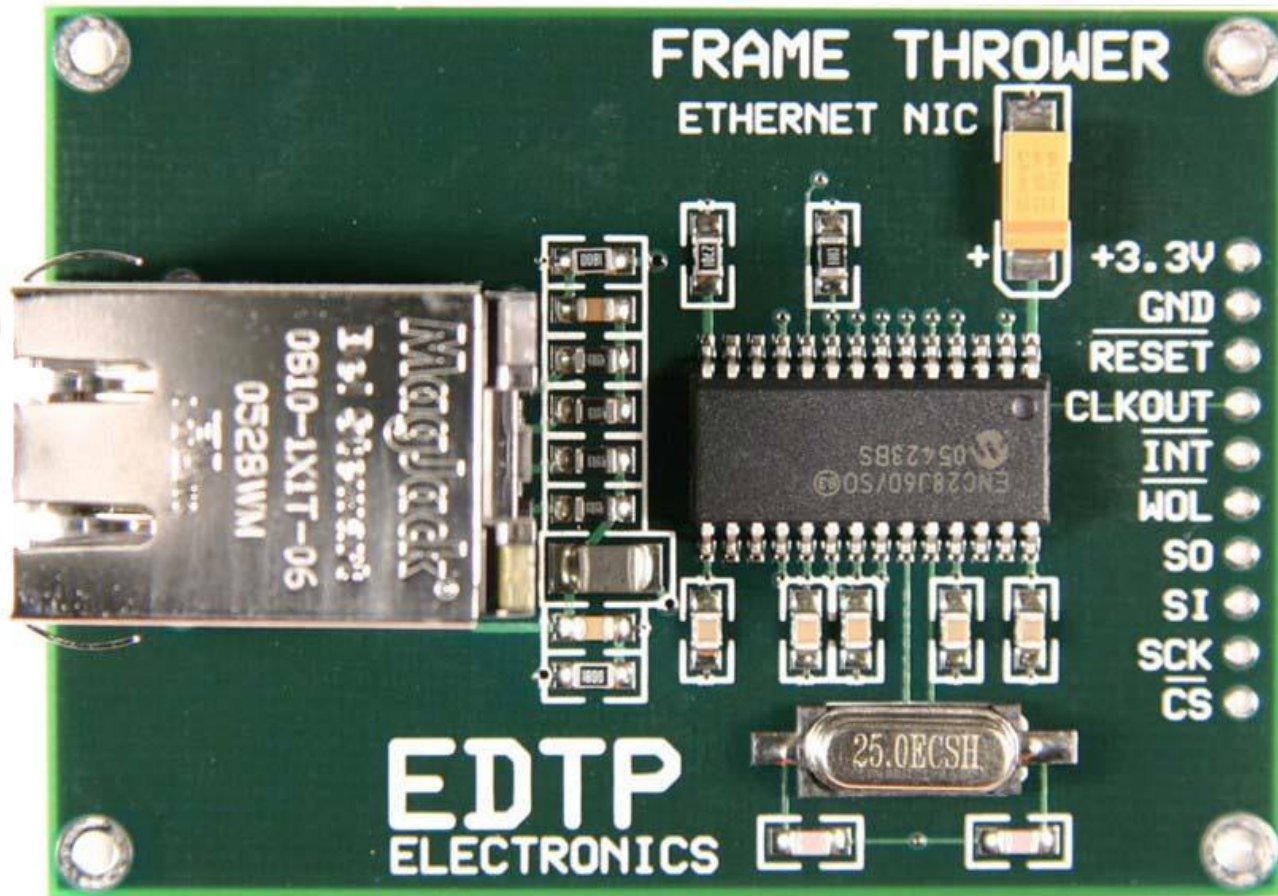


Easy TCP/IP for IoT



TCP/IP Fundamentals

October 21, 2019

Fred Eady

Presented by:

DesignNews

Information Classification: General

CEC CONTINUING
EDUCATION
CENTER



Easy TCP/IP for IoT

AGENDA

- Firmware – **TCP/IP 101**
- Hardware – **Curiosity and Click**
- Firmware – **TCP/IP Lite**
- Day 1 Summary

ABCDBUGS

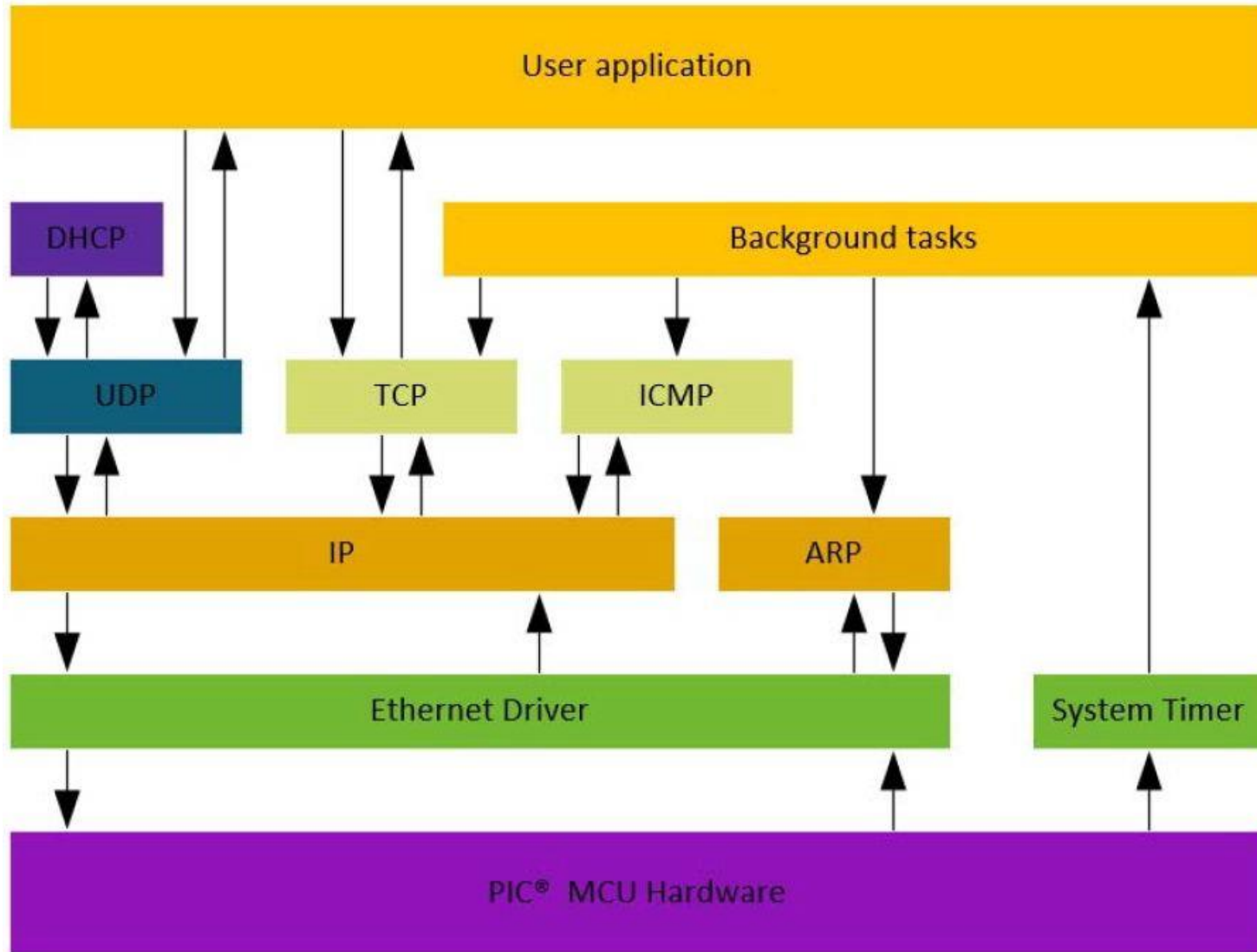
LMRNOBUGS

OSARBUGSCDEDBDIS

LILBMRBUGS

Easy TCP/IP for IoT

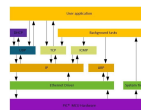
Firmware - TCP/IP 101



Easy TCP/IP for IoT

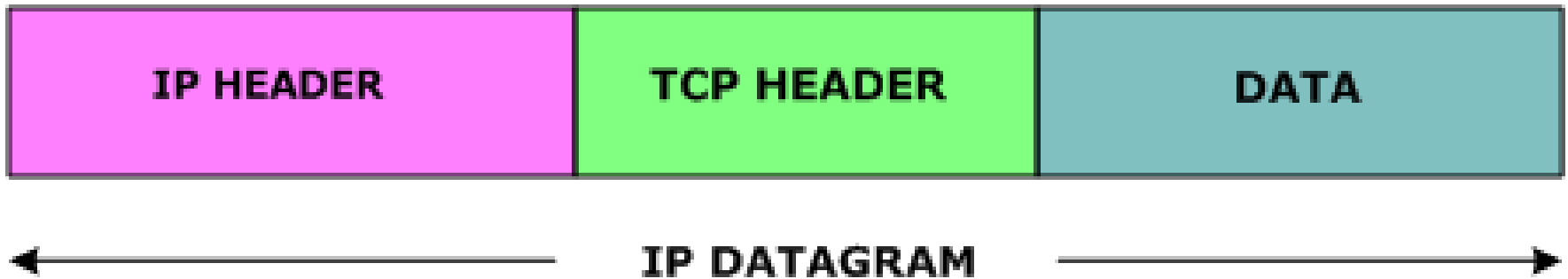
Firmware - TCP/IP 101 - Protocols

- **IP – Internet Protocol**
- **ARP – Address Resolution Protocol**
- **UDP – User Datagram Protocol**
- **TCP – Transmission Control Protocol**
- **ICMP – Internet Control Message Protocol**



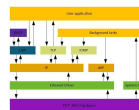
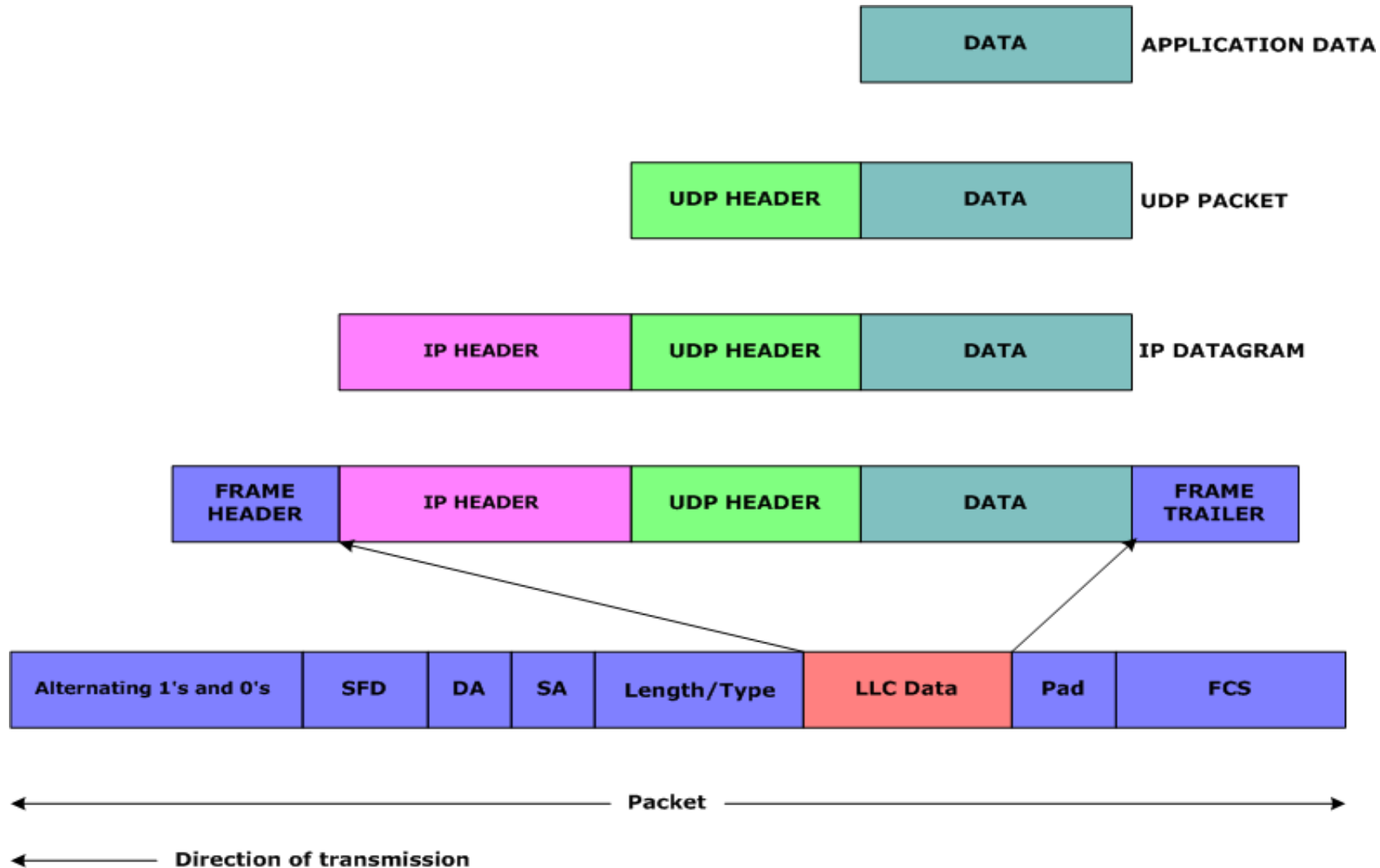
Easy TCP/IP for IoT

Firmware - TCP/IP 101 - IP Datagram



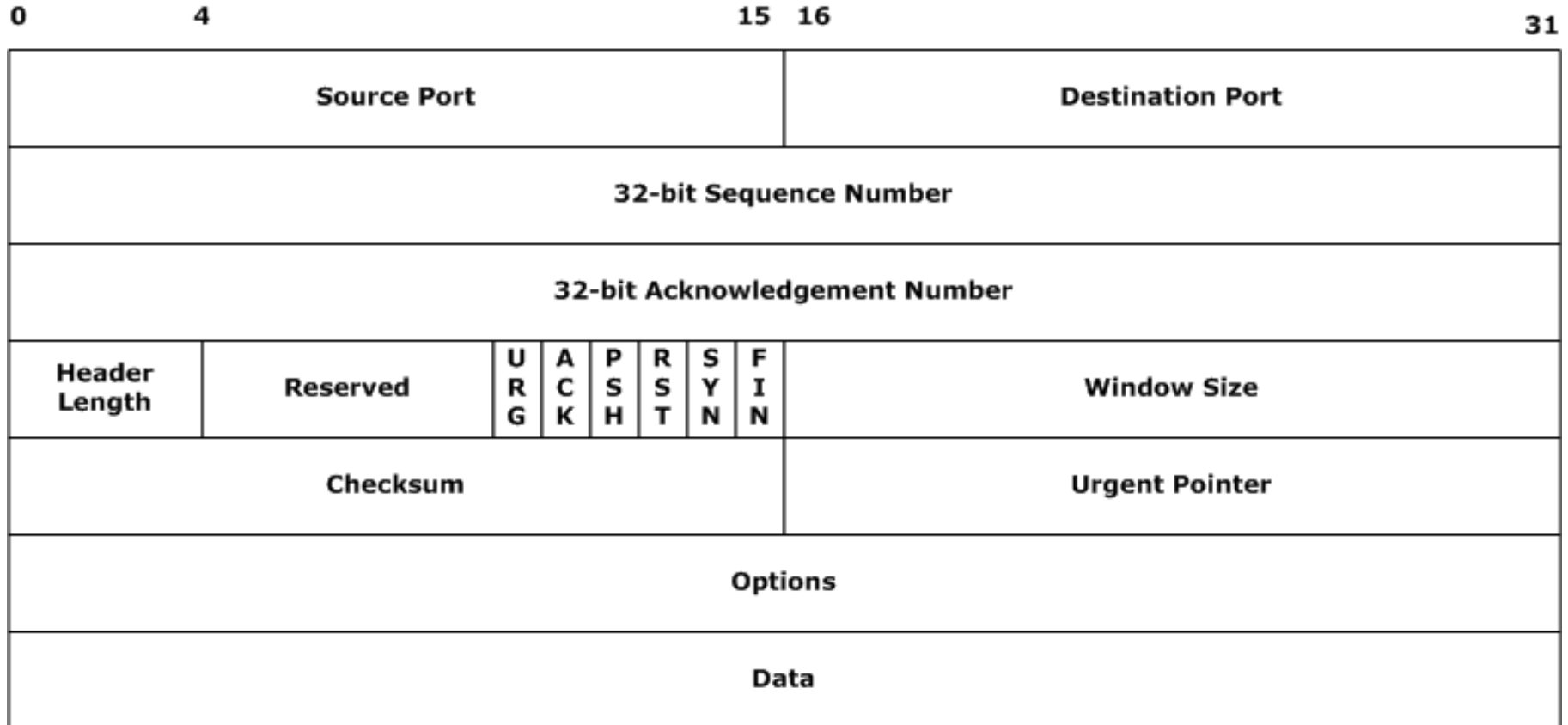
Easy TCP/IP for IoT

Firmware - TCP/IP 101 - UDP Packet

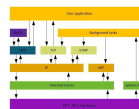


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Firmware - TCP/IP 101 - TCP Header

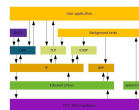
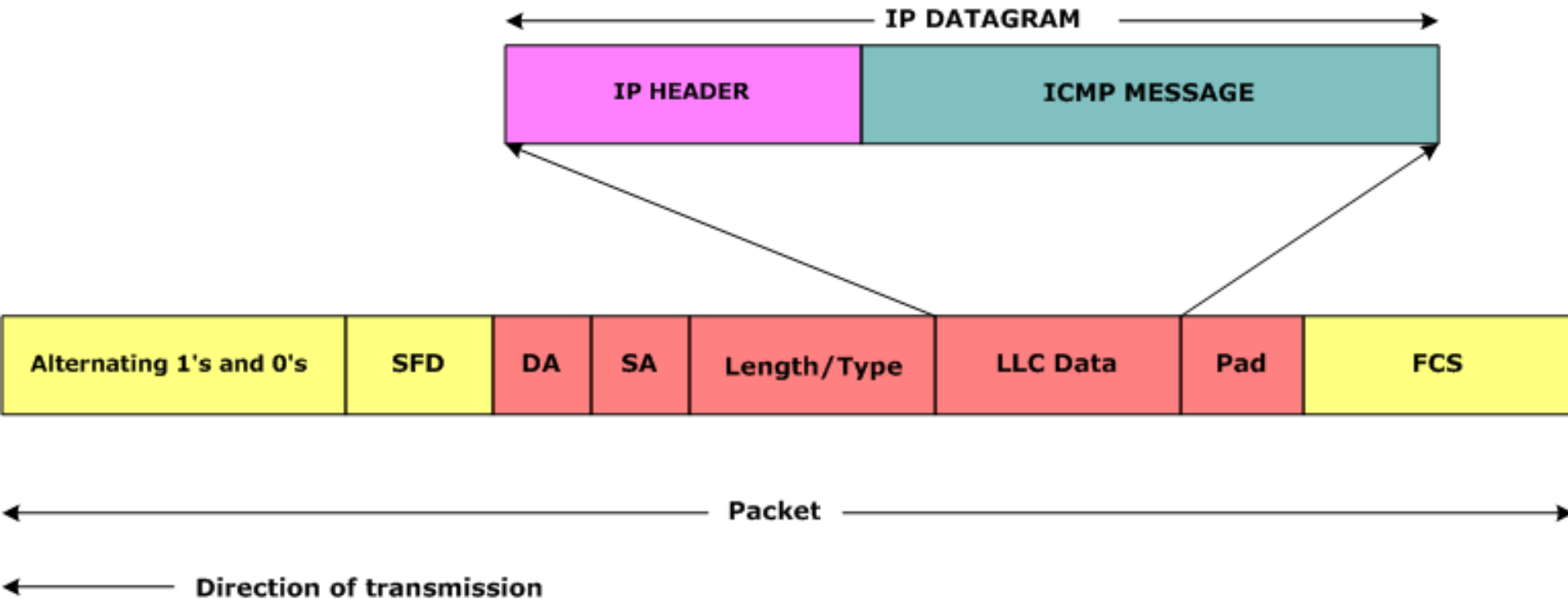


TCP Header



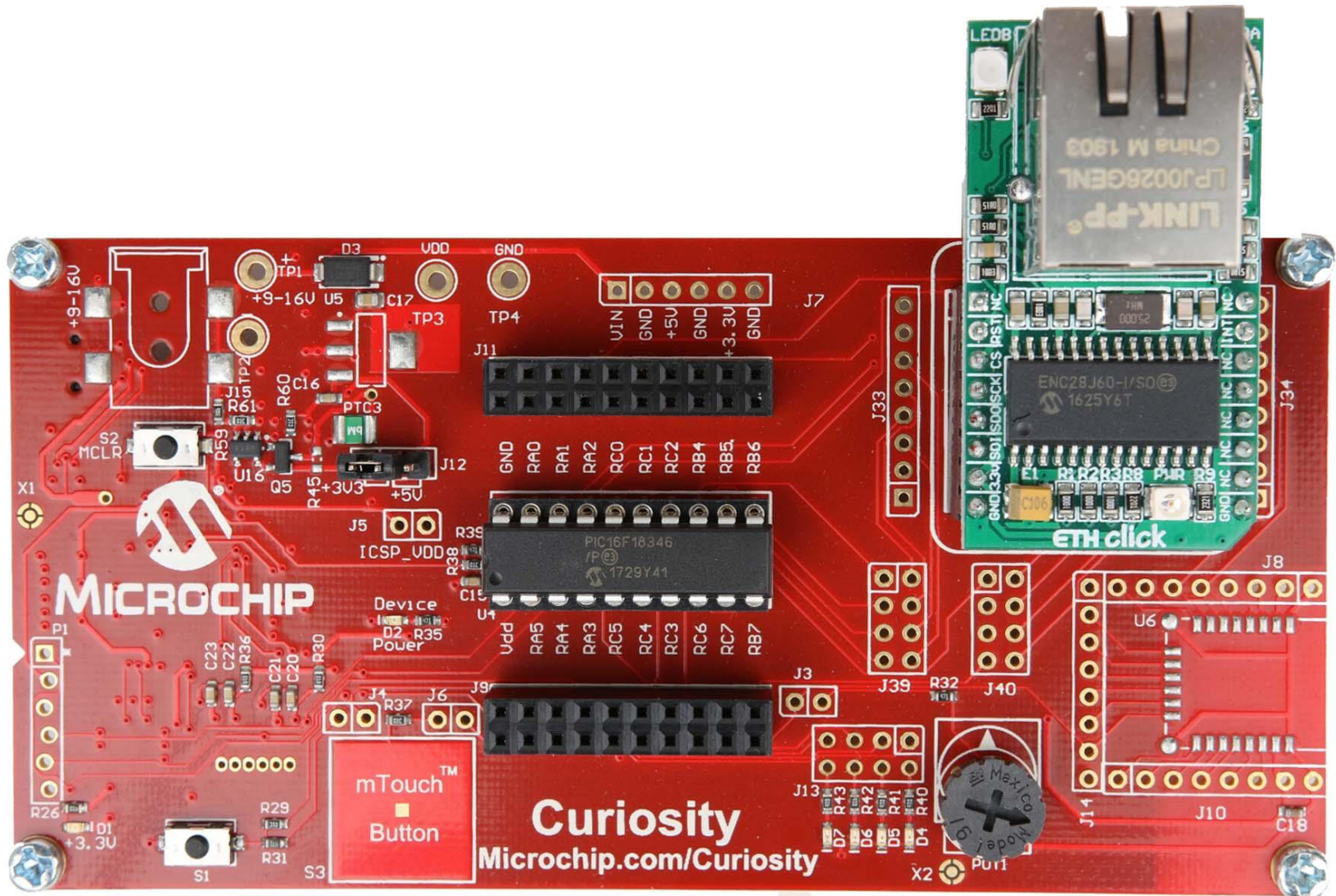
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Firmware - TCP/IP 101 - ICMP Packet



Easy TCP/IP for IoT

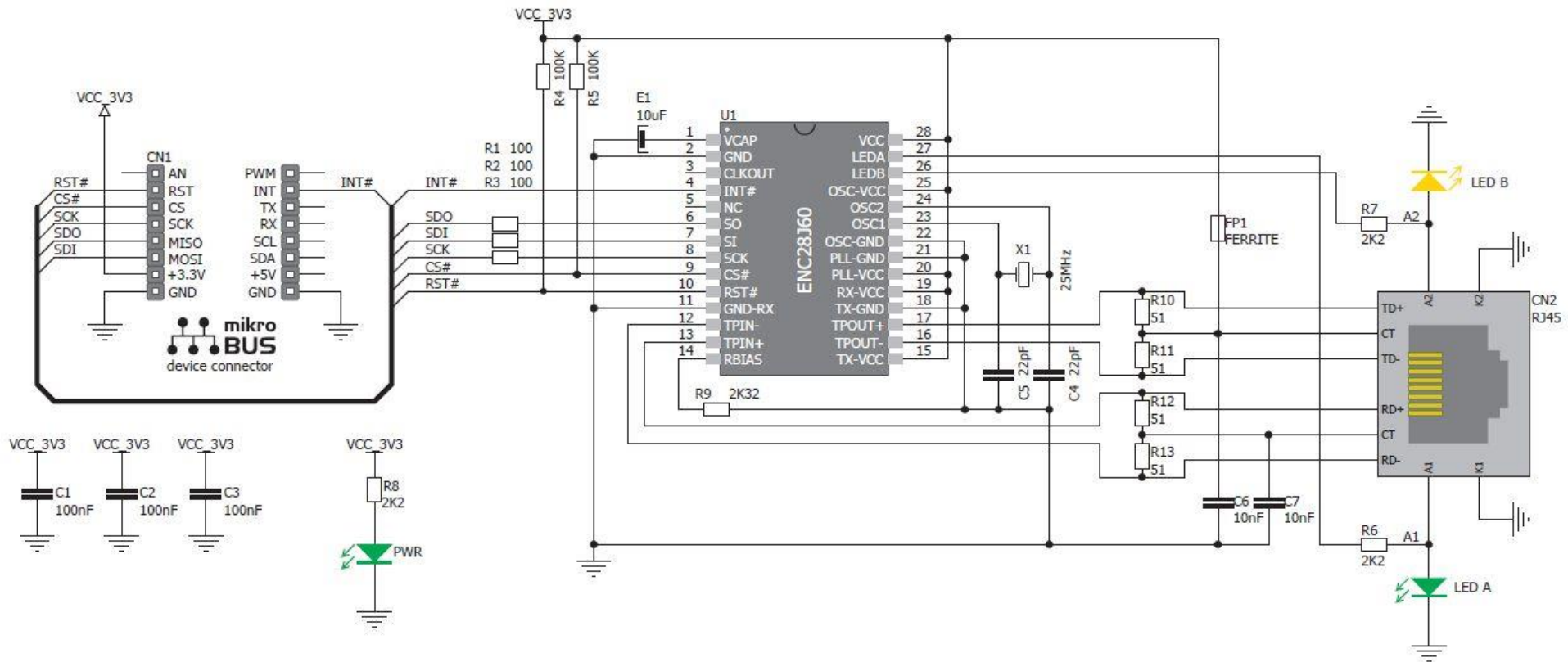
Hardware - TCP/IP 101 - Curiosity and Click



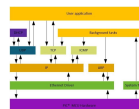
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Easy TCP/IP for IoT

Hardware - TCP/IP 101 - Click



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Firmware - TCP/IP 101 - TCP/IP Lite - Configuration

TCP/IP Lite

Easy Setup

Microchip Lightweight TCPIP Stack

☐ UDP ☐ DHCP ☒ IPV4 ☒ TCP ☒ ICMP ☒ ARP ☐ TFTP ☐ NTP ☐ DNS

☐ LLDP

► TCP

▼ ICMP

☒ Tx Echo Response ☒ Port unreachable

▼ IPV4

IP Address

Subnet Mask

Default Gateway

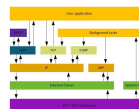
Preferred DNS Server

Alternate DNS Server

Nothing to Configure

▼ ARP

ARP Table Size



Easy TCP/IP for IoT

Firmware - TCP/IP 101 - TCP/IP Lite - Configuration

MSSP1

Easy Setup

Hardware Settings

☐ Enable I2C ☒ Enable SPI

SPI Settings

Default SPI Clock Frequency kHz

Actual Clock Frequency 125.0 kHz

MAC

Easy Setup

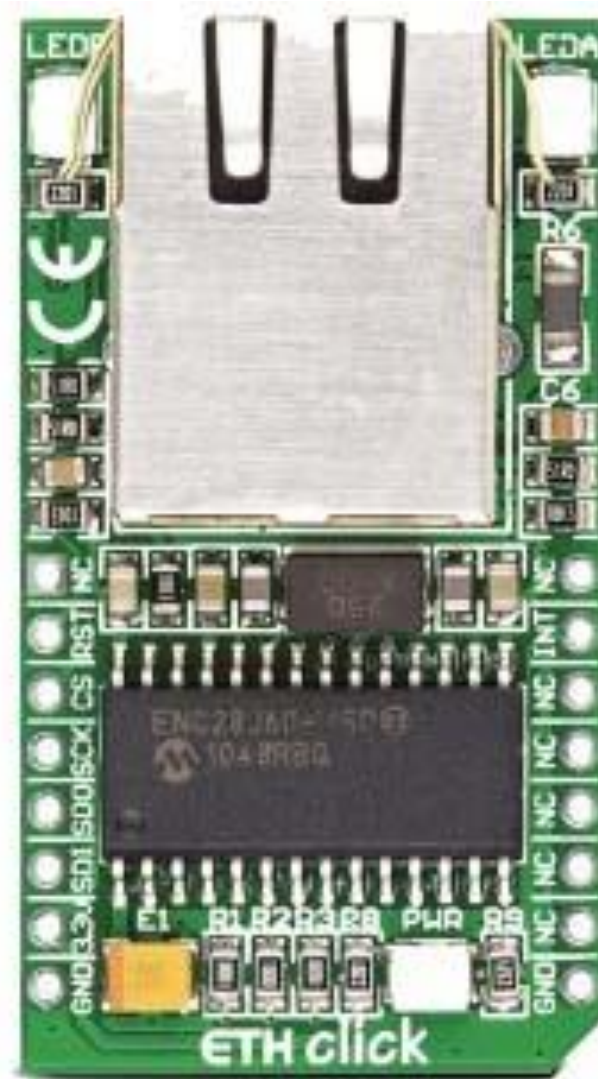
Media Access Controller

ENC28J60

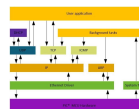
02:00:00:00:00:01

▼ SPI Configuration

Name	SPI Mode	SPI Data Input...	
MASTER0	MODE0	MIDDLE	12
MAC	MODE0	END	80



Presented by:

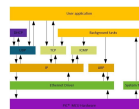


Easy TCP/IP for IoT

Firmware - TCP/IP 101 - TCP/IP Lite - Configuration

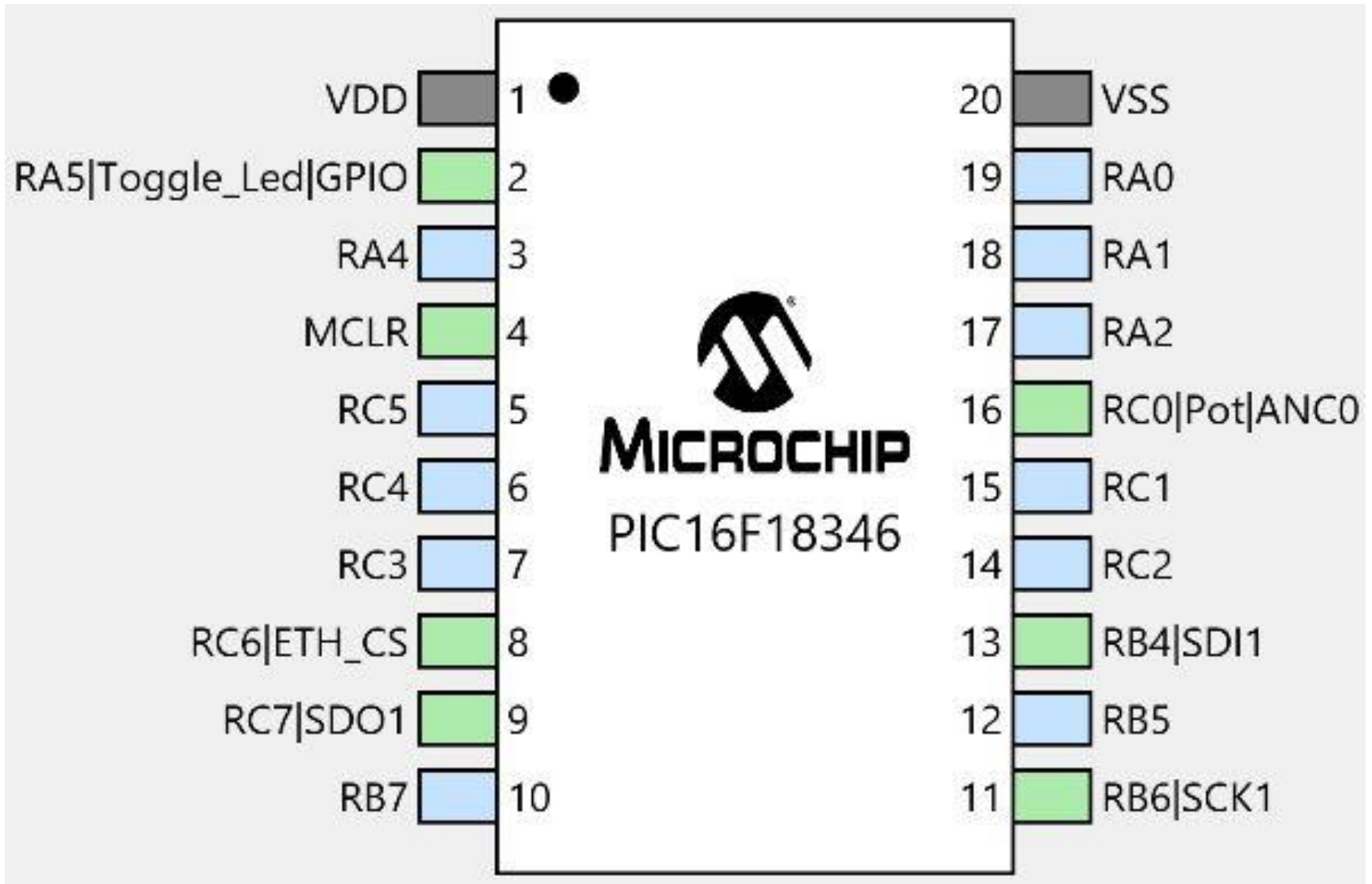
TMR1

<input checked="" type="checkbox"/> Easy Setup <input type="checkbox"/> Registers	
Hardware Settings	
<input checked="" type="checkbox"/> Enable Timer	
Timer Clock	Timer Period
Clock Source: FOSC/4	Timer Period: 4 μ s \leq 250 ms \leq 262.144 ms
External Frequency: 32.768 kHz	Period count: 0x0 \leq 0xBDC \leq 0xFFFF
Prescaler: 1:1	Calculated Period: 250 ms
<input checked="" type="checkbox"/> Enable Synchronization	<input type="checkbox"/> Enable Gate
<input type="checkbox"/> Enable Oscillator Circuit	<input type="checkbox"/> Enable Gate Toggle Gate Signal Source: T1G_pin
	<input type="checkbox"/> Enable Gate Single-Pulse mode Gate Polarity: low
<input checked="" type="checkbox"/> Enable Timer Interrupt	
<input type="checkbox"/> Enable Timer Gate Interrupt	
Software Settings	
Callback Function Rate: 4 x Time Period = 1 s	



Easy TCP/IP for IoT

Firmware - TCP/IP 101 - TCP/IP Lite - Configuration



Easy TCP/IP for IoT

Firmware - TCP/IP 101 - TCP Server

File Edit Clear Help

Client

IP Address/Name: Port:

Elaps Time: Connection Status:

Edit/Send Data:

☒ ASCII ☐ Hex ☐ Line Feed ☐ Carriage Return

Auto Send: ☐ Send every sec.

Edit/Data Log:

Display data as: ☒ ASCII ☐ Binary ☐ Decimal ☐ Hex

HEX Data Log:

Display: ☐ Time ☐ Date Sound: ☐ Enabled

Server

Current connections 1/250:

(1) 192.168.10.10/1031

Listening on: Set Listening Port:

Edit/Send Data:

☒ ASCII ☐ Hex ☐ Line Feed ☐ Carriage Return

Auto Send: ☐ Send every sec.

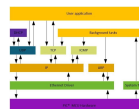
Edit/Data Log:

Display data as: ☒ ASCII ☐ Binary ☐ Decimal ☐ Hex

HEX Data Log:

Display: ☐ Time ☐ Date Sound: ☐ Enabled

Bytes Sent: 0 Bytes Received: 0 10/3/2019 10:29:58 AM Bytes Sent: 17 Bytes Received: 20462



Easy TCP/IP for IoT

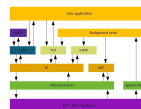
Firmware - TCP/IP 101 - Application Code

Transmit Code

```
// send board status message only once at 2 seconds
socketTimeout = t_client + 2;
pot = ADC_GetConversion(Pot);
sprintf(txdataPort60, "Pot: %d\n LED's state: %d\n", pot, LATAbits.LATA5);
//send data back to the source
TCP_Send(&port60TCB, txdataPort60, strlen(txdataPort60));
```

Receive Code

```
if(rxdataPort60[0] == 'l' && rxdataPort60[1] == 'e' && rxdataPort60[2] == 'd') {
    if(rxdataPort60[6] == 'o' && rxdataPort60[7] == 'n') {
        Toggle_Led_SetHigh();
    }else {
        if(rxdataPort60[6] == 'o' && rxdataPort60[7] == 'f' && rxdataPort60[8] == 'f') {
            Toggle_Led_SetLow();
        }
    }
}
```



Easy TCP/IP for IoT

Firmware - TCP/IP 101 - ARP

No.	Time	Source	Destination	Protocol	Length	Info
2	0.9474...	Elitegro_...	Broadcast	ARP	42	Who has 192.168.10.10? Tell 192.168.10.100
3	1.9477...	Elitegro_...	Broadcast	ARP	42	Who has 192.168.10.10? Tell 192.168.10.100
4	8.4898...	192.168.1...	239.255.2...	SS...	3...	NOTIFY * HTTP/1.1
5	8.5931...	192.168.1...	239.255.2...	SS...	3...	NOTIFY * HTTP/1.1
6	8.6972...	192.168.1...	239.255.2...	SS...	3...	NOTIFY * HTTP/1.1
7	8.8011...	192.168.1...	239.255.2...	SS...	3...	NOTIFY * HTTP/1.1
8	8.9051...	192.168.1...	239.255.2...	SS...	4...	NOTIFY * HTTP/1.1
9	9.0091...	192.168.1...	239.255.2...	SS...	4...	NOTIFY * HTTP/1.1
...	9.1135...	192.168.1...	239.255.2...	SS...	4...	NOTIFY * HTTP/1.1
...	9.2171...	192.168.1...	239.255.2...	SS...	4...	NOTIFY * HTTP/1.1

> Frame 2: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface 0

> Ethernet II, Src: Elitegro_f1:4f:36 (94:c6:91:f1:4f:36), Dst: Broadcast (ff:ff:ff:ff:ff:ff)

> Address Resolution Protocol (request)

Hardware type: Ethernet (1)

Protocol type: IPv4 (0x0800)

Hardware size: 6

Protocol size: 4

Opcode: request (1)

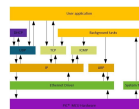
Sender MAC address: Elitegro_f1:4f:36 (94:c6:91:f1:4f:36)

Sender IP address: 192.168.10.100

Target MAC address: 00:00:00_00:00:00 (00:00:00:00:00:00)

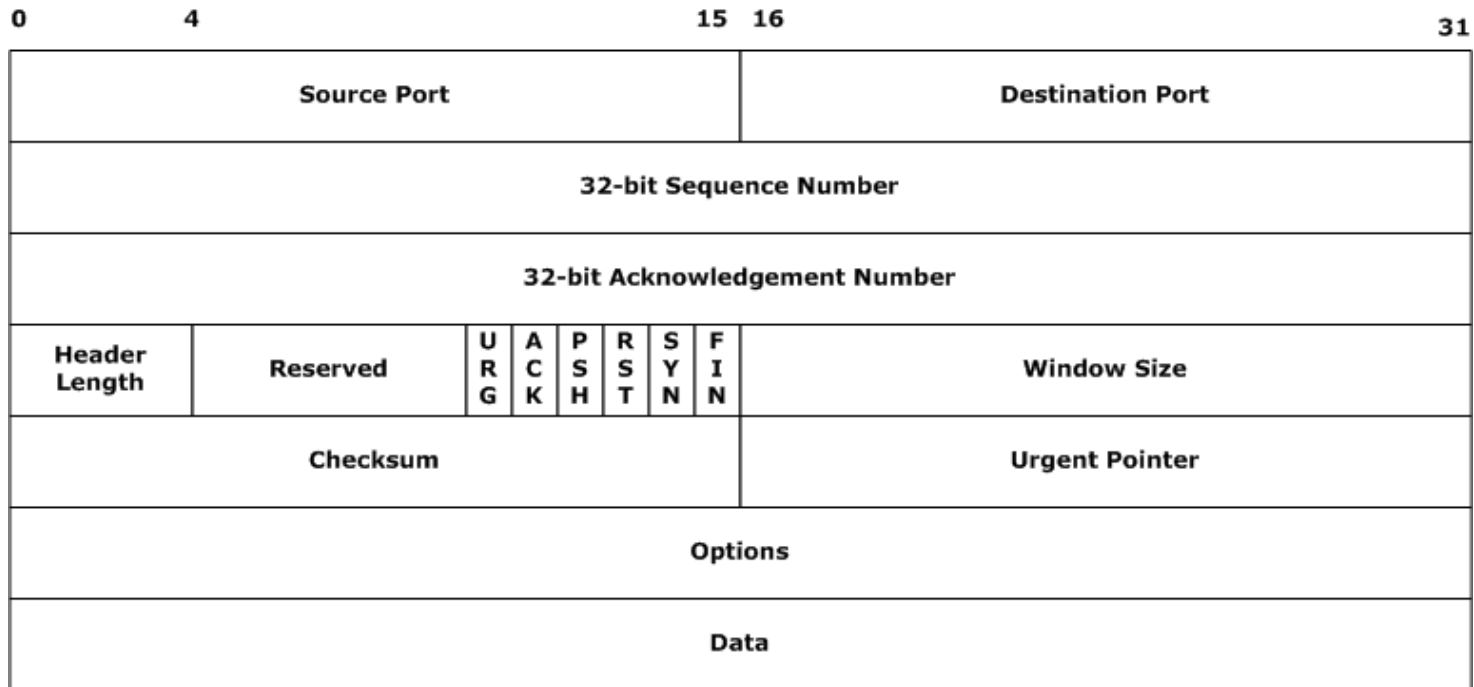
Target IP address: 192.168.10.10

0000	ff ff ff ff ff 94 c6 91 f1 4f 36 08 00 00 0106....
0010	08 00 06 04 00 01 94 c6 91 f1 4f 36 c0 a8 0a 6406...d
0020	00 00 00 00 00 00 c0 a8 0a 0a



Easy TCP/IP for IoT

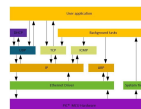
Firmware - TCP/IP 101 - 3-Way Handshake



TCP Header

No.	Time	Source	Destination	Protocol	Length	Info
9	4.4006...	02:00:00:00:0...	Broadcast	ARP	60	Who has 192.168.10.100? Tell 192.168.10.10
...	4.4006...	Elitegro_f1:4...	02:00:00:00:00:01	ARP	42	192.168.10.100 is at 94:c6:91:f1:4f:36
...	6.1148...	02:00:00:00:0...	Broadcast	ARP	60	Who has 192.168.10.100? Tell 192.168.10.10
...	6.1148...	Elitegro_f1:4...	02:00:00:00:00:01	ARP	42	192.168.10.100 is at 94:c6:91:f1:4f:36
...	8.0554...	192.168.10.10	192.168.10.100	TCP	60	1025 → 60 [SYN] Seq=0 Win=50 Len=0
...	8.0554...	192.168.10.100	192.168.10.10	TCP	54	[TCP ACKed unseen segment] 60 → 1025 [ACK] Seq=1 Ack=4187 Win=65028 Len=0
...	8.1766...	192.168.10.10	192.168.10.100	TCP	60	1028 → 60 [SYN] Seq=0 Win=50 Len=0
...	8.1767...	192.168.10.100	192.168.10.10	TCP	58	60 → 1028 [SYN, ACK] Seq=0 Ack=1 Win=65392 Len=0 MSS=1460
...	8.2891...	192.168.10.10	192.168.10.100	TCP	60	1028 → 60 [ACK] Seq=1 Ack=1 Win=50 Len=0

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Easy TCP/IP for IoT

Firmware - TCP/IP 101 - IP

Frame 48: 81 bytes on wire (648 bits), 81 bytes captured (648 bits) on interface 0

Ethernet II, Src: 02:00:00:00:00:01 (02:00:00:00:00:01), Dst: Elitegro_f1:4f:36 (94:c6:91:f1:4f:36)

- Destination: Elitegro_f1:4f:36 (94:c6:91:f1:4f:36)
- Source: 02:00:00:00:00:01 (02:00:00:00:00:01)
- Type: IPv4 (0x0800)

Internet Protocol Version 4, Src: 192.168.10.10, Dst: 192.168.10.100

- 0100 = Version: 4
- 0101 = Header Length: 20 bytes (5)
- Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
- Total Length: 66
- Identification: 0xaa55 (43605)
- Flags: 0x4000, Don't fragment
- Time to live: 64
- Protocol: TCP (6)
- Header checksum: 0xfaa1 [validation disabled]
- [Header checksum status: Unverified]
- Source: 192.168.10.10
- Destination: 192.168.10.100

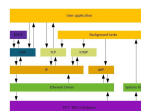
Transmission Control Protocol, Src Port: 1028, Dst Port: 60, Seq: 313, Ack: 1, Len: 26

Data (26 bytes)

0000	94 c6 91 f1 4f 36 02 00 00 00 00 01 08 00 45 00	...06... ..E.
0010	00 42 aa 55 40 00 40 06 fa a1 c0 a8 0a 0a c0 a8	.B.U@.@.
0020	0a 64 04 04 00 3c 00 00 03 92 b0 5d e4 90 50 18	.d...<... ..]..P.
0030	00 32 34 82 00 00 50 6f 74 3a 20 31 30 32 33 0a	.24...Po t: 1023.
0040	20 4c 45 44 27 73 20 73 74 61 74 65 3a 20 30 0a	LED's s tate: 0.
0050	fd	.

Close

Help



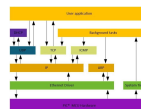
Easy TCP/IP for IoT

Firmware - TCP/IP 101 - Ethernet

```
> Frame 48: 81 bytes on wire (648 bits), 81 bytes captured (648 bits) on interface 0
< Ethernet II, Src: 02:00:00:00:00:01 (02:00:00:00:00:01), Dst: Elitegro_f1:4f:36 (94:c6:91:f1:4f:36)
  > Destination: Elitegro_f1:4f:36 (94:c6:91:f1:4f:36)
  > Source: 02:00:00:00:00:01 (02:00:00:00:00:01)
  Type: IPv4 (0x0800)
< Internet Protocol Version 4, Src: 192.168.10.10, Dst: 192.168.10.100
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
  Total Length: 66
  Identification: 0xaa55 (43605)
  > Flags: 0x4000, Don't fragment
  Time to live: 64
  Protocol: TCP (6)
  Header checksum: 0xfaa1 [validation disabled]
  [Header checksum status: Unverified]
  Source: 192.168.10.10
  Destination: 192.168.10.100
  > Transmission Control Protocol, Src Port: 1028, Dst Port: 60, Seq: 313, Ack: 1, Len: 26
  < Data (26 bytes)
0000  94 c6 91 f1 4f 36 02 00 00 00 00 01 08 00 45 00  ....06.. ....E.
0010  00 42 aa 55 40 00 40 06 fa a1 c0 a8 0a 0a c0 a8  .B.U@.@. ....
0020  0a 64 04 04 00 3c 00 00 03 92 b0 5d e4 90 50 18  .d...<... ..]..P.
0030  00 32 34 82 00 00 50 6f 74 3a 20 31 30 32 33 0a  .24...Po t: 1023.
0040  20 4c 45 44 27 73 20 73 74 61 74 65 3a 20 30 0a  LED's s tate: 0.
0050  fd
```

Close

Help



Easy TCP/IP for IoT

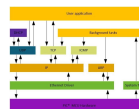
Firmware - TCP/IP 101 - Data Transfer - Client to Server

```
Type: IPv4 (0x0800)
v Internet Protocol Version 4, Src: 192.168.10.10, Dst: 192.168.10.100
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 66
    Identification: 0xaa55 (43605)
  > Flags: 0x4000, Don't fragment
    Time to live: 64
    Protocol: TCP (6)
    Header checksum: 0xfaa1 [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.10.10
    Destination: 192.168.10.100
  > Transmission Control Protocol, Src Port: 1028, Dst Port: 60, Seq: 313, Ack: 1, Len: 26
v Data (26 bytes)
  Data: 506f743a203130323330a204c454427732073746174653a20...
    [Length: 26]
  > VSS-Monitoring ethernet trailer, Source Port: 253
```

0000	94 c6 91 f1 4f 36 02 00 00 00 00 01 08 00 45 00 06 E .
0010	00 42 aa 55 40 00 40 06 fa a1 c0 a8 0a 0a c0 a8	. B . U @ . @
0020	0a 64 04 04 00 3c 00 00 03 92 b0 5d e4 90 50 18	. d . . . <] . . P .
0030	00 32 34 82 00 00 50 6f 74 3a 20 31 30 32 33 0a	. 24 . . . P o t : 1023 .
0040	20 4c 45 44 27 73 20 73 74 61 74 65 3a 20 30 0a	. LED ' s s t a t e : 0 .
0050	fd	.

Close

Help



Easy TCP/IP for IoT

Firmware - TCP/IP 101 - Data Transfer - Server to Client

The screenshot displays the 'Easy TCP/IP for IoT' software interface, which is divided into two main sections: 'Client' and 'Server'.

Client Section:

- IP Address/Name:** localhost
- Port:** 12345
- Connect:** Button
- Elaps Time:** 00:00:00
- Reset:** Button
- Connection Status:** Idle
- Edit/Send Data:** Text area with 'Enter data to send...'
- Format Selection:** ☒ ASCII, ☐ Hex, ☐ Line Feed, ☐ Carriage Return
- Auto Send:** ☐ Send every 1 sec.
- Clear:** Button
- Send:** Button
- Edit/Data Log:** Text area for logging data
- Display data as:** ☒ ASCII, ☐ Binary, ☐ Decimal, ☐ Hex
- HEX Data Log:** Text area for logging hex data
- Display:** ☐ Time, ☐ Date
- Sound:** ☐ Enabled
- Clear Log:** Button

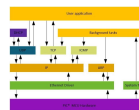
Server Section:

- Current connections 2/250:** List of active connections: {1} 192.168.10.10/1031, {2} 192.168.10.10/1028 (highlighted)
- Listening on:** 192.168.10.100/60
- Set Listening Port:** 60
- Bind:** Button
- Edit/Send Data:** Text area with 'led on|'
- Format Selection:** ☒ ASCII, ☐ Hex, ☐ Line Feed, ☐ Carriage Return
- Auto Send:** ☐ Send every 1 sec.
- Clear:** Button
- Send:** Button
- Edit/Data Log:** Text area with 'Pot: 1023 LED's state: 0'
- Display data as:** ☒ ASCII, ☐ Binary, ☐ Decimal, ☐ Hex
- HEX Data Log:** Text area showing hex data logs, including the highlighted line: <- {192.168.10.10/1028} 50 6F 74 3A 20 31 30 32 33 0A 2C
- Display:** ☐ Time, ☐ Date
- Sound:** ☐ Enabled
- Clear Log:** Button

Status Bar:

- Client: Bytes Sent: 0, Bytes Received: 0
- Server: Bytes Sent: 0, Bytes Received: 650
- Timestamp: 10/3/2019 10:50:56 AM

Presented by:



Easy TCP/IP for IoT

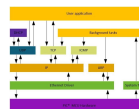
Firmware - TCP/IP 101 - Data Transfer - Server to Client

- > Frame 1: 81 bytes on wire (648 bits), 81 bytes captured (648 bits) on interface 0
- > Ethernet II, Src: 02:00:00:00:00:01 (02:00:00:00:00:01), Dst: Elitegro_f1:4f:36 (94:c6:91:f1:4f:36)
- > Internet Protocol Version 4, Src: 192.168.10.10, Dst: 192.168.10.100
- > Transmission Control Protocol, Src Port: 1031, Dst Port: 60, Seq: 1, Ack: 1, Len: 26
- > Data (26 bytes)
 - Data: 506f743a203130323330a204c454427732073746174653a20...
 - [Length: 26]
- > VSS-Monitoring ethernet trailer, Source Port: 253

0000	94 c6 91 f1 4f 36 02 00 00 00 00 01 08 00 45 00 06 E .
0010	00 42 aa 55 40 00 40 06 fa a1 c0 a8 0a 0a c0 a8	. B U @ . @
0020	0a 64 04 07 00 3c 00 00 20 38 9b c5 52 33 50 18	. d . . . < . . 8 . R3P .
0030	00 32 bd ce 00 00 50 6f 74 3a 20 31 30 32 33 0a	. 2 Po t: 1023 .
0040	20 4c 45 44 27 73 20 73 74 61 74 65 3a 20 31 0a	LED's s tate: 1 .
0050	fd	.

Close

Help



Easy TCP/IP for IoT

Day 1 Summary

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

not ssdp

No.	Time	Source	Destination	Protocol	Length	Info
33	5.3990...	BelkinIn_b7:c...	Elitegro_f1:4f:36	ARP	60	Who has 192.168.10.100? Tell 192.168.10.1
34	5.3990...	Elitegro_f1:4...	BelkinIn_b7:cb:e0	ARP	42	192.168.10.100 is at 94:c6:91:f1:4f:36
35	14.889...	02:00:00:00:0...	Broadcast	ARP	60	Who has 192.168.10.100? Tell 192.168.10.10
36	14.889...	Elitegro_f1:4...	02:00:00:00:00:01	ARP	42	192.168.10.100 is at 94:c6:91:f1:4f:36
37	16.834...	192.168.10.10	192.168.10.100	TCP	60	1025 → 60 [SYN] Seq=0 Win=50 Len=0
38	16.834...	192.168.10.100	192.168.10.10	TCP	58	60 → 1025 [SYN, ACK] Seq=0 Ack=1 Win=65392 Len=0 MSS=1460
39	16.957...	192.168.10.10	192.168.10.100	TCP	60	1028 → 60 [SYN] Seq=0 Win=50 Len=0
40	18.829...	192.168.10.10	192.168.10.100	TCP	60	[TCP Retransmission] 1028 → 60 [SYN] Seq=0 Win=50 Len=0
41	18.900...	192.168.10.10	192.168.10.100	TCP	60	1031 → 60 [SYN] Seq=0 Win=50 Len=0
42	18.900...	192.168.10.100	192.168.10.10	TCP	58	60 → 1031 [SYN, ACK] Seq=0 Ack=1 Win=65392 Len=0 MSS=1460
43	19.012...	192.168.10.10	192.168.10.100	TCP	60	1031 → 60 [ACK] Seq=1 Ack=1 Win=50 Len=0
44	19.834...	192.168.10.100	192.168.10.10	TCP	58	[TCP Retransmission] 60 → 1025 [SYN, ACK] Seq=0 Ack=1 Win=65392 Len=0 MSS=1460
53	20.890...	192.168.10.10	192.168.10.100	TCP	81	1031 → 60 [PSH, ACK] Seq=1 Ack=1 Win=50 Len=26
54	20.931...	192.168.10.100	192.168.10.10	TCP	54	60 → 1031 [ACK] Seq=1 Ack=27 Win=65366 Len=0
55	22.449...	192.168.10.100	192.168.10.255	BRO...	2...	Host Announcement DESKTOP-5SJRAIJ, Workstation, Server, NT Workstation

> Frame 53: 81 bytes on wire (648 bits), 81 bytes captured (648 bits) on interface 0

> Ethernet II, Src: 02:00:00:00:00:01 (02:00:00:00:00:01), Dst: Elitegro_f1:4f:36 (94:c6:91:f1:4f:36)

> Internet Protocol Version 4, Src: 192.168.10.10, Dst: 192.168.10.100

> Transmission Control Protocol, Src Port: 1031, Dst Port: 60, Seq: 1, Ack: 1, Len: 26

> Data (26 bytes)

Data: 506f743a203130323330a204c454427732073746174653a20...

```
0000  94 c6 91 f1 4f 36 02 00 00 00 01 08 00 45 00  ....06.. .....E.
0010  00 42 aa 55 40 00 40 06 fa a1 c0 a8 0a 0a c0 a8  .B.U@@. ....
0020  0a 64 04 07 00 3c 00 00 00 06 9b c5 52 2b 50 18  .d...<... ..R+P.
0030  00 32 df 08 00 00 50 6f 74 3a 20 31 30 32 33 0a  .2....Po t: 1023.
0040  20 4c 45 44 27 73 20 73 74 61 74 65 3a 20 30 0a  LED's s tate: 0.
0050  fd
```

Data (data.data), 26 bytes

Packets: 65 · Displayed: 49 (75.4%) · Dropped: 0 (0.0%)

Profile: Default

