ANALOG DEVICES

Circuit Note
CN-0420

Circuits from the Lab Reference Designs

Circuits from the Lab® reference designs are engineered and tested for quick and easy system integration to help solve today's analog, mixed-signal, and RF design challenges. For more information and/or support, visit www.analog.com/CN0420

Devices Connected/Referenced	
CN-0397	Ultra Low Power RGB Light Recognition System for Smart Agriculture
CN-0398	Soil Moisture and pH Measurement System with Temperature Compensation
CN-0410	3-Channel, Programmable 1 A LED Current Driver
ADICUP3029	Ultra Low Power, Arduino Form Factor Development Platform for IoT Applications
CFTL-LED-BAR	RGB Light Emitting Diode(LED) Bar in a 4 × 3 Configuration

Internet of Things(IoT) Smart Greenhouse System

EVALUATION AND DESIGN SUPPORT

Circuit Evaluation Boards

CN-0397 Circuit Evaluation Board (EVAL-CN0397-ARDZ)
CN-0398 Circuit Evaluation Board (EVAL-CN0398-ARDZ)
CN-0410 Circuit Evaluation Board (EVAL-CN0410-ARDZ)
Development Board (EVAL-ADICUP3029)

Design and Integration Files

Smart Greenhouse Wiki User Guide
Schematics, Layout Files, Bill of Materials

CIRCUIT FUNCTION AND BENEFITS

The IoT smart greenhouse is an application for monitoring and controlling several important parameters that help maximize the growth of plants. The data is processed locally and sent via Wi-Fi to a local gateway, before arriving at the cloud connected platform.

Light is the single most important factor in plant growth and photosynthesis. Most plants typically absorb light in the red and orange wavelength and the blue and purple wavelength. Light in the green and yellow wavelength is typically reflected, and does not contribute much to growth or flowering.

Plants even require different spectrum of light at different intensities during their life cycle. For example, plants tend to want more blue light during sprouting and seedling, whereas red light appears to be more important during later growth stages and flowering or fruiting.

By controlling the spectrum and intensity of light the plant is exposed to during the various stages of life, the growth of the plant can be more effectively and efficiently maximized and the yield from these crops can ultimately increase.

Soil moisture, soil pH, and temperature measurements ensure that the plant has the correct amount of water and nutrients available for optimal growth conditions.

The solution is Wi-Fi enabled so that the data being collected can be displayed and viewed in a web browser on a computer or smartphone, and commands can be sent back to the system to change the light settings.

Rev. 0
Circuits from the Lab reference designs from Analog Devices have been designed and built by Analog Devices engineers. Standard engineering practices have been employed in the design and construction of each circuit, and their function and performance have been tested and verified in a lab environment at room temperature. However, you are solely responsible for testing the circuit and determining its suitability and applicability for your use and application. Accordingly, in no event shall Analog Devices be liable for direct, indirect, special, incidental, consequential or punitive damages due to any cause whatsoever connected to the use of any Circuits from the Lab circuits. (Continued on last page)

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 **www.analog.com**
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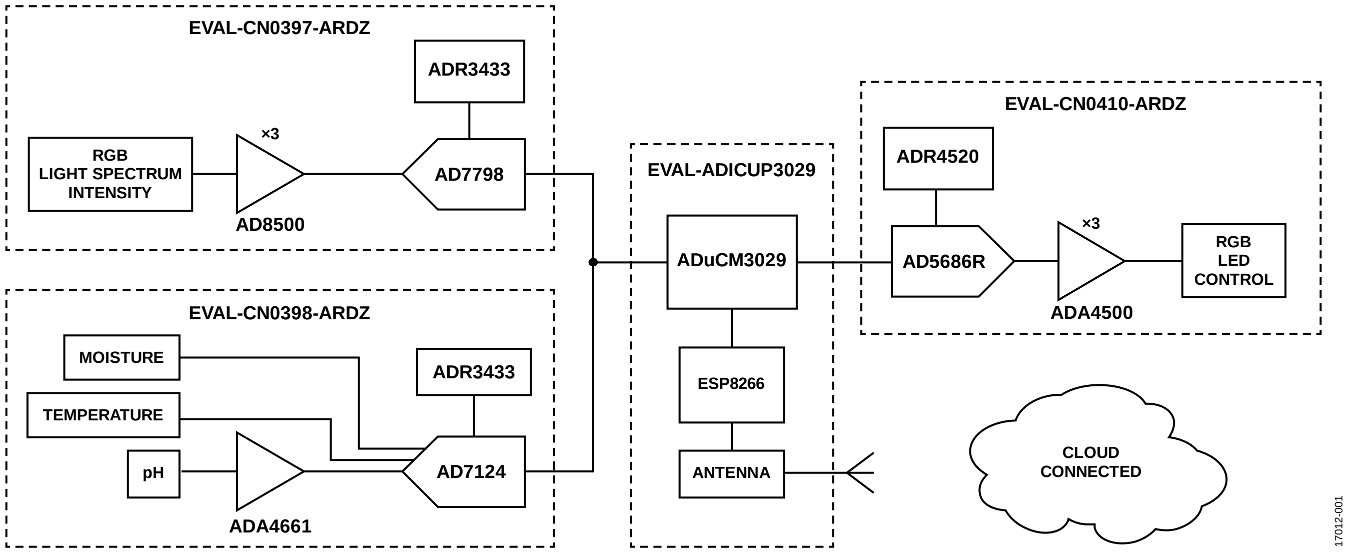

Figure 1. Simplified System Block Diagram

CIRCUIT DESCRIPTION

The smart greenhouse application focuses on increasing the growth efficiency and maximizing the yield cycles of various types of plants. The theory and details apply to many agriculture sectors such as indoor greenhouses, vertical farming, and container farming. The smart greenhouse application addresses other general concerns for users in the agriculture market, such as keeping operating costs down and decreasing overhead (preventing over watering or wasted soil enrichment).

Figure 2. Smart Greenhouse Demo Photo

The smart greenhouse application hardware is made up of three different Circuits from the Lab reference designs.

The CN-0397 is designed to measure the intensity of the visible light spectrum, particularly at the wavelengths that correspond to the colors red, green, and blue (RGB). Red and blue light are absorbed by the plant and used during photosynthesis, whereas green light is reflected by the plant. Each sensor measures the intensity of light at its targeted wavelength and outputs a proportional current. The CN-0397 converts that small current into a voltage, and transforms the voltage into the standard unit of measurement for light intensity (Lux). See the CN-0397 for more information on how the circuit operates.

The CN-0410 is a programmable, 3-channel, current drive LED circuit. Each channel of RGB is independently controlled, allowing for unique LED color combinations. The board allows connection to the CFTL-LED-BAR by connecting the terminal block on each board together with a twisted pair wire. Light intensity commands are sent via Wi-Fi to the smart greenhouse, and a proportional integral (PI) software control loop between the CN-0410 and the CN-0397 is used to create the RGB color combination.

The CN-0410 also has an isolated repeater function on the board, so that the user can set multiple banks or bays of CN-0410 and LED bar combinations to a single value with only a single controller board, which minimizes the cost over a large LED network. See the CN-0410 documentation (available from the circuit note webpage) for complete details on the repeater function, LED settings, and power consumption.

The CN-0398 measures three other critical parameters including soil moisture, pH, and temperature. Soil moisture measurements are important to ensure that the vegetation has the proper amount of water to promote growth, and also to ensure that water is not being unnecessarily wasted. pH monitoring is also important. pH affects nutrient availability and absorption of potentially harmful materials. Some plants germinate or flower within certain temperature requirements or profiles, and therefore the temperature measurements are used to help regulate the HVAC system. See the CN-0398 for more information on how the circuit operates.

The ADICUP3029 Arduino form factor-compatible development platform controls the Arduino shield hardware modules described previously. This platform contains the

ADuCM3029 ultra low power Cortex-M3 microprocessor. The development platform also has onboard Bluetooth and Wi-Fi connectivity for connection to the internet and development of IoT connected applications.

For the smart greenhouse application, data is sent wirelessly from the node (ADICUP3029 and shield modules) to an existing wireless gateway through Wi-Fi. The Wi-Fi uses a message queuing telemetry transport (MQTT) standard protocol, which is typically used in low power, IoT sensor nodes that need to send small amounts of data to the gateway.

The IBM® Watson cloud service is used to collect and display the smart greenhouse data. Bidirectional communication receives the data and transmits it from the cloud service back down to the remote node. There are other connectivity options available. For complete details on the IBM Watson option and other cloud connection options, see the Smart Greenhouse Wiki User Guide.

Figure 3. IBM Watson Data Using Node Red

COMMON VARIATIONS

In the current application, there is no closed loop feedback for the temperature, watering system, or adding soil nutrients. All these actions can be included in the control hardware and software as needed for the user's system requirements. For example, the temperature reading can be tied into the HVAC system to turn on the air conditioning or heat, or the moisture reading can be used to control a valve on the irrigation system to ensure that the moisture of the soil stays within a required range.

The LED being driven may require a certain wavelength for the vegetation, and therefore may need to be customized in the user specific application. The CN-0397 can be customized to accommodate different LED sources by adjusting the peak wavelength at which the photodiodes sense the light. See the CN-0397 for information on how to change the photodiodes and gain values for full-scale usage.

CIRCUIT EVALUATION AND TEST

To set up the smart greenhouse system, stack the boards on stop of each other. The sensors plug directly into the designated connectors. The following sections provide the basics of how to connect the system. For complete details, see the Smart Greenhouse Wiki User Guide.

Equipment Needed

The following equipment is needed:

- EVAL-CN0397-ARDZ
- EVAL-CN0398-ARDZ
- EVAL-CN0410-ARDZ
- CFTL-LED-BAR
- EVAL-ADICUP3029
- Smart Greenhouse Embedded Software
- PC with a USB port and Windows® XP or Windows Vista® (32-bit), or Windows 7 (32-bit)
- Micro USB cable
- Power supply: 6 V to 19 V wall wart

Getting Started

See the Smart Greenhouse Wiki User Guide for complete step by step instructions on setting up the smart greenhouse. The following are the basic steps for setup:

1. First, configure the hardware. Ensure that the jumpers are set on each board correctly.
2. Make sure that all the sensors are connected to the boards.
3. Stack the shield boards on top of each other in the following order: CN-0397, CN-0410, and then CN-0398.
4. Set up the ADICUP3029 so that the Wi-Fi module is plugged in to P1. Set the S2 switch to the Wi-Fi position (if using cloud connectivity). Otherwise, set the S2 switch to the USB position for serial terminal run mode.
5. Plug the USB cable from the ADICUP3029 to the PC and flash the smart greenhouse firmware onto the board.
6. Press the 3029_Reset button or power cycle the system, and follow the instructions in the Smart Greenhouse Wiki User Guide.

Functional Block Diagram

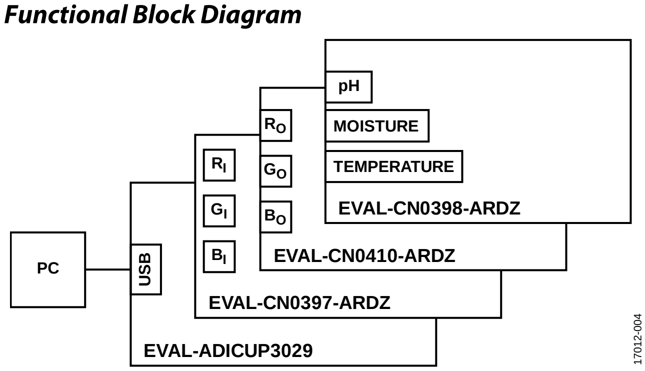

Figure 4. Smart Greenhouse System Functional Block Diagram

LEARN MORE

CN-0397 Design Support Package: www.analog.com/CN0397-DesignSupport

CN-0398 Design Support Package: www.analog.com/CN0398-DesignSupport

CN-0410 Design Support Package: www.analog.com/CN0410-DesignSupport

ADICUP3029 User Guide

ADICUP3029 Github Repository

Mahdavian, Mehdi and Naruemon Wattanapongsakorn. "Optimizing Greenhouse Lighting for Advanced Agriculture Based on Real Time Electricity Market Price." *Mathematical Problems in Engineering*, Volume 2017, Article ID 6862038. 2017.

"LED application in agricultural lighting can efficiently increase crop yields." Arrow.com, June 26, 2017. www.arrow.com/en/research-and-events/articles/agriculture-lighting

Data Sheets and Evaluation Boards

CN-0397 Circuit Evaluation Board (EVAL-CN0397-ARDZ)

CN-0398 Circuit Evaluation Board (EVAL-CN0398-ARDZ)

CN-0410 Circuit Evaluation Board (EVAL-CN0410-ARDZ)

ADICUP3029 Development Platform (EVAL-ADICUP3029)

LED Bar Circuit Evaluation Board (CFTL-LED-BAR)

REVISION HISTORY

7/2108—Revision 0: Initial Version

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