

ON Semiconductor

Is Now

onsemi™

To learn more about onsemi™, please visit our website at
www.onsemi.com

onsemi and **onsemi** and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi** product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner. Other names and brands may be claimed as the property of others.



Is Now Part of



ON Semiconductor®

To learn more about ON Semiconductor, please visit our website at
www.onsemi.com

ON Semiconductor and the ON Semiconductor logo are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

AN-6010

FAN5069 Component Calculation and Simulation Tools

Background / Overview

This app note describes design tools for FAN5069, which include:

- An Excel workbook to calculate recommended external component values
- A continuous-time behavioral model of the modulator that runs in PSPICE A/D v 9.1 or above. The model is small enough to run under Cadence's Orcad Lite Edition (includes Orcad Capture and PSPICE A/D), which can be ordered on CD at <http://www.ema-eda.com> or downloaded from: <http://www.orcad.com>
Note: These links have been verified as of this publication date, but may change over time.

These design aids can be requested from:

<https://www.fairchildsemi.com/design/design-tools/pwm-uldo-controller-combo/>.

To install, copy AN-6010.ZIP to an empty folder (e.g. "FAN5069Design"), then unzip / extract AN-6010.ZIP into that folder.

This tool set applies to the following products:

FAN5069
[FAN5069 Product Folder](#)

Design Procedure

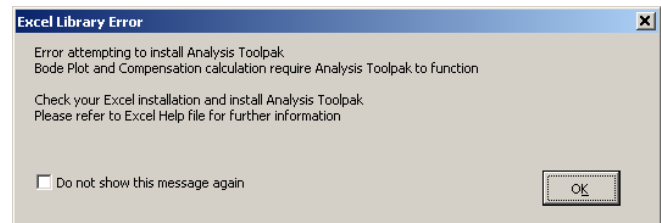
1. Use the spreadsheet (FAN5069 Design calculation aid.xls). The "**Instructions**" tab provides detailed instructions for the spreadsheet.
2. After completing the "**Component Selection**" tab, the regulator's small signal response can be viewed in the "Bode Plot" tab.
3. Verify transient and small signal stability using the PSPICE Simulation Model provided, using the components chosen in the "Component Selection" tab.

Note: There will be minor differences between the PSPICE and Spreadsheet bode plots. The PSPICE model has a more accurate representation of the IC.

Spreadsheet Start-up

The spreadsheet uses functions in Excel's Analysis ToolPak add-in to optimize compensation and installs it automatically if it is not already installed.

Some Excel installations may not have Analysis ToolPak included. If the following message appears, run Microsoft Office installation to make the Analysis ToolPak add-in available.



Consult your Microsoft Excel documentation for information should this error occur.

Macro Security Note

FAN5069 Design calculation aid.xls uses macros extensively. For the spreadsheet to operate properly, check the "Always trust macros from this source" box if a security warning appears, then click the **Enable Macros** button.

This is only required the first time you run a Fairchild spreadsheet tool with macros.

PSPICE Simulation Model

The simulation model is a sampled-data, continuous-time model, which is adapted from Ray Ridley and Dennis Feucht's modeling work for current mode controllers^{i, ii, iii}. The model provides a bode plot where the red trace is phase margin (in degrees) and the green trace is gain (in dB). The model also provides transient response using a pulsed current source (Istep) as the load. The IC's error-amp behavioral model is based on Ray Kendall's Macromodelling article in EDN.^{iv}

1. To run the model, start Capture (9.1 or higher).
2. Open FAN5069 PSpice Avg Model.opj.
3. Double-click on Page 1 under: \FAN5069 pspice avg model.dsn\Application.

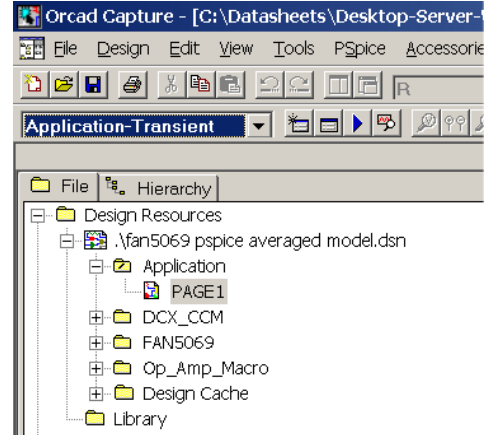


Figure 1. Project View

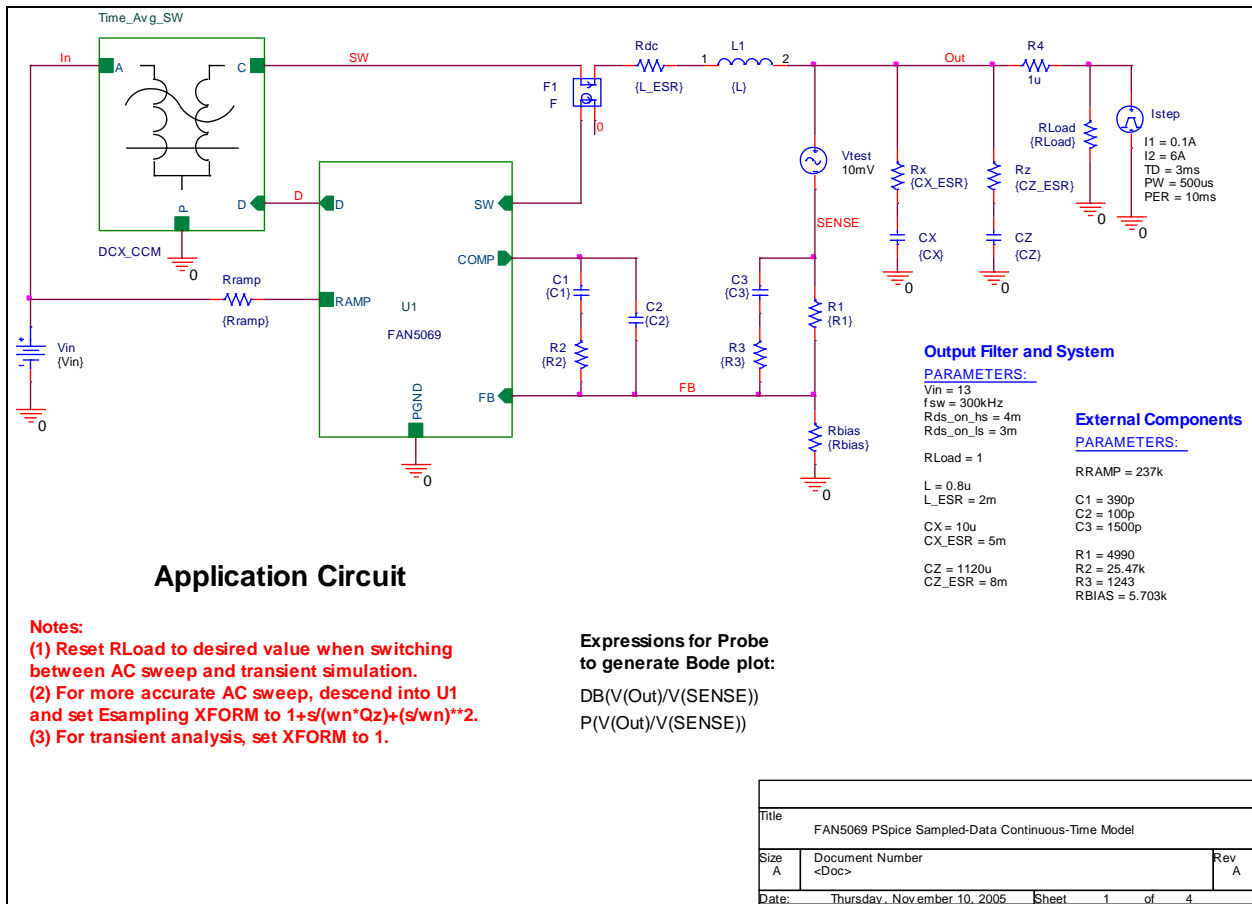


Figure 2. PSPICE behavioral model schematic for 1.5V output @ 300Khz

Note: The parameters for this model (from the results of the spreadsheet) are entered in the “Output Filter and System” and “External Components” parameter blocks on the lower left-hand corner of the schematic; there should be no need to edit the schematic itself.

4. Double click on any parameter in that block to set the values in the schematic.
5. Once the schematic is set up, press the F11 (function key) to display the bode plot.
6. To choose between bode plot (AC small signal) and transient response, select the simulation profile type from the drop-down box in the upper left corner.



Figure 3. Simulation profile select drop-down

Note: If you are simulating for transient response, be sure to set RLOAD appropriately. If you skip this step, the output and inductor current [I(L1)] traces may exceed the current limit of the IC. Example simulation outputs begin with Figure 8.

Note: When running transient response, be sure that the XFORM value in the ELAPLACE block inside U1 (the FAN5069 block) is set to 1. See detailed instructions below for setting this value.

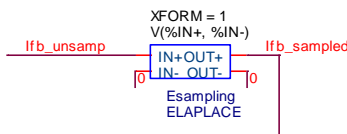


Figure 4. ELAPLACE block, XFORM parameter settings for Transient response

AC Sweep (Bode Plot) Tips

For maximum accuracy, define the Laplace block inside the FAN5069 sub-circuit.

1. Right click on U1 (FAN5069) and choose “Descend hierarchy.”
2. Double-click the text block above the ELAPLACE block whose value is: $1+s/(wn*Qz)+(s/wn)**2$.
3. Copy the entire text (CTRL-C) to the clipboard.
4. Close the text window, double-click the “XFORM” value, and paste the text from the clipboard into the value for XFORM (CTRL-V).

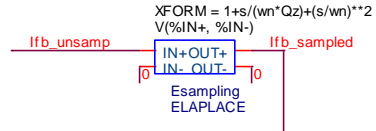


Figure 5. ELAPLACE block, XFORM parameter settings for Transient response

To obtain cross-over frequency and phase margin from the AC sweep plot (see Figure 8), turn on cursors (see Figure 6) then left-click the gain plot marker $DB(-U(Out)/U(Sense))$ in the lower left corner of the graph and right-click the phase plot marker $P(U(Out)/U(Sense))$, which establishes gain and phase as A1 and A2 respectively in the cursor window. Left-click, then right-click where gain crosses 0. A1 and A2 X values show the gain cross-over frequency and the A2 Y value displays phase margin.

Troubleshooting the Plot Window

Some older versions of PSPICE may not automatically load the probe settings (which are contained in the *.prb files). These settings define the XY axis settings, trace colors, and signals displayed. If you run a simulation and the probe window displays no traces, then click the “Add Traces” button as shown in Figure 6, and paste the following expressions for the signals.

Expressions for the bode plot:

Gain:	DB(-V(Out)/V(Sense))
Phase:	P(V(Out)/V(Sense))

The schematic also contains the expressions for the Bode plot in the “Bode Plot Instructions” in the schematic window, as shown in Figure 2.

Expressions for Transient response:

Output Voltage:	V(Out)
Load Current:	I(R4)
Inductor Current:	I(L1)

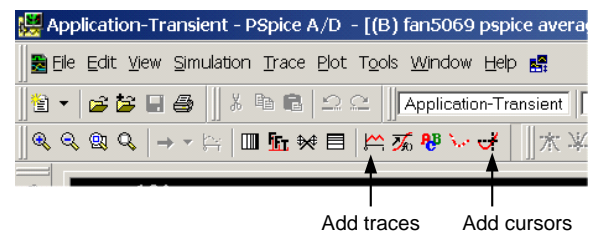


Figure 6. Probe window tips

FAN5069 Loop Gain Bode Plot

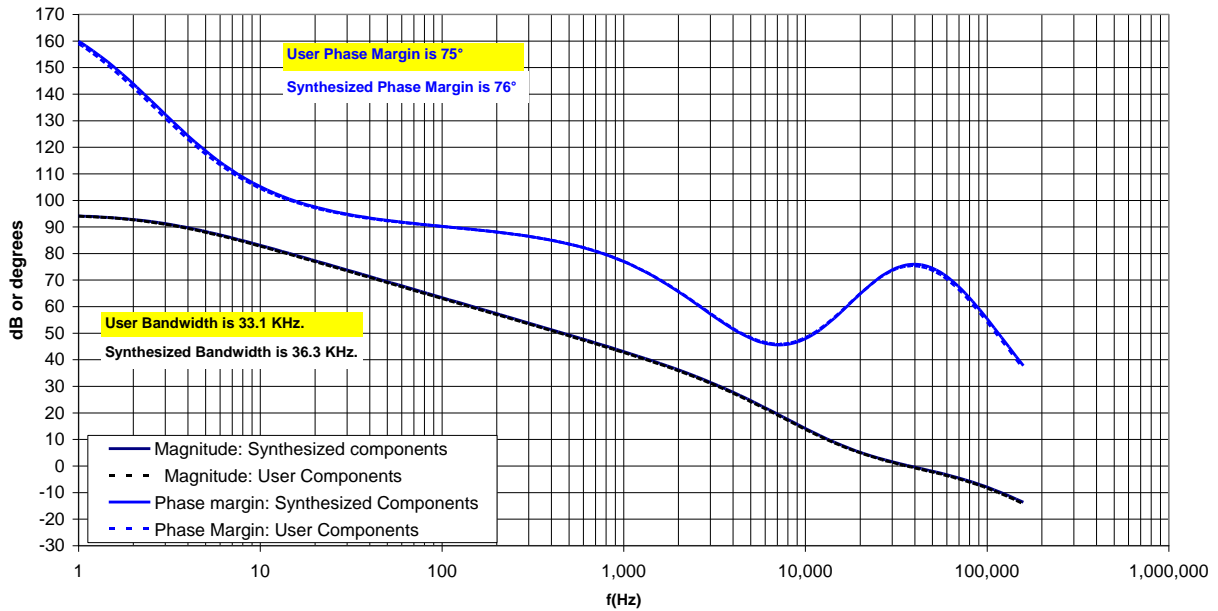


Figure 7. Bode plot from spreadsheet using Ckt values per Figure 2

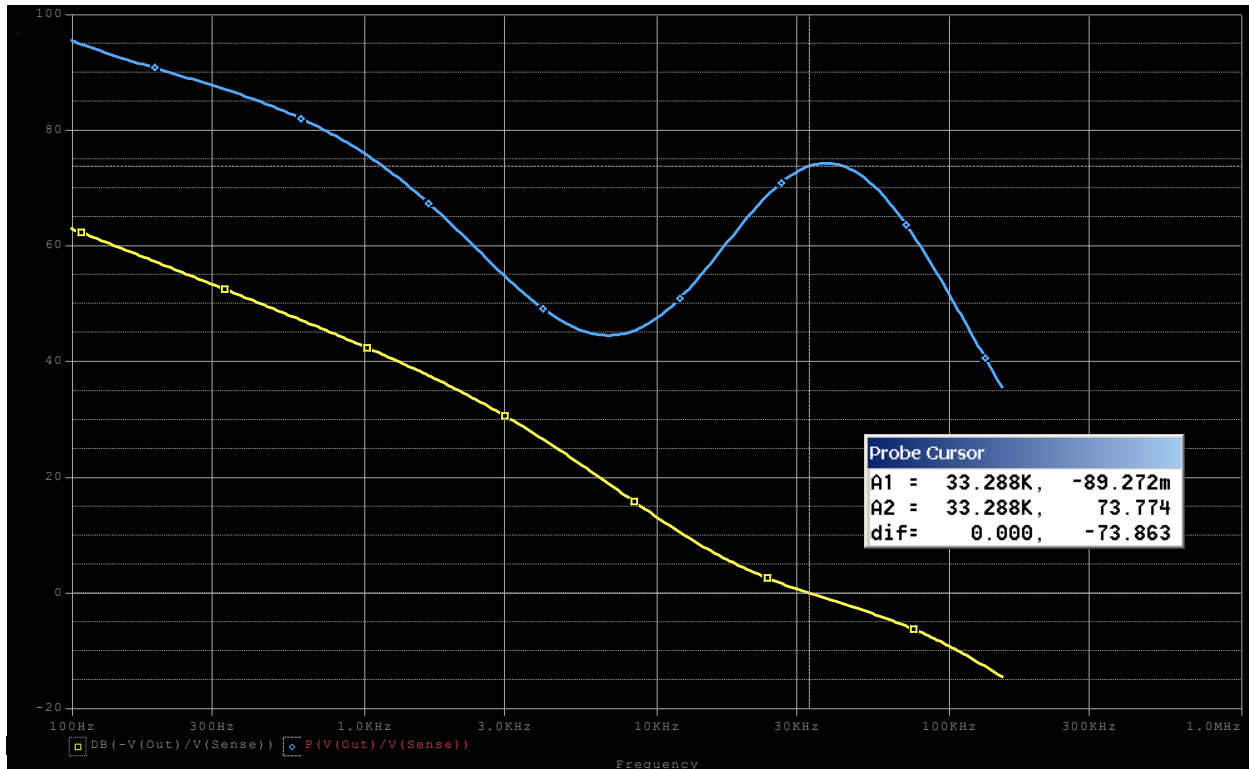


Figure 8. Bode plot response simulation result using Ckt values per Figure 2
 For probe window, A1 X value is the cross-over frequency and A2 Y value is phase margin

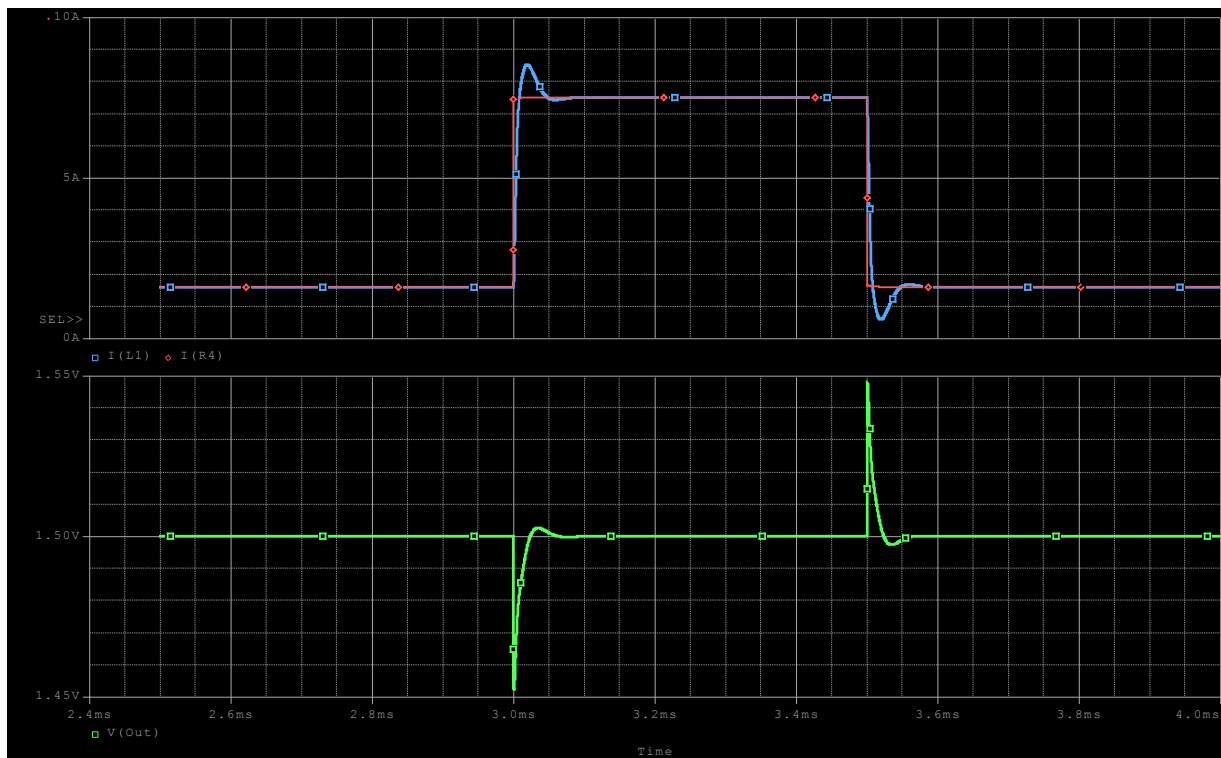


Figure 9. Transient response simulation result using Ckt values per Figure 2

References

- i Ray Ridley, *An Accurate and Practical Small-Signal Model for Current-Mode Control*, 1999, <http://www.ridleyengineering.com/downloads/curr.pdf>
- ii Dennis Feucht, *The Tymerski Switch Model*, <http://www.chipcenter.com/eexpert/dfeucht/dfeucht036.html>
- iii Dennis Feucht, *Basic Power Converter Configurations*, <http://www.chipcenter.com/eexpert/dfeucht/dfeucht037.html>
- iv Ray Kendall, *Modular macromodeling techniques for Spice simulators*, EDN, March 7, 2002

DISCLAIMER

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION, OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS.

LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF FAIRCHILD SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support, device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA
Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800-282-9855 Toll Free
USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center
Phone: 81-3-5817-1050

ON Semiconductor Website: www.onsemi.com
Order Literature: <http://www.onsemi.com/orderlit>
For additional information, please contact your local
Sales Representative