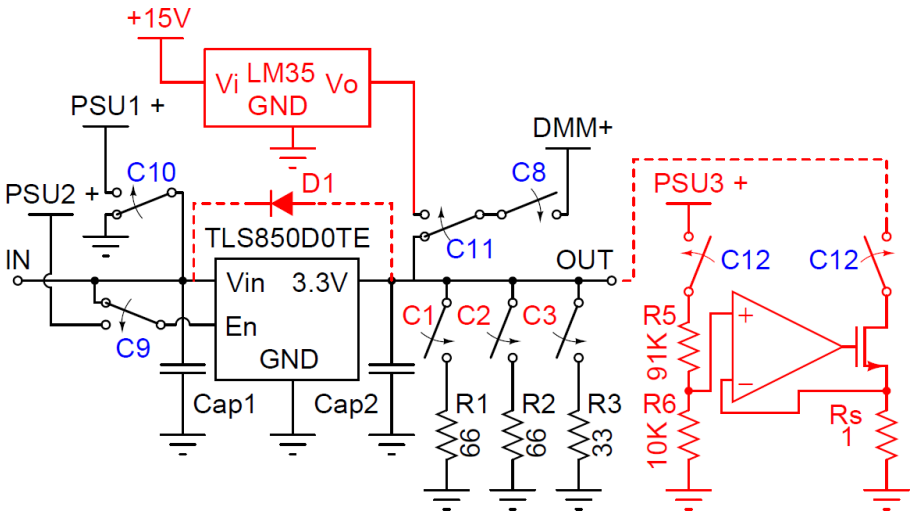
https://www.markdownguide.org/cheat-sheet/ (https://www.markdownguide.org/cheat-sheet/)

Testarea Automată a Circuitelor

--- Îndrumar de Laborator ---

Lucrarea nr. 3_1 - Tensiunea de iesire a unui LDO vs tensiunea de alimentare

3.1.1 Montajul experimental:



3.1.2 Procedura de masurare:

In circuit este conectat un stabilizatorul linear de 3.3V, TLS850D0TE (datasheet). Sarcina de la iesirea circuitului si tensiunea de “Enable” pot fi configurate. Prin actionearea lui C8 canalul 1 al sursei de tensiune este conectat la intrarea circ iesirea acestuia. C1 – Conecteaza la iesire un resistor de 66 ohmi (50mA) C2 – Conecteaza la iesire un resistor de 66 ohmi (50mA) C3 – Conecteaza la iesire un resistor de 33 ohmi (100mA) C9 – Deconecteaza intrarea “Enable” de la Can si o conecteaza la canalul 2 (PSU2).

Multimetrul măsoară tensiunea de iesire a stabilizatorului LDO. Tensiunea de alimentare poate fi monitorizata cu sursa de alimentare. Se variaza tensiunea de alimentare si se masoara tensiunea de iesire.

3.2 Codul sursa:

3.2.1 Initializarea instrumentelor si a interfetelor grafice

In [ ]:
```
#using TIVM; # libraria responsabila de comunicatia cu instrumentele si cu interfetele grafice(front panels)
#using Plots; # libraria responsabila de generarea de grafice
#using DataFrames; #
#using CSV; # libraria responsabila de salvarea datelor in format .csv
```

In [1]:
```
find_resources()
```

```
Found RIGOL TECHNOLOGIES,DS1104Z Plus,DS1ZD231200355,00.04.04.SP4 on address: USB0::0x1AB1::0x04CE::DS1ZD231200355::INSTR
Found GW.Inc,GDM-8246,FW2.01 on address: ASRL1::INSTR
Found TIVM Relays v0.1 on address: ASRL8::INSTR
Found GW.Inc,PST-3201,I180077 ,FW1.00 on address: ASRL9::INSTR
```

In [1]:
```
dmm_handle = connect!("ASRL1::INSTR")
psu_handle = connect!("ASRL9::INSTR")
relays_handle = connect!("ASRL8::INSTR")
relays = TIVM.Relays(relays_handle);
#fgen = connect!("ASRL4::INSTR")
#scope = connect!("USB0::0x0699::0x0364::C057729::INSTR")
dmm = TIVM.GDM8246(dmm_handle);
psu = TIVM.PST3201(psu_handle);
```

In [2]:
```
# Panouri frontale pentru instrumente
#@async start_gui(psu_handle = psu_handle, dmm_handle = dmm_handle, fgen_handle = fgen_handle, scope_handle = scope_handle)
@async start_gui(psu = psu, dmm = dmm);
```

3.2.2 Connfigurarea instrumentelor

In [25]:
```
# Sursa de tensiune
# C1
set_source_lev(psu, "C1", 0)
set_volt_protection(psu, "C1", 25)
set_max_curr(psu, "C1", 0.5)
# C2
set_source_lev(psu, "C2", 0)
set_volt_protection(psu, "C2", 25)
set_max_curr(psu, "C2", 0.5)
# C3
set_source_lev(psu, "C3", 0)
set_volt_protection(psu, "C3", 25)
set_max_curr(psu, "C3", 0.5)
# Output on
set_outp(psu, "C1", "on") # PST3201 nu poate porni/opri canale individual

# Multimetrul GDM8246
set_sense_func(dmm, "C1", "DCV") # alte functii: ACV, AC+DCV, RIPPLE, OHM
#set_sense_range_auto(dmm, "C1", "on") # autorange
set_sense_range(dmm, "C1", 10) # 10V range
```

In [44]:
```
set_state(relays,"C1","off")
set_state(relays,"C2","off")
set_state(relays,"C3","off")
set_state(relays,"C4","off")
set_state(relays,"C5","off")
set_state(relays,"C6","off")
set_state(relays,"C7","off")
set_state(relays,"C8","off")
set_state(relays,"C9","off")
set_state(relays,"C10","off")
set_state(relays,"C11","off")
```

3.2.3 Definirea stimulilor si a variabilelor auxiliare

In [34]:
```
volt_step = 0.1
volt_range = 1:volt_step:4
Vi_meas = []
Vo_meas = []
```

Out[34]: Any[]

3.2.4 Bucla de masurare

In [35]:
```
#R1
Vi_meas1 = []
Vo_meas1 = []
v1=0
v2=0
i1=0
i2=0
R=66
set_state(relays,"C10","on")
set_state(relays,"C8","on")
set_state(relays,"C1","on")
for crt_volt in volt_range
    # setare tensiune psu
    set_source_lev(psu, "C1", crt_volt)
    sleep(1) # sursa de tensiune si multimetrul raspund lent la comenzi
    # masurare tensiune cu dmm
    crt_Vo_meas = get_primary_measurement(dmm, "C1")
    crt_Io_meas=crt_Vo_meas/R
    # adaugarea masuratorilor in vectorii de rezultate
    push!(Vi_meas1, crt_volt)
    push!(Vo_meas1, crt_Vo_meas)
    @info "Vi_meas1=$crt_volt, Vo_meas1=$crt_Vo_meas"

    if(crt_volt<2.3)
        v1=crt_volt-crt_Vo_meas
        i1=crt_Io_meas
    end
        if(crt_volt<3.1)
        v2=crt_volt-crt_Vo_meas
        i2=crt_Io_meas
    end
end
```

```
┌ Info: Vi_meas1=1.0, Vo_meas1=0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=1.1, Vo_meas1=-0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=1.2, Vo_meas1=-0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=1.3, Vo_meas1=0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=1.4, Vo_meas1=0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=1.5, Vo_meas1=-0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=1.6, Vo_meas1=-0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=1.7, Vo_meas1=0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=1.8, Vo_meas1=0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=1.9, Vo_meas1=0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=2.0, Vo_meas1=0.0
└ @ Main In[35]:22
┌ Info: Vi_meas1=2.1, Vo_meas1=2.06
└ @ Main In[35]:22
┌ Info: Vi_meas1=2.2, Vo_meas1=2.16
└ @ Main In[35]:22
┌ Info: Vi_meas1=2.3, Vo_meas1=2.257
└ @ Main In[35]:22
┌ Info: Vi_meas1=2.4, Vo_meas1=2.353
└ @ Main In[35]:22
┌ Info: Vi_meas1=2.5, Vo_meas1=2.456
└ @ Main In[35]:22
┌ Info: Vi_meas1=2.6, Vo_meas1=2.557
└ @ Main In[35]:22
┌ Info: Vi_meas1=2.7, Vo_meas1=2.653
└ @ Main In[35]:22
┌ Info: Vi_meas1=2.8, Vo_meas1=2.755
└ @ Main In[35]:22
┌ Info: Vi_meas1=2.9, Vo_meas1=2.854
└ @ Main In[35]:22
┌ Info: Vi_meas1=3.0, Vo_meas1=2.951
└ @ Main In[35]:22
┌ Info: Vi_meas1=3.1, Vo_meas1=3.051
└ @ Main In[35]:22
┌ Info: Vi_meas1=3.2, Vo_meas1=3.151
└ @ Main In[35]:22
┌ Info: Vi_meas1=3.3, Vo_meas1=3.251
└ @ Main In[35]:22
┌ Info: Vi_meas1=3.4, Vo_meas1=3.35
└ @ Main In[35]:22
┌ Info: Vi_meas1=3.5, Vo_meas1=3.314
└ @ Main In[35]:22
┌ Info: Vi_meas1=3.6, Vo_meas1=3.314
└ @ Main In[35]:22
┌ Info: Vi_meas1=3.7, Vo_meas1=3.314
└ @ Main In[35]:22
┌ Info: Vi_meas1=3.8, Vo_meas1=3.315
└ @ Main In[35]:22
┌ Info: Vi_meas1=3.9, Vo_meas1=3.315
└ @ Main In[35]:22
┌ Info: Vi_meas1=4.0, Vo_meas1=3.315
└ @ Main In[35]:22
```

In [37]:
```
v1


```

Out[37]: 0.040000000000000036

In [38]:
```
i1
```

Out[38]: 0.03272727272727273

In [39]:
```
v2
```

Out[39]: 0.04899999999999993

In [40]:
```
i2
```

Out[40]: 0.04471212121212121

In [41]:
```
ESR1=(v2-v1)/(i2-i1)
```

Out[41]: 0.7509481668773621

In [42]:

```
#R1+R2
Vi_meas2 = []
Vo_meas2 = []
v1=0
v2=0
i1=0
i2=0
R=33
set_state(relays,"C10","on")
set_state(relays,"C8","on")
set_state(relays,"C1","on")
set_state(relays,"C2","on")
for crt_volt in volt_range
    # setare tensiune psu
    set_source_lev(psu, "C1", crt_volt)
    sleep(1) # sursa de tensiune si multimetrul raspund lent la comenzi
    # masurare tensiune cu dmm
    crt_Vo_meas = get_primary_measurement(dmm, "C1")
    crt_Io_meas=crt_Vo_meas/R
    # adaugarea masuratorilor in vectorii de rezultate
    push!(Vi_meas2, crt_volt)
    push!(Vo_meas2, crt_Vo_meas)
    @info "Vi_meas2=$crt_volt, Vo_meas2=$crt_Vo_meas"
     if(crt_volt<2.3)
        v1=crt_volt-crt_Vo_meas
        i1=crt_Io_meas
    end
        if(crt_volt<3.1)
        v2=crt_volt-crt_Vo_meas
        i2=crt_Io_meas
    end
end
```

```
┌ Info: Vi_meas2=1.0, Vo_meas2=-0.0
└ @ Main In[42]:23
┌ Info: Vi_meas2=1.1, Vo_meas2=-0.0
└ @ Main In[42]:23
┌ Info: Vi_meas2=1.2, Vo_meas2=0.0
└ @ Main In[42]:23
┌ Info: Vi_meas2=1.3, Vo_meas2=-0.0
└ @ Main In[42]:23
┌ Info: Vi_meas2=1.4, Vo_meas2=0.0
└ @ Main In[42]:23
┌ Info: Vi_meas2=1.5, Vo_meas2=0.0
└ @ Main In[42]:23
┌ Info: Vi_meas2=1.6, Vo_meas2=0.0
└ @ Main In[42]:23
┌ Info: Vi_meas2=1.7, Vo_meas2=0.0
└ @ Main In[42]:23
┌ Info: Vi_meas2=1.8, Vo_meas2=-0.0
└ @ Main In[42]:23
┌ Info: Vi_meas2=1.9, Vo_meas2=0.0
└ @ Main In[42]:23
┌ Info: Vi_meas2=2.0, Vo_meas2=0.147
└ @ Main In[42]:23
┌ Info: Vi_meas2=2.1, Vo_meas2=2.016
└ @ Main In[42]:23
┌ Info: Vi_meas2=2.2, Vo_meas2=2.116
└ @ Main In[42]:23
┌ Info: Vi_meas2=2.3, Vo_meas2=2.212
└ @ Main In[42]:23
┌ Info: Vi_meas2=2.4, Vo_meas2=2.307
└ @ Main In[42]:23
┌ Info: Vi_meas2=2.5, Vo_meas2=2.408
└ @ Main In[42]:23
┌ Info: Vi_meas2=2.6, Vo_meas2=2.508
└ @ Main In[42]:23
┌ Info: Vi_meas2=2.7, Vo_meas2=2.603
└ @ Main In[42]:23
┌ Info: Vi_meas2=2.8, Vo_meas2=2.704
└ @ Main In[42]:23
┌ Info: Vi_meas2=2.9, Vo_meas2=2.802
└ @ Main In[42]:23
┌ Info: Vi_meas2=3.0, Vo_meas2=2.899
└ @ Main In[42]:23
┌ Info: Vi_meas2=3.1, Vo_meas2=2.997
└ @ Main In[42]:23
┌ Info: Vi_meas2=3.2, Vo_meas2=3.096
└ @ Main In[42]:23
┌ Info: Vi_meas2=3.3, Vo_meas2=3.194
└ @ Main In[42]:23
┌ Info: Vi_meas2=3.4, Vo_meas2=3.292
└ @ Main In[42]:23
┌ Info: Vi_meas2=3.5, Vo_meas2=3.312
└ @ Main In[42]:23
┌ Info: Vi_meas2=3.6, Vo_meas2=3.313
└ @ Main In[42]:23
┌ Info: Vi_meas2=3.7, Vo_meas2=3.313
└ @ Main In[42]:23
┌ Info: Vi_meas2=3.8, Vo_meas2=3.313
└ @ Main In[42]:23
┌ Info: Vi_meas2=3.9, Vo_meas2=3.313
└ @ Main In[42]:23
┌ Info: Vi_meas2=4.0, Vo_meas2=3.314
└ @ Main In[42]:23
```

In [43]:

```
ESR2=(v2-v1)/(i2-i1)
```

Out[43]:

```
0.7164750957854368
```

In [46]:
```
#Electronic Load
Vi_meas3 = []
Vo_meas3 = []
v1=0
v2=0
i1=0
i2=0
set_state(relays,"C10","on")
set_state(relays,"C8","on")
set_state(relays,"C12","on")
set_source_lev(psu, "C3", 1.8)
for crt_volt in volt_range
    # setare tensiune psu
    set_source_lev(psu, "C1", crt_volt)
    sleep(1) # sursa de tensiune si multimetrul raspund lent la comenzi
    # masurare tensiune cu dmm
    crt_Vo_meas = get_primary_measurement(dmm, "C1")
    crt_Io_meas = get_meas(psu,"C1","current")#curentul de pe canalul1
    # adaugarea masuratorilor in vectorii de rezultate
    push!(Vi_meas3, crt_volt)
    push!(Vo_meas3, crt_Vo_meas)
    @info "Vi_meas3=$crt_volt, Vo_meas3=$crt_Vo_meas"
     if(crt_volt<2.3)
        v1=crt_volt-crt_Vo_meas
        i1=crt_Io_meas
    end
        if(crt_volt<3.1)
        v2=crt_volt-crt_Vo_meas
        i2=crt_Io_meas
    end
end
```

```
┌ Info: Vi_meas3=1.0, Vo_meas3=0.001
└ @ Main In[46]:22
┌ Info: Vi_meas3=1.1, Vo_meas3=0.001
└ @ Main In[46]:22
┌ Info: Vi_meas3=1.2, Vo_meas3=0.0
└ @ Main In[46]:22
┌ Info: Vi_meas3=1.3, Vo_meas3=0.0
└ @ Main In[46]:22
┌ Info: Vi_meas3=1.4, Vo_meas3=0.001
└ @ Main In[46]:22
┌ Info: Vi_meas3=1.5, Vo_meas3=0.001
└ @ Main In[46]:22
┌ Info: Vi_meas3=1.6, Vo_meas3=0.001
└ @ Main In[46]:22
┌ Info: Vi_meas3=1.7, Vo_meas3=0.0
└ @ Main In[46]:22
┌ Info: Vi_meas3=1.8, Vo_meas3=0.001
└ @ Main In[46]:22
┌ Info: Vi_meas3=1.9, Vo_meas3=0.001
└ @ Main In[46]:22
┌ Info: Vi_meas3=2.0, Vo_meas3=0.001
└ @ Main In[46]:22
┌ Info: Vi_meas3=2.1, Vo_meas3=1.851
└ @ Main In[46]:22
┌ Info: Vi_meas3=2.2, Vo_meas3=1.96
└ @ Main In[46]:22
┌ Info: Vi_meas3=2.3, Vo_meas3=2.068
└ @ Main In[46]:22
┌ Info: Vi_meas3=2.4, Vo_meas3=2.172
└ @ Main In[46]:22
┌ Info: Vi_meas3=2.5, Vo_meas3=2.28
└ @ Main In[46]:22
┌ Info: Vi_meas3=2.6, Vo_meas3=2.384
└ @ Main In[46]:22
┌ Info: Vi_meas3=2.7, Vo_meas3=2.486
└ @ Main In[46]:22
┌ Info: Vi_meas3=2.8, Vo_meas3=2.592
└ @ Main In[46]:22
┌ Info: Vi_meas3=2.9, Vo_meas3=2.695
└ @ Main In[46]:22
┌ Info: Vi_meas3=3.0, Vo_meas3=2.797
└ @ Main In[46]:22
┌ Info: Vi_meas3=3.1, Vo_meas3=2.901
└ @ Main In[46]:22
┌ Info: Vi_meas3=3.2, Vo_meas3=3.004
└ @ Main In[46]:22
┌ Info: Vi_meas3=3.3, Vo_meas3=3.108
└ @ Main In[46]:22
┌ Info: Vi_meas3=3.4, Vo_meas3=3.209
└ @ Main In[46]:22
┌ Info: Vi_meas3=3.5, Vo_meas3=3.309
└ @ Main In[46]:22
┌ Info: Vi_meas3=3.6, Vo_meas3=3.315
└ @ Main In[46]:22
┌ Info: Vi_meas3=3.7, Vo_meas3=3.316
└ @ Main In[46]:22
┌ Info: Vi_meas3=3.8, Vo_meas3=3.316
└ @ Main In[46]:22
┌ Info: Vi_meas3=3.9, Vo_meas3=3.316
└ @ Main In[46]:22
┌ Info: Vi_meas3=4.0, Vo_meas3=3.316
└ @ Main In[46]:22
```

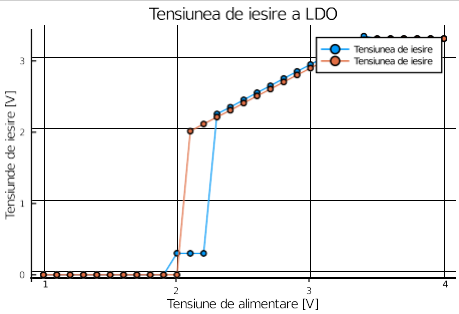
In [ ]:
```

```

```
3.2.5 Oprirea instrumentelor
```

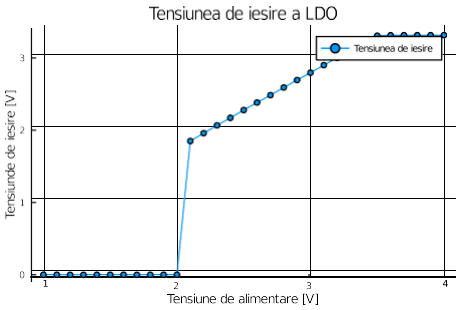
In [18]:
```
set_source_lev(psu, "C1", 0)
set_source_lev(psu, "C2", 0)
set_source_lev(psu, "C3", 0)
set_outp(psu, "C1", "off") # PST3201 nu poate porni/opri canale individual
```

3.2.6 Generarea caracteristicii Vo vs Vi a LDO-ului

In [31]:
```
h=plot(Vi_meas1, Vo_meas1; markershape=:circle, label="Tensiunea de iesire");
h=plot!(Vi_meas2, Vo_meas2; markershape=:circle, label="Tensiunea de iesire");
title!("Tensiunea de iesire a LDO");
xlabel!("Tensiune de alimentare [V]");
ylabel!("Tensiunde de iesire [V]");
display(h)
```



In [47]:
```
#Load plot
h=plot(Vi_meas3, Vo_meas3; markershape=:circle, label="Tensiunea de iesire");

title!("Tensiunea de iesire a LDO");
xlabel!("Tensiune de alimentare [V]");
ylabel!("Tensiunde de iesire [V]");
display(h)
```



In [49]:
```
i1
```

Out[49]: 0.175

3.2.7 Salvarea datelor in fisierul .csv

In [8]:
```
df = DataFrame("Tensiune de alimentare [V]" => Vi_meas, "Tensiunde de iesire [V]" => Vo_meas)
CSV.write("0003_LDO_Vo_vs_Vi.csv", df; append=false)
```

Out[8]: "0003_LDO_Vo_vs_Vi.csv"

3.2.8 Deconectarea instrumentelor

In [13]:
```
disconnect!(dmm_handle)
disconnect!(psu_handle)
```

Out[13]: 0

3.3 Desfasurarea lucrarii:

In [1]:
```
1. Mariti precizia masuratorilor
2. Masurati caracteristica tensiunii de iesire fata de tensiunea de intrare pentru 2 curenti de sarcina diferiti. Introduceti datele in acelasi fisier CSV.
Indicatie: Se realizeaza o noua masuratoare; vectorii in care vor fi introduse datele au nume diferit; se introduce o noua coloana pentru curentul de sarcina

df = DataFrame("I" => "0", "Tensiune de alimentare [V]" => Vi_meas, "Tensiune de iesire [V]" => Vo_meas)
CSV.write("0003_LDO_Vo_vs_Vi_new.csv", df)

Df1 = DataFrame("I" => "50mA", "Tensiune de alimentare [V]" => Vi_meas1, "Tensiune de iesire [V]" => Vo_meas1)

CSV.write("0003_LDO_Vo_vs_Vi_new.csv", df1, append = true)

3. Masurati pragurile de „Enable” si histerezisul.
Indicatie: Se mentine tensiunea de intrare fixa (PSU CH1, de ex. 8V), si se aplica o rampa de tensiune pe pinul de enable intre 0-2V (PSU CH2). Pentru a determina cele doua praguri, rampa
4. Repetati masuratoarea de la punctul 3 pentru cazul in care sarcina este diferita de 0. Ce observati?
5. Masurati rezistenta serie a elementului regulator.
Indicatie: Pentru a masura rezistenta serie, se iau o pereche curent/tensiune in „dropout”(atunci cand tensiunea de la iesirea regulatorului este mai mica decat cea nominala); se masoara
6. Masurati rezistenta serie utilizand sursa de curent
```

```
syntax: extra token "Mariti" after end of expression

Stacktrace:
 [1] top-level scope at In[1]:1
 [2] include_string(::Function, ::Module, ::String, ::String) at .\loading.jl:1091
```