

Appendix C. LDO SINK for the HP 48 Calculator

The following program, written for the HP 48 calculator, will calculate all power dissipation and heat sink related parameters and ease your design optimization process. It will also graph the resulting heat sink characteristics versus input voltage. The program listing follows the user information. It was written on a HP 48S and runs on both the "S" and the 48G(X) version of the calculator. If you would like to receive the program electronically, send e-mail to Micrel at apps@micrel.com and request program "LDO SINK for the HP48". It will be sent via return e-mail.

Using LDO SINK

After loading the program, change to the directory containing it. In the example shown, it is loaded into {HOME MICREL LDO SINK}.

The first screen you will see looks like this:

```
{ HOME MICREL LDO SINK }
```

```
4:
3:
2:
1:
FIRST DTIN REVW GRAF  $\theta$ SA HELP
```

Pressing the white HELP function key displays a screen of on-line help.

```
Regulator Thermals
HELP file
Press FIRST to begin.
DTIN is DaTaINput
RE VW is REView data
GRA F shows  $\theta$ sa
SOLVR solves numericly
FIRST DTIN REVW GRAF  $\theta$ SA HELP
```

Pressing either FIRST or DTIN will start the program and prompt you for the most commonly changed data. REVW brings up a list of data already entered. GRAF draws the heat sink θ_{SA} versus input

voltage. SOLVR begins the built-in solve routine that allows you to solve for any variable numerically.

Let's run the program. Press FIRST to begin. Your screen shows:

```
Regulator Thermals
Enter data, then press
← CONT

FIRST DTIN REVW GRAF  $\theta$ SA HELP
```

After a brief pause, the output voltage prompt appears:

```
Vout=3.30?

4:
3:
2:
1: 3.30
FIRST DTIN REVW GRAF  $\theta$ SA HELP
```

Enter a new number and press ← CONT to continue. If the data previously entered is still correct, you may simply press ← CONT to retain it. Proceed through the list, entering data as prompted and pressing ← CONT to continue. You will be prompted for

- Vout the desired regulator output voltage
- Iout regulator output current
- Vmax the maximum input voltage
- Vmin the lowest input voltage (used only by the graphing routine)
- θ_{jc} thermal resistance, junction to case (from the device data sheet)
- θ_{cs} thermal resistance from the case to the heat sink

After these data are entered, the Review screen appears and confirms your entries.

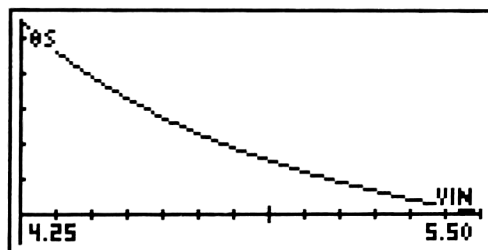
```

==Regulator Thermals==
Output V: 3.30
Output I: 3.00
Vin: 5.50
 $\theta_{jc}$ : 2.00
 $\theta_{cs}$ : 0.50
Ambient Temp: 50.00°C
GRAF SOLVR REVW VMAX VMIN NEXT

```

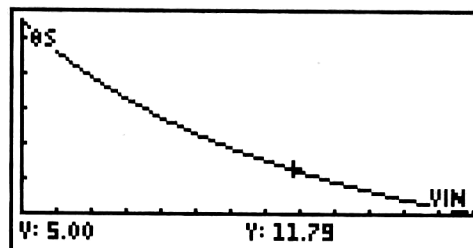
Ambient temperature was not on the list of prompted data. If you wish to change it, press ON (CANCEL) followed by the white NEXT key. Enter the ambient temperature followed by the white TA key. Press the white NEXT key twice to get to the calculation menu. Another variable used but not prompted for is TJM, the maximum junction temperature for the regulator.

You may now press GRAF to calculate and view the θ_{sa} versus Vin graph, or SOLVR to start the numerical solve routine. If we press GRAF, the following is displayed:



This shows the thermal resistance of the heat sink as the input voltage varies from a low of 4.25V to a high of 5.50V. Pressing ON/CANCEL at this time returns you to the stack display, with θ_{sa} at the maximum input voltage displayed.

NOTE: the x-axis is shown beneath the HP 48 graph menu. Press the minus (–) key to toggle between the menu and axis display. Pressing TRACE followed by (X,Y) puts the HP 48 in trace mode and displays the coordinate values of the plot. Press the cursor keys to move around the plot and show voltage (V) versus θ_{sa} and displays the coordinate values of the plot. Press the cursor keys to move around the plot and show voltage (V) versus θ_{sa} (y-axis). Here the cursor has been moved to a Vin of 5.00V and shows a required maximum θ_{sa} of 11.79 C/W.



Pressing ON/CANCEL returns you to the calculation menu. If you hit the white SOLVR key, the HP 48 Solve application is started and you may solve for any of the variables numerically.

```

EQ: 'theta_sa=(TJM-TA)/(( ...
4:
3:
2:
1:
 theta_sa | TJM | TA | Vin | VO | IO |
```

Enter a value and press its white function key to modify variables. Use the HP 48 NXT key to access θ_{jc} and θ_{cs} . Solve for a variable by pressing the ← key followed by the variable's white function key. Press → VIEW (HP 48G) or ← REVIEW (HP 48S) to review all variable values.

Program Listing

For those without the HP 48 compatible serial cable or e-mail access, here is the program listing for LDO SINK. "SINK" is installed as a directory. It is 1948.5 bytes long and has a checksum of # 35166d.

```

%%HP: T(1)A(D)F(.);
DIR
  FIRST
    << DTIN
    >>
  DTIN
    << CLLCD
  "Regulator Thermals
  Enter data, then press
  ← CONT"
  1 DISP 3 WAIT CLEAR
  VO "Vout=" VO + "?"
  + PROMPT 'VO' STO
  CLEAR IO "Iout=" IO

```

```

+ "?" + PROMPT 'IO'
STO CLEAR VMAX
"Vmax=" VMAX + "?"
+ PROMPT 'VMAX' STO
CLEAR VMIN "Vmin="
VMIN + "?" + PROMPT
'VMIN' STO CLEAR
θJC "θjc=" θJC +
"?" + PROMPT 'θJC'
STO CLEAR θCS
"θcs=" θCS + "?" +
PROMPT 'θCS' STO
RE VW
    »
    RE VW
    « CLLCD
    "==Regulator Thermals=="
1 DISP "Output V: "
VO + 2 DISP
"Output I: " IO + 3
DISP "Vin: "
VMAX VMAX 'VIN' STO
+ 4 DISP
"Ambient Temp: " TA
+ "°C" + 7 DISP
"θjc: " θJC +
5 DISP "θcs: "
θCS + 6 DISP NEX1
TMENU 3 FREEZE
    »
    GRAF
    « CLLCD
    "Regulator Thermals
    Graphing θsa vs Vin"
2 FIX 1 DISP '(TJM-
TA)/((1.02*VIN-VO)*
IO)-θJC-θCS' STEQ
FUNCTION 'VIN'
INDEP VMIN VMAX
XRNG VMIN VMAX
'VIN' STO EQ EVAL
R+C AXES { "Vin"
"θS" } AXES AUTO
ERASE DRAW DRAX
LABEL VMAX 'VIN'
STO EQ EVAL 1 TRNC
"θsa(min)" →TAG
PICTURE
    »
    θsa 1.19549150037
    HELP

```

```

« CLLCD
"Regulator Thermals
HELP file
Press FIRST to begin.
DTIN is DaTaINput
RE VW is REView data
GRAF shows θsa
SOLVR solves numerically"
1 DISP 3 FREEZE
    »
    NEX1 { GRAF {
    "SOLVR"
    « HS STEQ 30
MENU
    » } RE VW VMAX
VMIN { "NEXT"
    « NEX2 TMENU
    » } }
    NEX2 { VO IO VIN
TA TJM { "NEXT"
    « NEX3 TMENU
    » } }
    NEX3 { θJC θCS ""
"" HELP { "NEXT"
    « NEX1 TMENU
    » } }

```

Variables

```

θJC 2
VMAX 5.5
VMIN 4.25
HS 'θsa=(TJM-TA)/
((1.02*VIN-VO)*IO)-
θJC-θCS'
PPAR {
(4.25,6.47110814478)
(5.5,22.6889168766)
VIN 0 {
(4.25,8.5864745011)
"Vin" "θS" }
FUNCTION Y {
EQ 'θsa=(TJM-TA)/
((1.02*VIN-VO)*IO)-
θJC-θCS'
θCS .5
IO 6
VO 3.3
VIN 5.5
TJM 125
TA 75
END

```