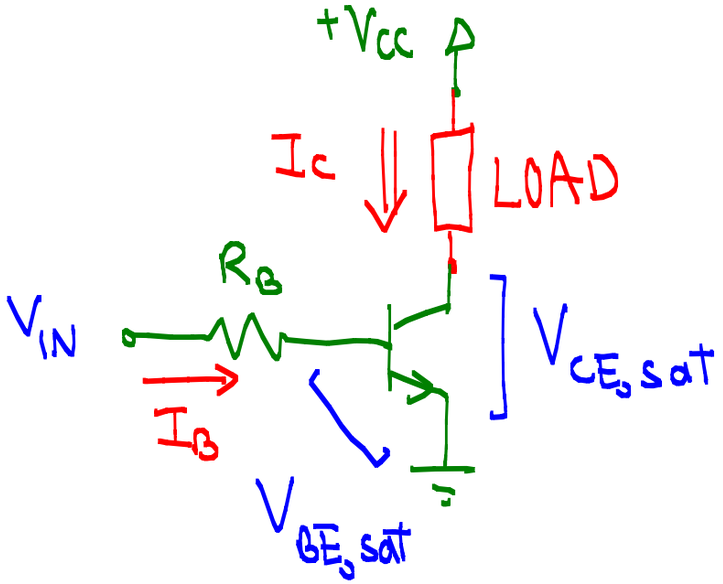
0. Review

Step 1 Know your load: Current, voltage, etc

★

Step 2 Wisely choose the transistor

↳ check max I_c, max V_{CE}, T_J



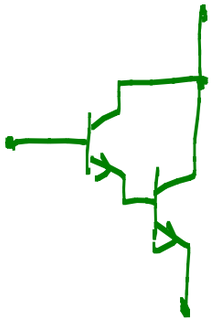
Step 3 Properly saturate the transistor

Ⓐ $V_{CE} = V_{CE,sat}$

Ⓑ $I_B \approx \frac{I_c}{10}$ or $I_B \approx \frac{I_c}{250}$

single BJT

Darlington

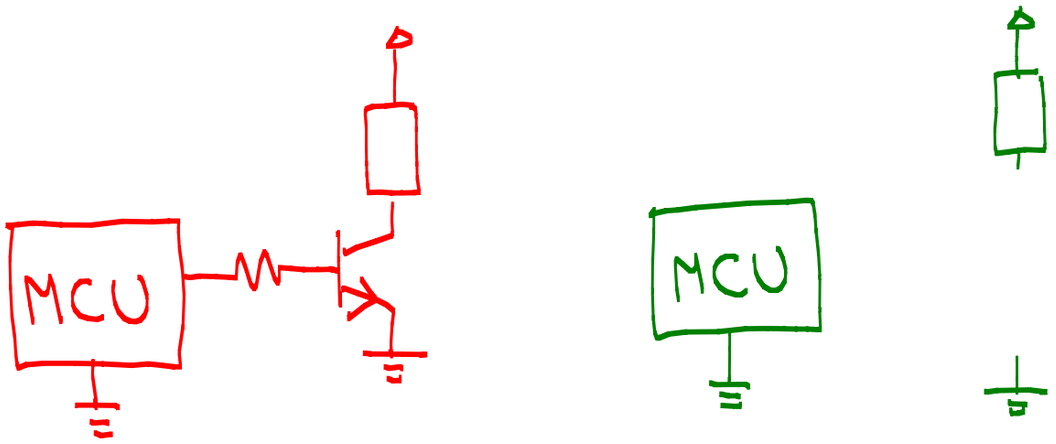


1. MOSFET Intro

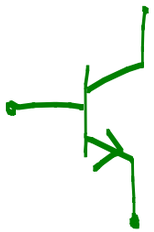
- BJT switches are very useful, but some issues to consider:

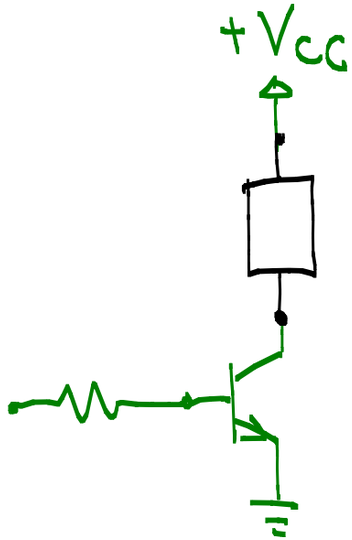
① Base Current

② Power Dissipation

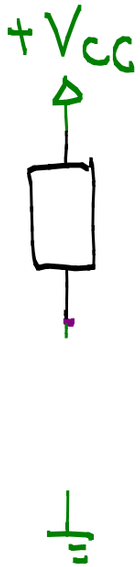


BJT:





- Control
- Load
- Mode



MOSFET:

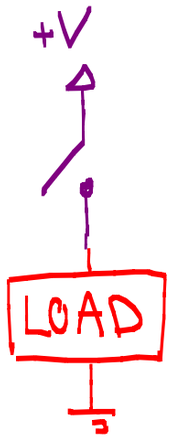
- Control

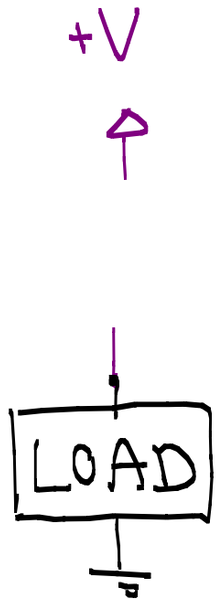
- Load

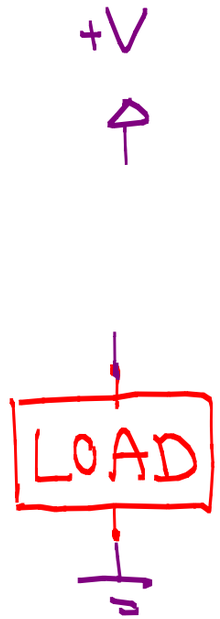
- Mode

Low-side vs. High-side Switch

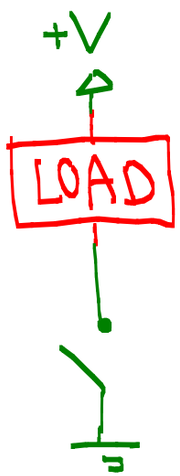
High-side (p-ch)

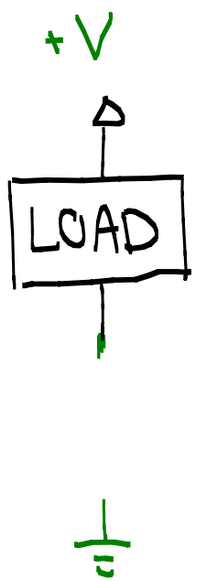


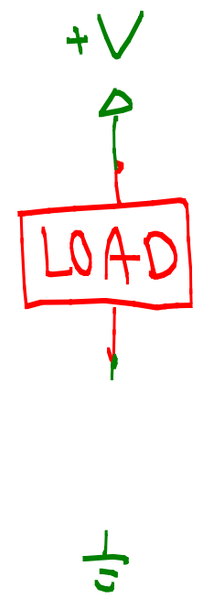




Low-side (n-ch)

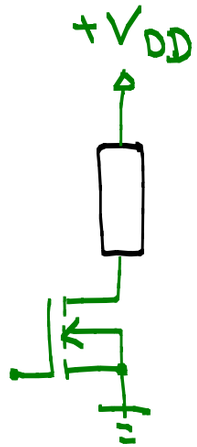






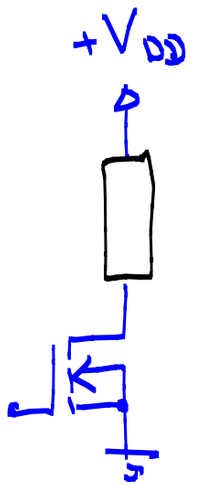
- MOSFET Properties : 2 major ones

Small signal MOSFET

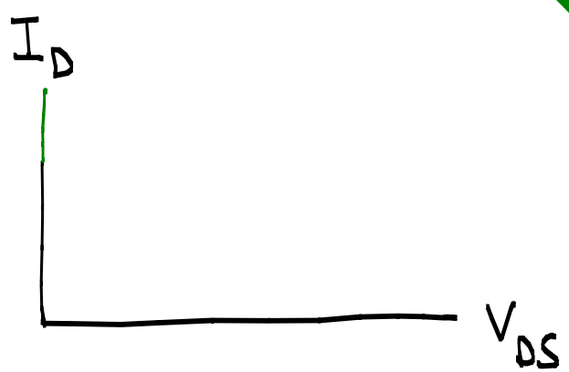


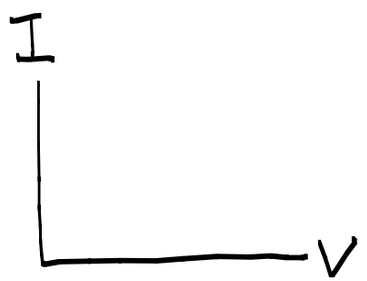
(1)

Power MOSFET



(2)



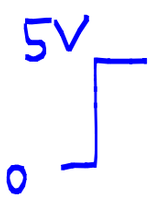


Q: How to convert 0-5V logic to higher voltage (e.g. 10V)?

A: Make a _____ using...

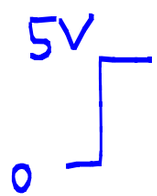
One MOSFET

Example:



Two MOSFETs

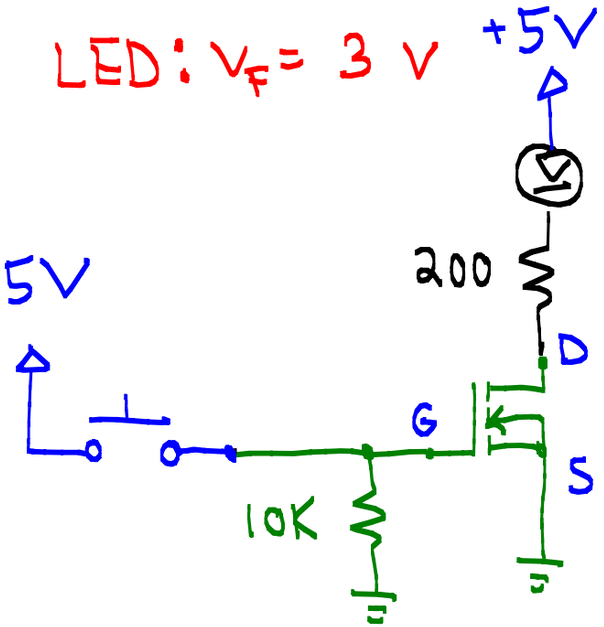
Example:



2. MOSFET Switch Analysis ECE248 Style

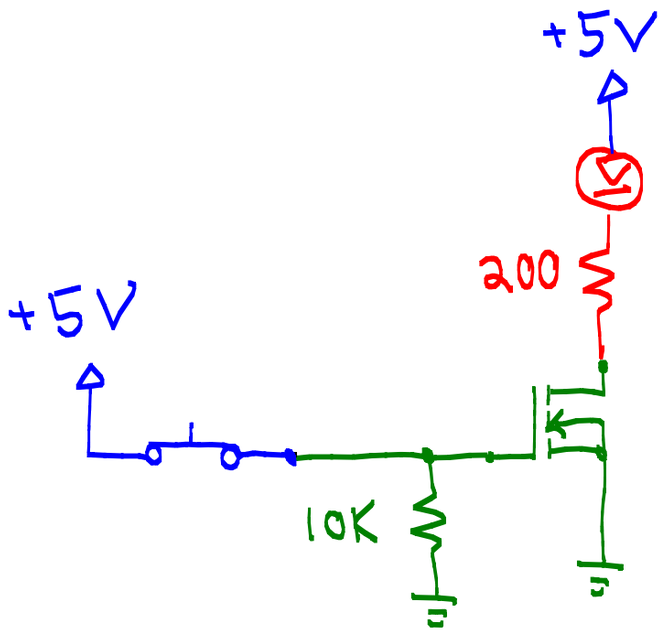
- Example: LED Driver

MOSFET Properties: $V_{GS,TH} = 2.4V$, $R_{DS,ON} = 3\Omega$ { $V_{GS} = 5V$, $I_{D,ON} = 250mA$



- open push button:

- Closed push button:



ECE 363 style analysis

- MOSFET data sheet has a plot like this:

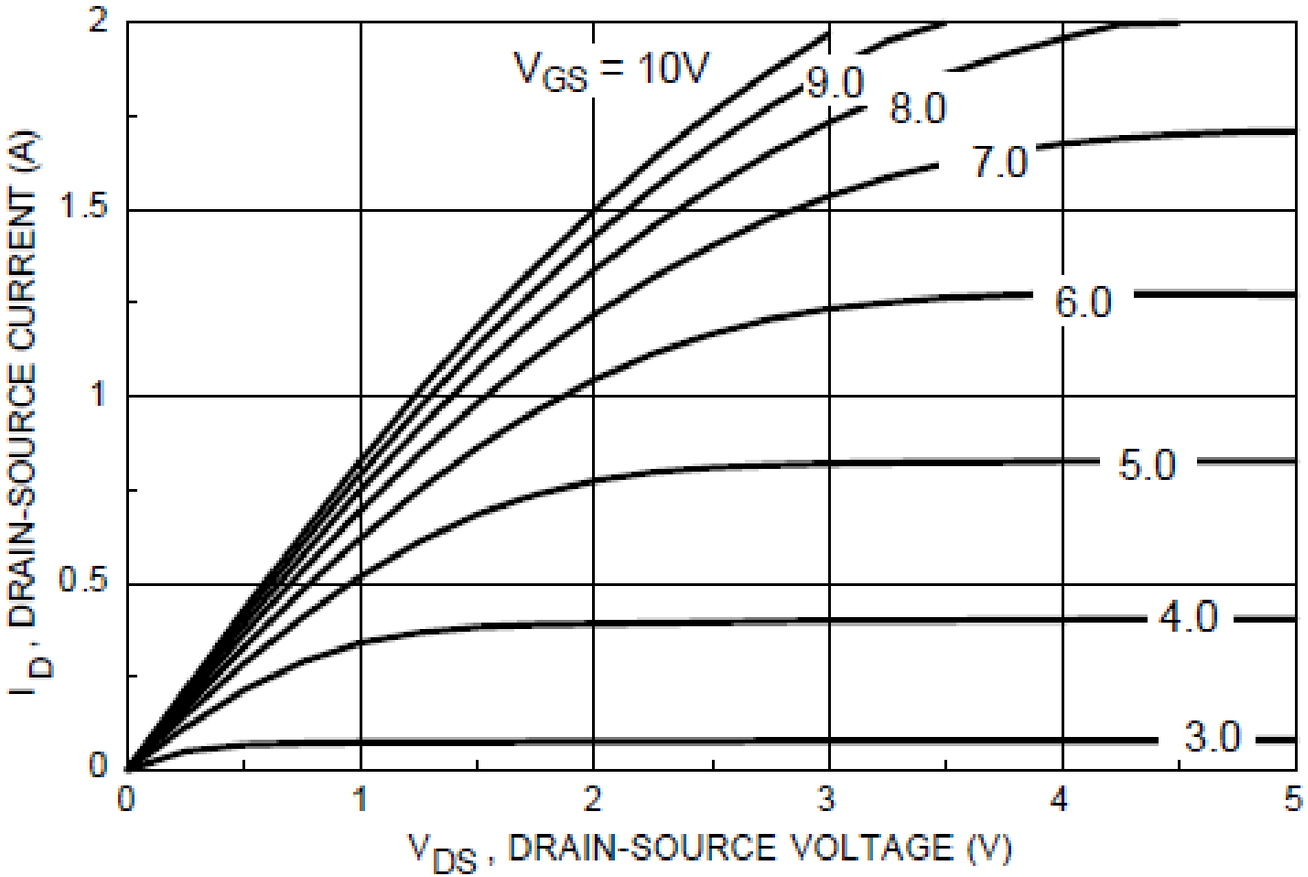
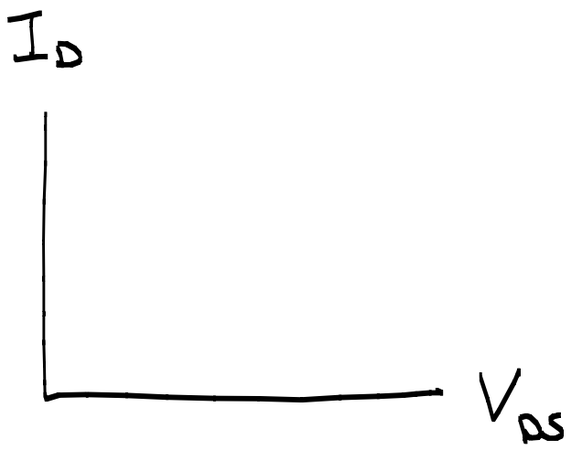


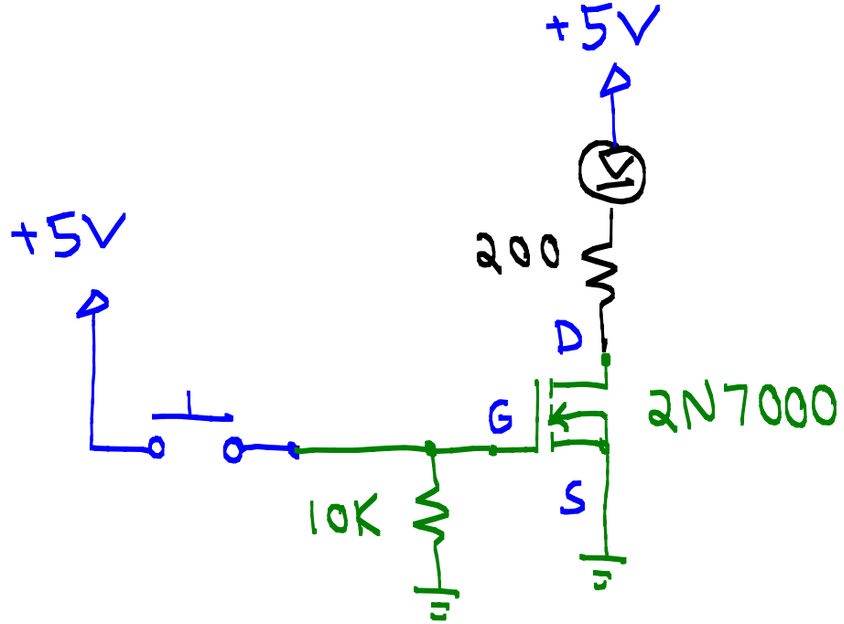
Figure 1. On-Region Characteristics



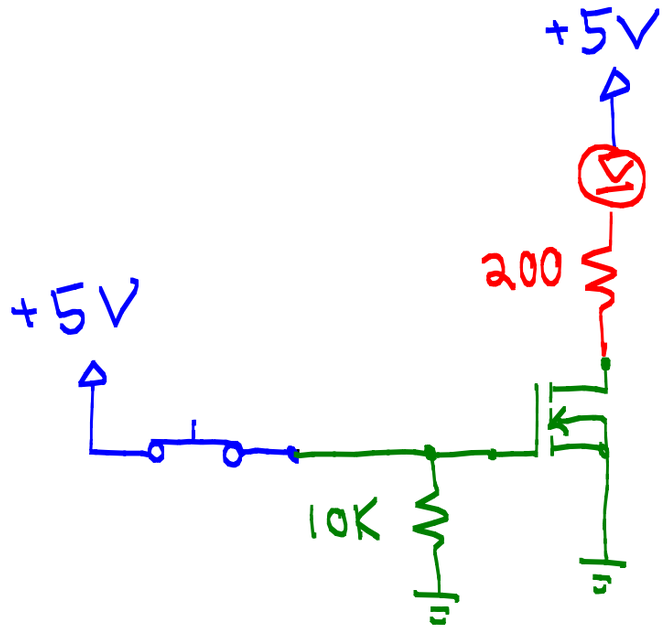
- From data sheet:

  $V_{GS,TH}$ = , $R_{DS,ON}$ =

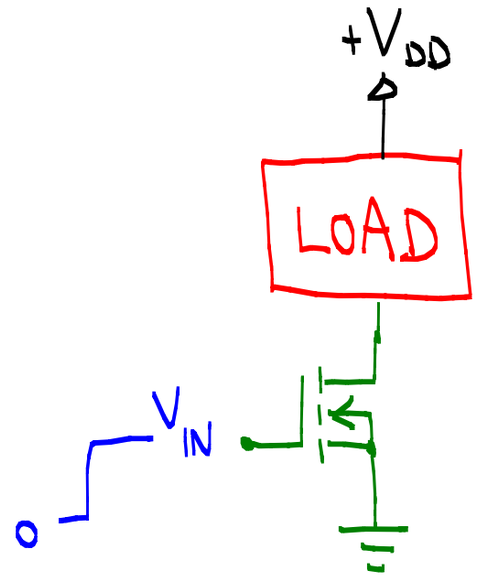
- Push button open:



- Push button closed:



3. MOSFET switch design



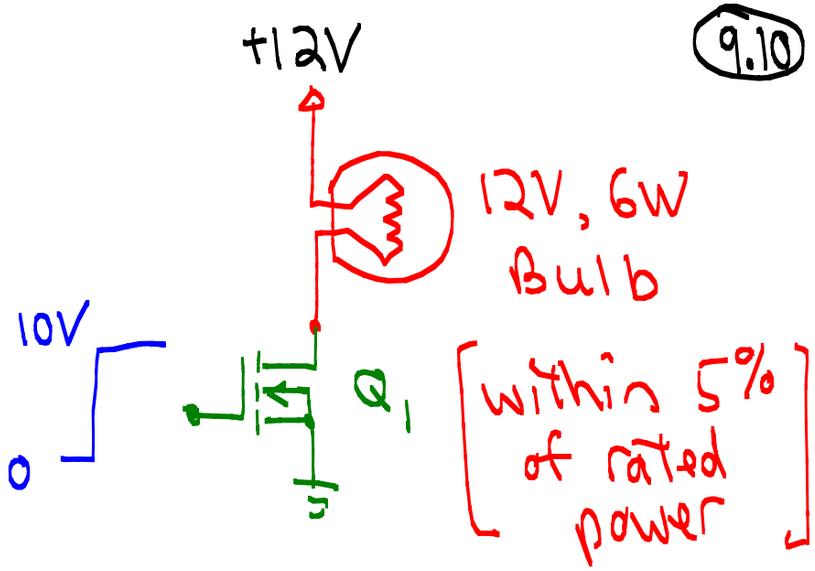
STEP 1

STEP 2

STEP 3

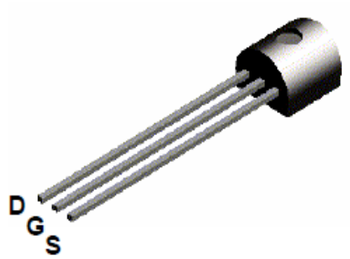
- **Design example using typical properties:**

STEP 1 Load properties

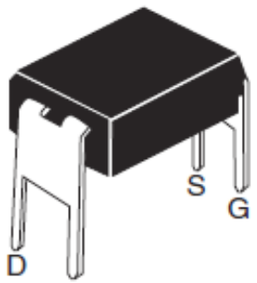


STEP 2 Choose MOSFETs

Q_1:



TO-92
2N7000

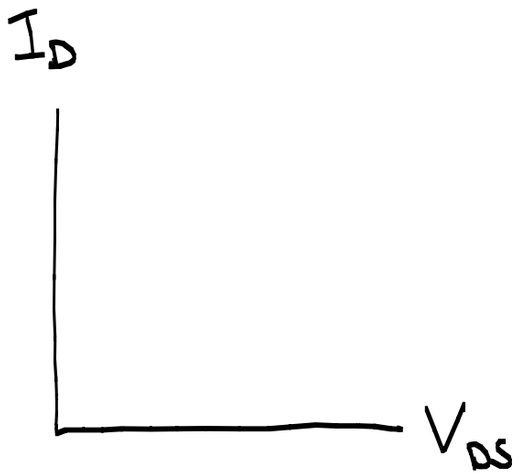


	Max I_D	V_{GS}	V_{DS}	Rated P (no HS)	Rated P (w/HS)
2N7000	200mA	±20V	60V	0.4W	
IRFD120	1.3A	±20V	100V	1.3W	

- Threshold V_{GS} :

SPECIFICATIONS (T_J = 25 °C, unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
Static						
Drain-Source Breakdown Voltage	V_{DS}	V_{GS} = 0 V, I_D = 250 µA	100	-	-	V
V_{DS} Temperature Coefficient	$\Delta V_{DS}/T_J$	Reference to 25 °C, I_D = 1 mA	-	0.13	-	V/°C
Gate-Source Threshold Voltage	$V_{GS(th)}$	V_{DS} = V_{GS}, I_D = 250 µA	2.0	-	4.0	V
Gate-Source Leakage	I_{GSS}	V_{GS} = ± 20 V	-	-	± 100	nA
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 100 V, V_{GS} = 0 V	-	-	25	µA
		V_{DS} = 80 V, V_{GS} = 0 V, T_J = 150 °C	-	-	250	
Drain-Source On-State Resistance	$R_{DS(on)}$	V_{GS} = 10 V; I_D = 0.78 A[b]	-	-	0.27	Ω

Typical $R_{DS,on}$ @ V_{GS} = 10V :



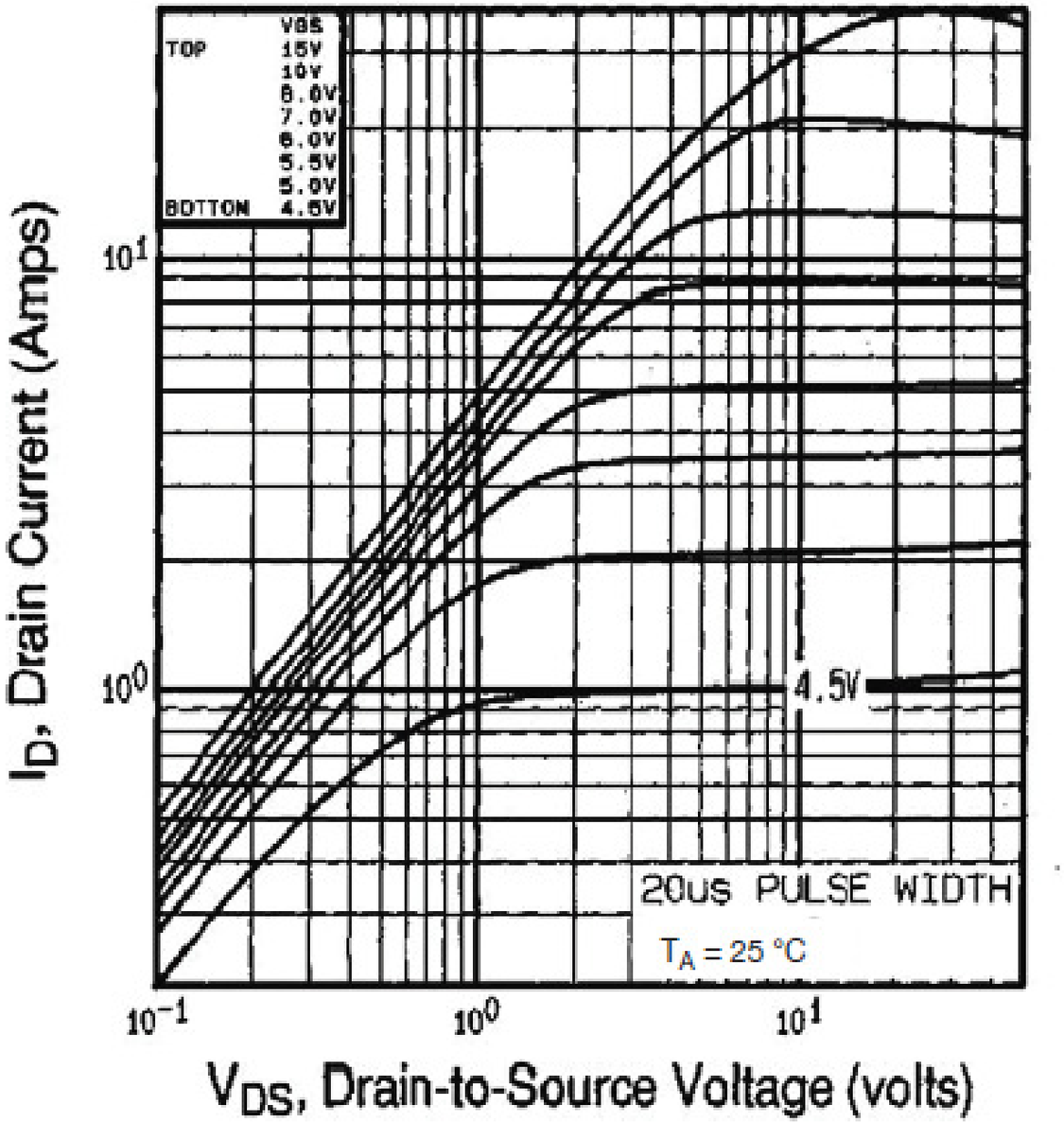


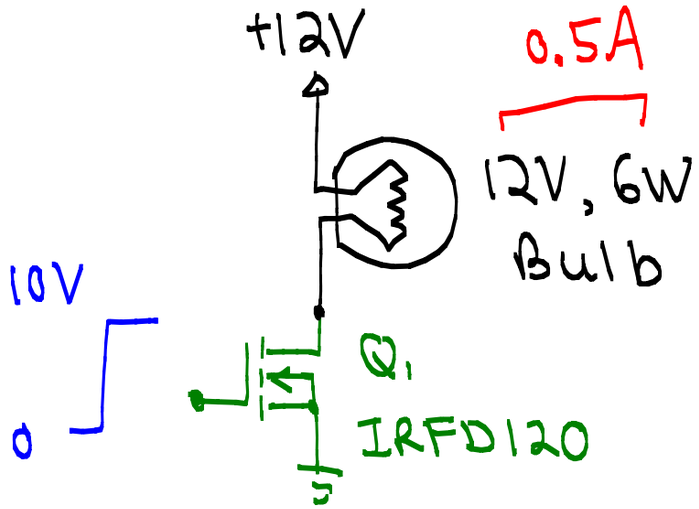
Fig. 1 - Typical Output Characteristics, T_A = 25 °C

- $V_{GS} = 10V$

$I_D =$

$P =$

$T_J =$



STEP 3 Confirm operation