

# Using the Stellaris® Ethernet Controller with Micro IP (uIP)

## Application Note



## Copyright

Copyright © 2007–2010 Texas Instruments, Inc. All rights reserved. Stellaris and StellarisWare are registered trademarks of Texas Instruments. ARM and Thumb are registered trademarks, and Cortex is a trademark of ARM Limited. Other names and brands may be claimed as the property of others.

Texas Instruments  
108 Wild Basin, Suite 350  
Austin, TX 78746  
<http://www.ti.com/stellaris>



## Table of Contents

Introduction .....	4
uIP TCP/IP Stack.....	4
Features.....	4
Implementation .....	4
Application Program Interface (API) .....	5
uIP Application Examples .....	5
DriverLib Example.....	5
FreeRTOS.org™ Embedded Ethernet Demo .....	7
Examples Provided with the uIP Package .....	8
Conclusion .....	8
References .....	8

## Introduction

Many of the devices in the Stellaris® family of microcontrollers include an Ethernet controller. The Ethernet controller consists of a fully integrated media access controller (MAC) and a network physical (PHY) interface device. The controller conforms to IEEE 802.3 specifications and fully supports 10BASE-T and 100BASE-TX standards.

The Micro IP (uIP) stack is an open-source implementation of the TCP/IP stack developed specifically for embedded microcontrollers. For embedded systems, uIP makes it possible to connect the system to a local intranet or the Internet. The uIP stack has been ported to the Stellaris® family of microcontrollers. This application note gives an overview of the uIP TCP/IP stack followed by a discussion of uIP application examples provided for Stellaris evaluation boards with Ethernet controllers.

## uIP TCP/IP Stack

The uIP stack was developed by Adam Dunkels of the Networked Embedded Systems group at the Swedish Institute of Computer Science. uIP, written in the C programming language, is an open-source TCP/IP stack developed for embedded microcontrollers by minimizing the required code and data memory footprints. Typical code size is on the order of a few kilobytes while RAM usage can be as low as a few hundred bytes. A basic overview of the uIP stack is provided below. For more information, visit the uIP web page at <http://www.sics.se/~adam/uip>.

## Features

The uIP stack implementation is designed to have only the minimal set of features needed for a TCP/IP stack. The TCP/IP stack is a suite of protocols including the following which are supported by uIP:

- Transmission Control Protocol (TCP)
- User Datagram Protocol (UDP)
- Internet Protocol (IP)
- Internet Control Message Protocol (ICMP)
- Address Resolution Protocol (ARP)

The uIP stack can handle multiple concurrent TCP and UDP connections. The maximum number of connections allowed is configurable at compile time.

## Implementation

The uIP stack is mainly concerned with the TCP/IP protocols. The upper layer protocols are considered to be part of the application. The lower level protocols are handled by the networking hardware's device driver.

The TCP/IP suite of protocols are defined in a layered fashion where each layer has a specific function. The implementations of the protocols in uIP are not layered but instead are tightly coupled in order to save code space.

The requirements for the protocols in the TCP/IP stack are specified in a number of Request For Comments (RFC) documents published by the Internet Engineering Task Force (IETF). Each of the protocols is defined in one or more RFC documents. RFC1122 incorporates, amends, corrects, and supplements these RFC documents to define the requirements for the communication layers for internet hosts.

The RFC1122 requirements can be divided into two categories: those that affect host-to-host communication and those that affect communication between the TCP/IP stack and the application. All of the requirements for host-to-host communication are implemented in uIP. However, some of the requirements for stack-to-application communication, such as the soft error reporting mechanism and dynamically configurable type-of-service bits for TCP connections, were not implemented in order to reduce code size.

## Application Program Interface (API)

uIP provides two application program interfaces (API) which define how the application program interacts with the TCP/IP stack. The two APIs include protocols and a raw API. The protocols API is similar to a Berkeley (BSD) socket API without the full multi-threading overhead. Protocols only work with TCP connections. The raw API is an event-based driven interface where the application is invoked in response to certain events. The raw API is more of a low-level interface compared to protocols but uses less memory.

## uIP Application Examples

There are several uIP application examples available for the Stellaris LM3S6965 evaluation board. The example applications available include the example provided with the Stellaris driver library (DriverLib), a FreeRTOS demo, and the application examples provided with the uIP distribution package. These examples are supported by the following tool sets:

- Keil™ RealView® Microcontroller Development Kit
- IAR Embedded Workbench
- CodeSourcery Sourcery G++ for Stellaris EABI
- Code Red Technologies Red Suite
- Texas Instruments' Code Composer Studio™

## DriverLib Example

The Stellaris Peripheral Driver Library is a set of drivers for accessing the peripherals found on the Stellaris family of microcontrollers. The peripheral driver library is available in both source code and binary formats. The peripheral driver library is shipped as part of the Stellaris evaluation and development kits and is available as a free download from the <http://www.ti.com/stellaris> web site.

In addition to the peripheral driver library, the Stellaris® Firmware Development Package includes an example application using the uIP TCP/IP stack that is targeted for all Stellaris evaluation kits with Ethernet including the LM3S9B92, LM3S9B90, LM3S8962, and LM3S6965 evaluation boards. This example application demonstrates an HTTP server running on the uIP stack that serves up a web page, which displays a few lines of text and a counter that increments each time the page is sent

from the board. The example first configures the LM3S6965 microcontroller and then initializes the uIP TCP/IP stack and HTTP server. The IP address of the LM3S6965 evaluation board is displayed using the OLED display on the board. The main control loop looks for incoming packets, processes them using the uIP stack and HTTP server, and transmits packets back onto the network as required. The example also implements a TCP/IP periodic timer and transmits packets onto the network as required by uIP. The Ethernet controller device drivers provided within the peripheral driver library are used by this example. The source code and project files for the uIP example are provided in the StellarisWare® software in their respective StellarisWare\boards directories.

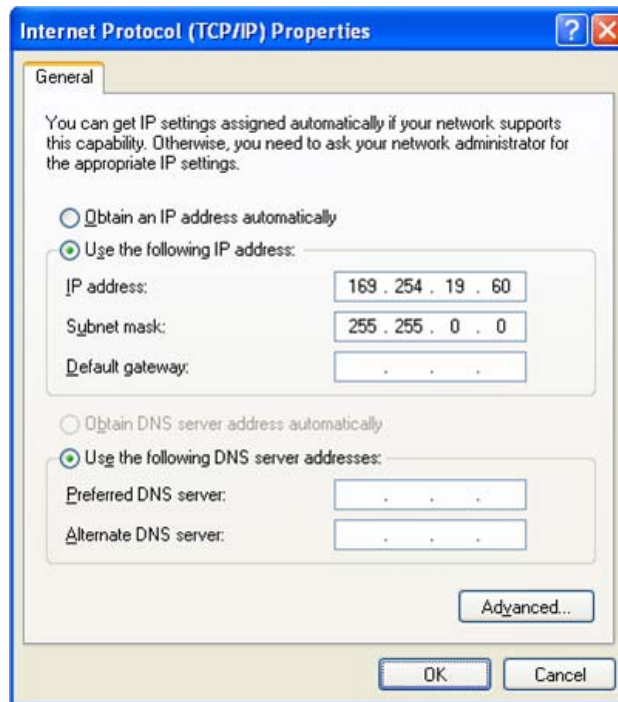
In this uIP example, the TCP/IP stack is configured so that it requires approximately 4.5 Kbytes of flash memory for code and approximately 2.5 Kbytes of SRAM for data and stack.

An Ethernet cable must be connected between a PC and the evaluation board. The integrated PHY on the LM3S9B92, LM3S9B90, LM3S8962, and LM3S6965 microcontrollers has an Auto-MDIX feature that allows the use of a straight-through or cross-over Ethernet cable. Use a web browser to view the web page served up by the microcontroller.

The default static IP address for the board is 169.254.19.63, but is configurable in the `enet_uip.c` file if a different IP address is desired. The PC must be configured to be on the same subnet as the board. In most cases, the PC detects the correct IP address and subnet settings automatically after several seconds. In some cases, the PC's IP address and subnet mask must be configured manually. To do this, disable the PC's wireless network connection and any other internet connections that could interfere with the network being created. Select the Internet Protocol (TCP/IP) connection within the Local Area Connection Properties and click on Properties. Next, manually configure the PC's IP address as 169.254.19.60 and subnet mask to 255.255.0.0, as shown in Figure 1.

After completing the above configuration and programming the microcontroller with the application, open a web browser and type the IP address into the address bar to view the web page being served up by the microcontroller. For example, if the default static IP address is used, type `http://169.254.19.63` in the address bar.

Figure 1. TCP/IP Properties



## FreeRTOS.org™ Embedded Ethernet Demo

FreeRTOS provides an embedded Ethernet demo using the uIP stack that supports the LM3S6965 evaluation board. The demo with source code can be downloaded from the LM3S6965 evaluation kit web page at [www.luminarymicro.com](http://www.luminarymicro.com).

The FreeRTOS demo creates a simple web server that serves up a few web pages using the LM3S6965 microcontroller. One of the web pages allows the user to write data to the OLED display and control the status LED on the LM3S6965 evaluation board. The other web pages display task, TCP, and network connection statistics. These web pages can be viewed by using a web browser.

Just as with the uIP example provided with StellarisWare®, an Ethernet cable should be connected between a PC and the LM3S6965 evaluation board. Either a straight-through or cross-over Ethernet cable can be used. By default, the IP address of the evaluation board is configured to be 172.25.218.9. The IP address is configurable at compile time by the constants `uipIP_ADDR0` through `uipIP_ADDR3` within the `uIP_Task.c` file.

If the PC does not detect the correct IP address and subnet mask settings, then they must be manually configured. To manually configure these settings, select the Internet Protocol (TCP/IP) connection within the Local Area Connection Properties and click on Properties. Assuming that the IP address for the board uses the default setting of 172.25.218.9, then the IP address for the PC can be configured as 172.25.218.10 and the subnet mask to 255.255.0.0. This configuration is the same as in Figure 1 except with a different IP address.

After completing the above configuration and programming the LM3S6965 microcontroller with the application, open a web browser and type the IP address into the address bar to view the web pages

being served up by the LM3S6965 microcontroller. For example, if the default static IP address is used, type <http://172.25.218.9> in the address bar.

Visit <http://www.freertos.org> for more information on FreeRTOS.

## Examples Provided with the uIP Package

The uIP TCP/IP stack package comes with a few example applications which can be used to run on top of the uIP stack. These example applications include dhcpc, hello-world, httpd, resolv, smtp, telnetd, webclient, and webserver. In addition, the uIP reference manual shows a few simple uIP applications. These examples as well as the uIP reference manual are installed with the DriverLib package for the Stellaris family of microcontrollers. For more information, visit the uIP webpage at <http://www.sics.se/~adam/uip>

## Conclusion

Many of the devices in the Stellaris family of microcontrollers include an Ethernet controller consisting of an integrated MAC and PHY. By using the open-source uIP stack which has been ported to the Stellaris family of microcontrollers, you can connect the system to a local intranet or the Internet. uIP application examples that support the Ethernet-enabled microcontrollers are provided and make it easy to get started writing network-enabled applications using the evaluation board.

## References

The following documents and source code are available for download at [www.ti.com/stellaris](http://www.ti.com/stellaris):

- *Stellaris® LM3S6965 microcontroller data sheet*
- *Stellaris® LM3S8962 microcontroller data sheet*
- *Stellaris® LM3S9B90 microcontroller data sheet*
- *Stellaris® LM3S9B92 microcontroller data sheet*
- Stellaris Peripheral Driver Library, order number SW-DRL
- *Stellaris Peripheral Driver Library User's Manual*, publication number SW-DRL-UG



## Important Notice

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

Copyright © 2009, Texas Instruments Incorporated

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2009, Texas Instruments Incorporated