Chapter 1: LDO (TPS7A4901)

Experiment 2: Impact of line and load conditions on the efficiency.

Test 1: Impact of load current and line voltage (at low V_{IN}) on efficiency

Objective: You will configure the design in WEBENCH and record the appropriate operating values to report the corresponding efficiency at several input voltage and output current combinations and record in Table 1 below.

Efficiency is calculated per the formula below:

$$\eta\ \% = (V_{OUT} I_{OUT})/(V_{IN} I_{IN}) \times 100$$

However, we must remember that Input Current equals all the current that flows to the output plus all the current that flows into ground.

Thus, to use the values from the WEBENCH Op Values, the equation will look like this:

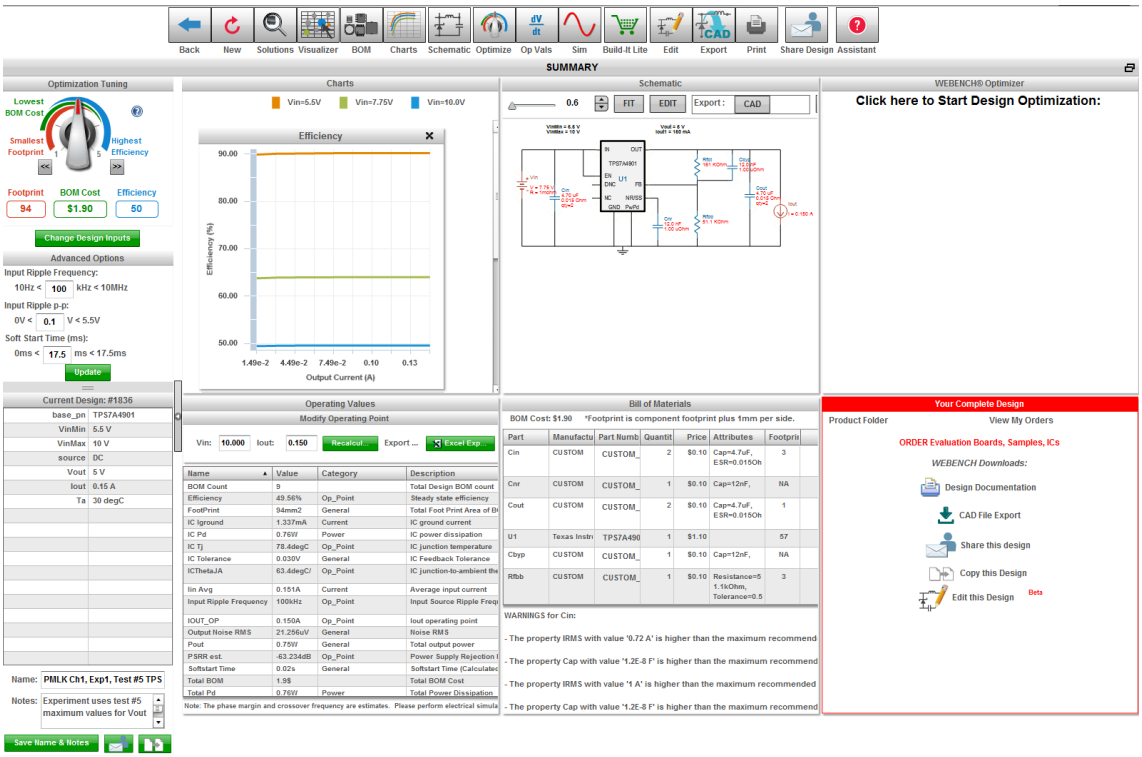
$$\eta\ \% = (V_{OUT\ Actual\ x}\ I_{OUT\ OP})/(V_{IN\ OP\ x}\ I_{IN\ Avg}) \times 100$$

$$\text{where } I_{IN}\ AVG = I_{OUT\ OP} + IC\ I_{ground}$$

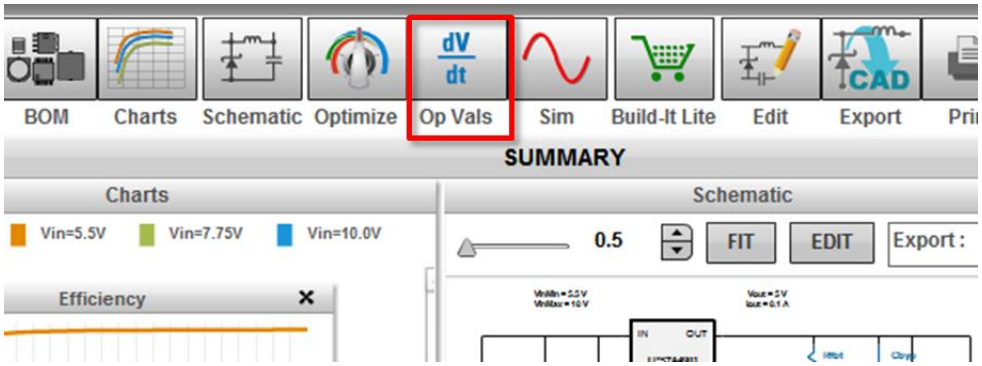
We have to calculate I_{IN} AVG from the two operating values ($I_{OUT\ OP}$ + IC I_{ground}) because the value for $I_{OUT\ OP}$ in WEBENCH does not have enough decimal places to show the included ground current. (You will notice $I_{OUT\ OP}$ in 'Amps' and IC I_{ground} in 'microAmps' so be sure and remember this when adding the two numbers together)

You will then produce a report and use as pre-work for lab measurements

1. Click on the link to open the TPS7A4901 design in WEBENCH® Power Designer. You may be required to login or register for your my.ti.com account to access WEBENCH.
2. Your design will be ready within WEBENCH Power Designer configured for this experiment.



3. Select the **Op Vals** icon at the top of the window to view the operating values.



4. In the '**Modify Operating Point**' window, enter 8V for Vin and 0.025 for Iout and **Recalculate**.

5. Read the values from the **Operating Values** table and enter them into Table 1: I_{OUT} OP, IC Iground, V_{OUT} Actual, and Efficiency. Calculate I_{IN} AVG from the equation below and enter into Table 1. Then calculate efficiency from the equation using the WEBENCH Op Values and enter that into Table 1 and compare that to the efficiency read from the Op Vals table. You may see a slight difference and this is due to the fact that WEBENCH uses V_{OUT} Op to calculate efficiency and we will use the V_{OUT} Actual voltage in our equation. Try to think of why the efficiency numbers are different.

Again, efficiency is calculated as follows:

$$\eta\ \% = (V_{OUT}I_{OUT})/(V_{IN}I_{IN}) \times 100$$

To use the values from the WEBENCH Op Values, the equation will look like this:

$$\eta\ \% = (V_{OUT\ Actual} \times I_{OUT\ OP})/(V_{IN\ OP} \times I_{IN\ AVG}) \times 100$$

$$\text{where } I_{IN}\ AVG = I_{OUT\ OP} + \text{IC } I_{ground}$$

Modify Operating Point

Vin: 8 Iout: 0.025 Recalculate Export to: Excel Export

Name	Value	Category	Description
BOM Count	9		Total Design BOM count
Efficiency	61.88%	Op_Point	Steady state efficiency
FootPrint	94mm2	General	Total Foot Print Area of BOM components
IC Iground	250.989uA	Current	IC ground current
IC Pd	0.07W	Power	IC power dissipation
IC Tj	34.9degC	Op_Point	IC junction temperature
IC Tolerance	0.030V	General	IC Feedback Tolerance
ICThetaJA	63.4degC/W	Op_Point	IC junction-to-ambient thermal resistance
Iin Avg	0.025A	Current	Average input current
Input Ripple Frequency	100kHz	Op_Point	Input Source Ripple Frequency for PSRR Calculation
IOUT_OP	0.025A	Op_Point	Iout operating point
Output Noise RMS	20.014uV	General	Noise RMS
Pout	0.12W	General	Total output power
PSRR est.	-63.234dB	Op_Point	Power Supply Rejection Ratio, estimated
Softstart Time	0.02s	General	Softstart Time (Calculated)
Total BOM	1.9$		Total BOM Cost
Total Pd	0.07W	Power	Total Power Dissipation
Vin p-p	0.100V	Op_Point	Input Source ripple voltage
VIN_OP	8.000V	Op_Point	Vin operating point
Vout Actual	4.931V	General	Vout Actual calculated based on selected voltage divider resistors
Vout OP	5.000V	Op_Point	Operational Output Voltage
Vout p-p	68.914uV	Op_Point	Peak-to-peak output ripple voltage
Vout Tolerance	2.27%	General	Vout Tolerance based on IC Tolerance and voltage divider resistors if applicable

I_{OUT} OP (A) IC Iground (A) $I_{IN\ AVG}$ (A)	I_{OUT} (A)					
$V_{OUT\ Actual}$ (V) η (%) from Op Vals η (%) calculated	0.025	0.050	0.075	0.100	0.125	0.150
V_{IN} = 8V						
V_{IN} = 10V						

Table 1: Efficiency of TPS7A4901 vs load current/input voltage for Vout = 5V
(make this table large and on one page for printing out)

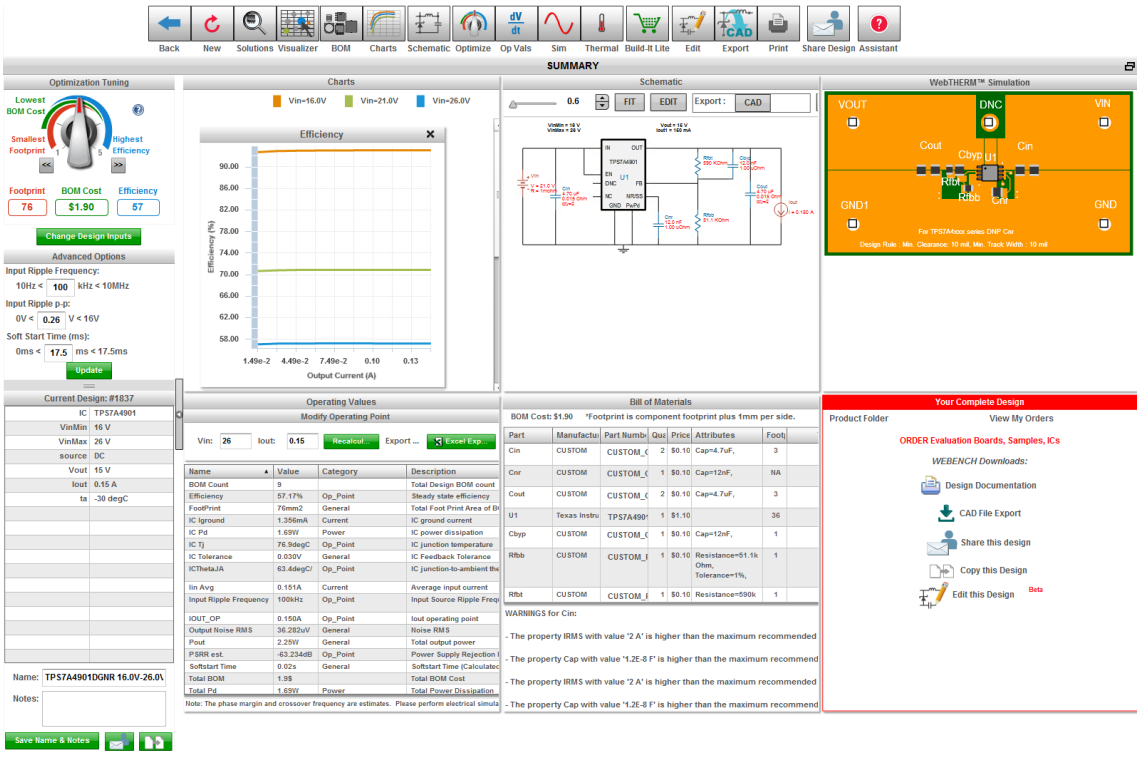
6. Continue as with Step 4 in the same manner until you recorded the values for all combinations of input voltage and output current.

Test 2: Impact of load current and line voltage (high Vin) on efficiency

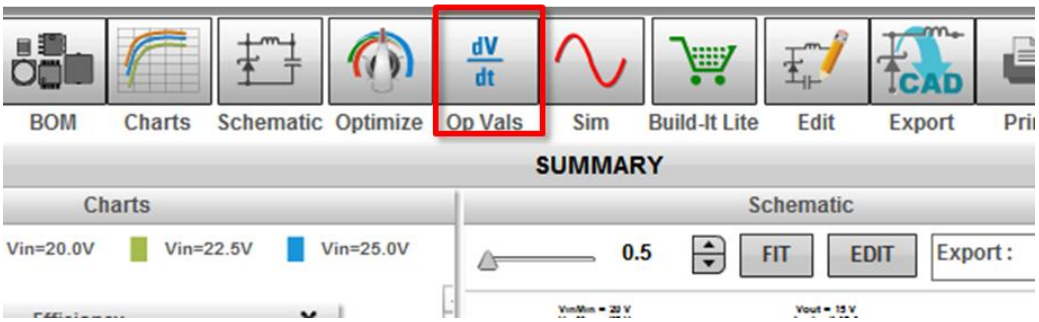
Objective: You will configure the design in WEBENCH and obtain the efficiency as calculated by WEBENCH, for several input voltage and output current combinations as shown in the Table 2 below.

You will then produce a report and use as pre-work for lab measurements and manual calculations.

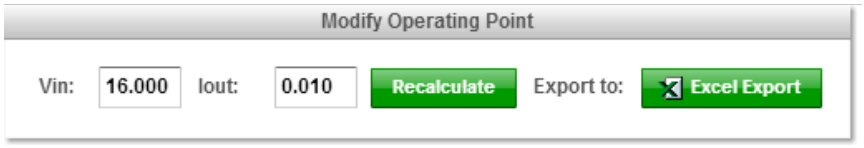
1. Click on the link to open the TPS7A4901 design in WEBENCH® Power Designer
2. Your design will be ready within WEBENCH Power Designer configured for this experiment. Note: this design has been configured with a -30 degree C ambient temperature so the design does not exceed the temperature limits within the tool.



3. Select the **Op Vals** icon at the top of the window to view the operating values.



4. In the **Operating Values Window** window, enter 16V for Vin and 0.010A for Iout and **Recalculate**.



5. Read the values from the **Operating Values** table and enter them into Table 2: I_{OUT} OP, IC Iground, V_{OUT} Actual, Efficiency, and Total Pd. Calculate I_{IN} AVG from the equation below and enter into Table 2. Then calculate efficiency from the equation using the WEBENCH Op Values and enter that into Table 2.

   Again, efficiency is calculated as follows:

$$\eta\ \% = (V_{OUT}I_{OUT})/(V_{IN}I_{IN}) \times 100$$

   To use the values from the WEBENCH Op Values, the equation will look like this:

$$\eta\ \% = (V_{OUT\ Actual} \times I_{OUT\ OP})/(V_{IN\ OP} \times I_{IN}\ AVG) \times 100$$

$$\text{where } I_{IN}\ AVG = I_{OUT\ OP} + IC\ I_{ground}$$

6. Continue in the same manner as with Step 4 and complete the table.

Modify Operating Point

Vin: 16 Iout: 0.01 Recalculate Export to: Excel Export

Name	Value	Category	Description
BOM Count	9		Total Design BOM count
Efficiency	92.55%	Op_Point	Steady state efficiency
FootPrint	76mm2	General	Total Foot Print Area of BOM components
IC Iground	129.636uA	Current	IC ground current
IC Pd	0.01W	Power	IC power dissipation
IC Tj	-29.234degC	Op_Point	IC junction temperature
IC Tolerance	0.030V	General	IC Feedback Tolerance
ICThetaJA	63.4degC/W	Op_Point	IC junction-to-ambient thermal resistance
Iin Avg	0.010A	Current	Average input current
Input Ripple Frequency	100kHz	Op_Point	Input Source Ripple Frequency for PSRR Calculation
IOUT_OP	0.010A	Op_Point	Iout operating point
Output Noise RMS	34.892uV	General	Noise RMS
Pout	0.15W	General	Total output power
PSRR est.	-46.311dB	Op_Point	Power Supply Rejection Ratio, estimated
Softstart Time	0.02s	General	Softstart Time (Calculated)
Total BOM	1.9$		Total BOM Cost
Total Pd	0.01W	Power	Total Power Dissipation
Vin p-p	0.260V	Op_Point	Input Source ripple voltage
VIN_OP	16.000V	Op_Point	Vin operating point
Vout Actual	14.905V	General	Vout Actual calculated based on selected voltage divider resistors
Vout OP	15.000V	Op_Point	Operational Output Voltage
Vout p-p	1.257mV	Op_Point	Peak-to-peak output ripple voltage
Vout Tolerance	2.47%	General	Vout Tolerance based on IC Tolerance and voltage divider resistors if applicable

I_{OUT} OP (A) IC Iground (A) $I_{IN\ AVG}$ (A) $V_{OUT\ Actual}$ (V) η (%) calculated	V_{IN}					
P_d loss (W)	16V	18V	20V	22V	24V	26V
IOUT = 10mA						
IOUT = 50mA						

Table 2: Efficiency and Power Loss of TPS7A4901 at V_{OUT} = 15V

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