



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.

Application Note AN-3005

Design Fundamentals for Phototransistor Circuits

The common-emitter amplifier circuit (Fig. 1) generates an output which transitions from a high state to a low state when light in the near-infrared range is detected by the phototransistor. The wavelength range for light in the near-infrared region is about 700 nanometers (nm) to 1100 nm. The output is created by connecting a resistor between the voltage supply and the collector pin of the component. The output voltage is read at the terminal of the collector. It is called an amplifier circuit because the current generated in the component when light is detected is very small. However, the component has an internal amplifier (in this case a phototransistor) which magnifies this current to useful levels.

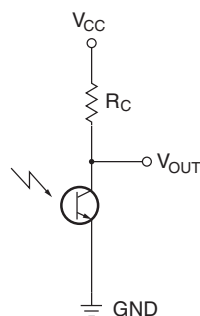


Figure 1. Common-Emitter Amplifier

The common-collector amplifier (Fig. 2) generates an output which transitions from a low state to a high state when IR light is detected by the phototransistor. The output is created by connecting a resistor between the emitter pin of the component and ground. The output is read at the emitter terminal.

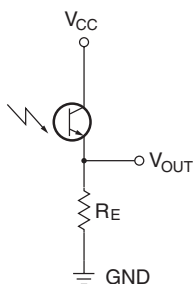


Figure 2. Common-Collector Amplifier

In both circuits the phototransistor can be used in two modes, an active mode and a switch mode. Operating in the active mode means that the phototransistor generates a response proportional to the light received by the component up to a certain light level. When the amount of light surpasses that level, the phototransistor becomes saturated and the output will not increase even as the light level increases. This mode is useful in applications where it is desired to detect two levels of inputs for comparison. Operating in the switch mode means that the phototransistor will either be "off" (cut-off) or "on" (saturated) in response to the light. This mode is useful when a digital output is required for object detection or encoder sensing.

By adjusting the load resistor in the amplifier circuit one can set the mode of operation. The correct value for the resistor can be determined by the following equations:

$$\text{Active Mode: } V_{CC} > R_L \times I_{CC}$$

$$\text{Switch Mode: } V_{CC} < R_L \times I_{CC}$$

Typically a resistor value of 5kΩ or higher is adequate to operate the phototransistor in the switch mode. The high level output voltage in the switching mode should equal the supply voltage. The low level output voltage in the switching mode should be less than 0.8 Volts.

The circuits just described can be applied to all two pin IR phototransistor components that Fairchild Semiconductor offers. They can also be applied to three pin phototransistor components that have a base lead.

A third phototransistor circuit (Fig. 3) involves only the three leaded components that have a base connection. Access to the base allows a base-emitter resistor to be connected. A high RBE value will prevent low levels of light from triggering the phototransistor and help provide a more digital output. The collector and emitter terminals can be connected in the same way as described above. Fairchild Semiconductor offers the three leaded component in a hermetic (metal can) package only.

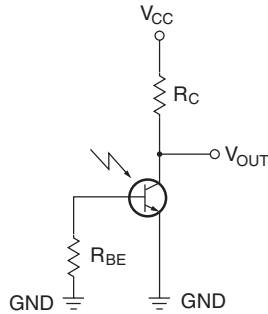


Figure 3. Phototransistor Circuit with Base Connection

Finally, the phototransistor should be biased (voltage applied to V_{CC}) with 5 Volts. The maximum bias is 16 V, however the performance of the component doesn't change with a greater bias except when the phototransistor is used as a switch -- the high level output will equal the higher setting.

Note: Fairchild's photodarlington products can be used in the same manner as the phototransistors. The photodarlingtons will provide greater outputs for the same light level because they have a greater internal gain, but will have a higher saturation voltage and slower turnoff than the phototransistor devices.

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, or (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 significant injury to the user.
2. A critical component is 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