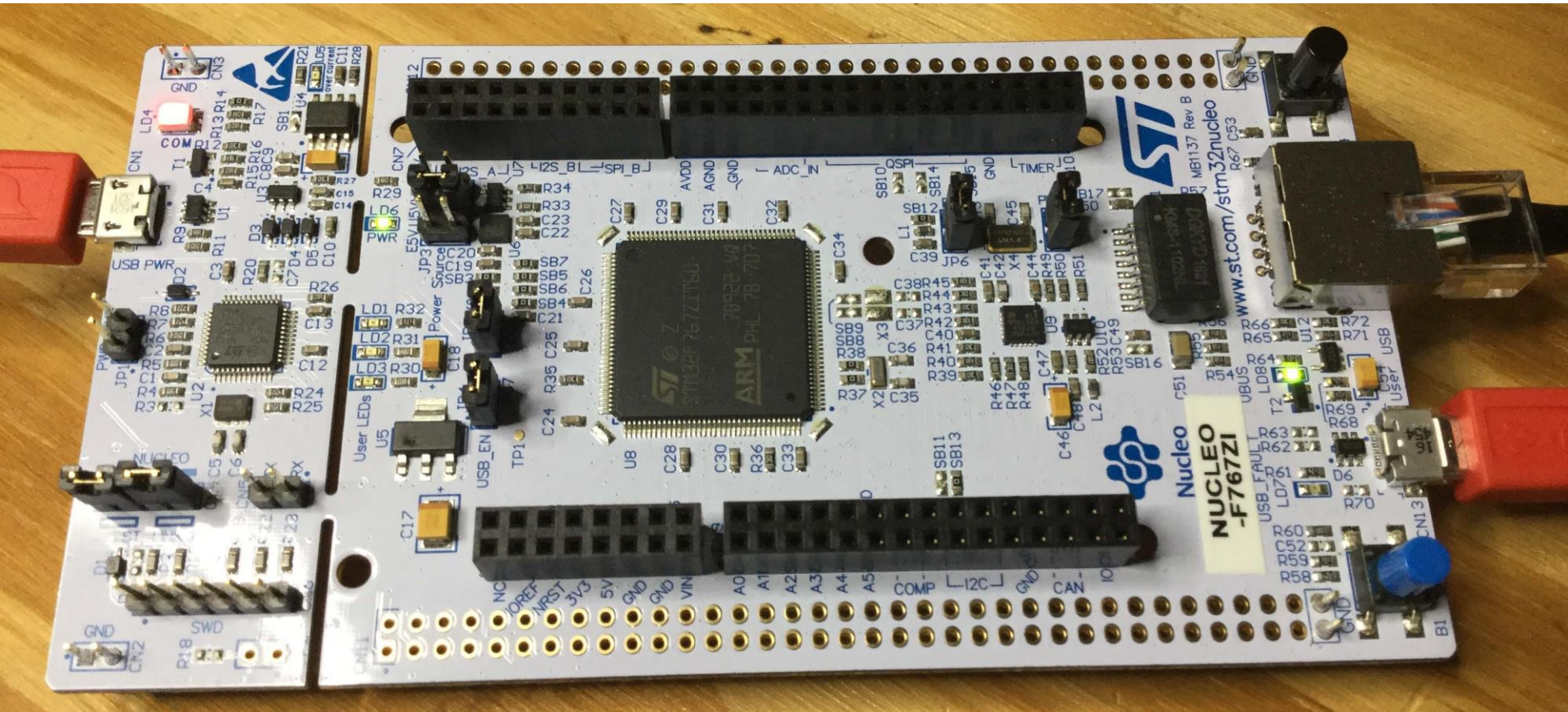


Easy TCP/IP for IoT



Implementing TCP/IP on STM32 Devices

October 24, 2019

Fred Eady

Presented by:

Easy TCP/IP for IoT

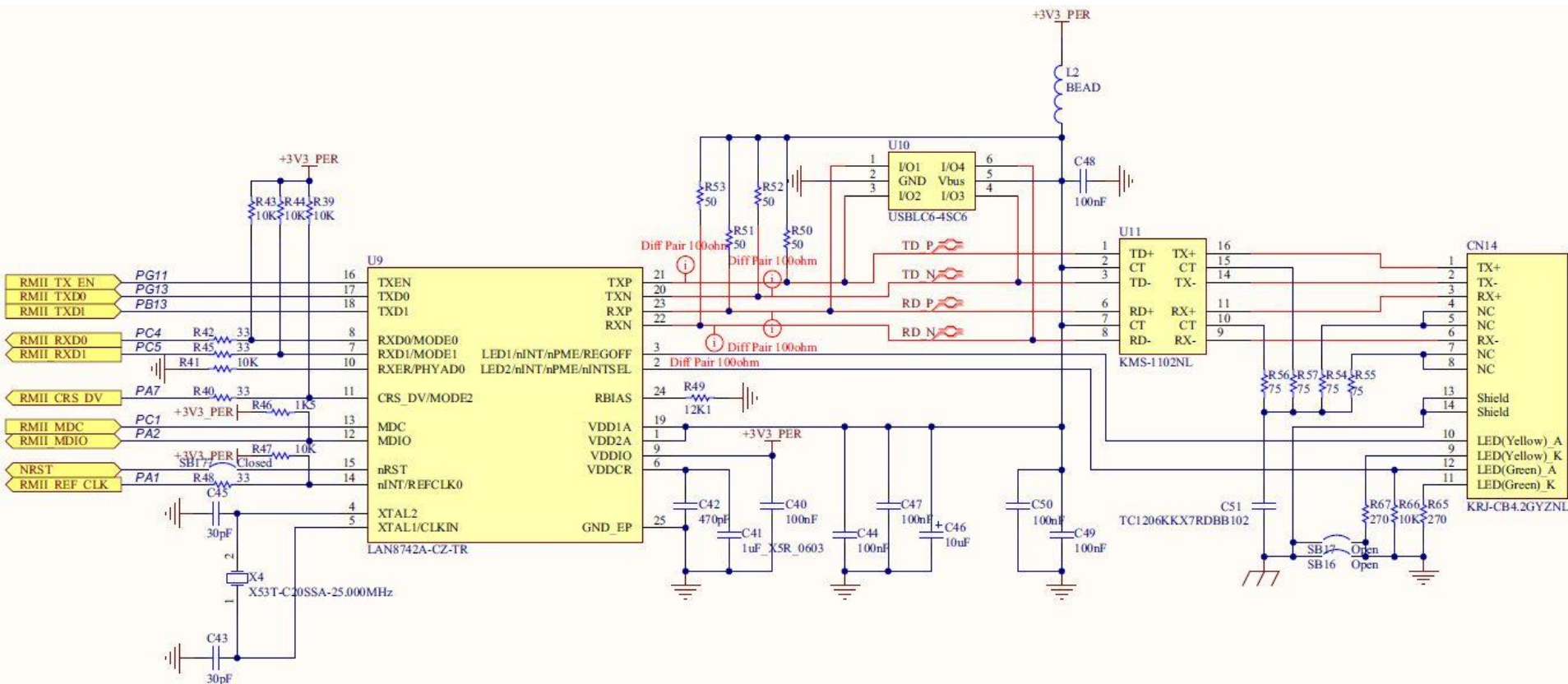
AGENDA

- Hardware – **The NUCLEO-F767ZI**
- Firmware – **STM32CubeMX: NUCLEO-F767ZI**
- Hardware – **STM32F4-Discovery**
- Firmware – **STM32CubeMX:STM32F407VG**
- **Day 4 Summary**



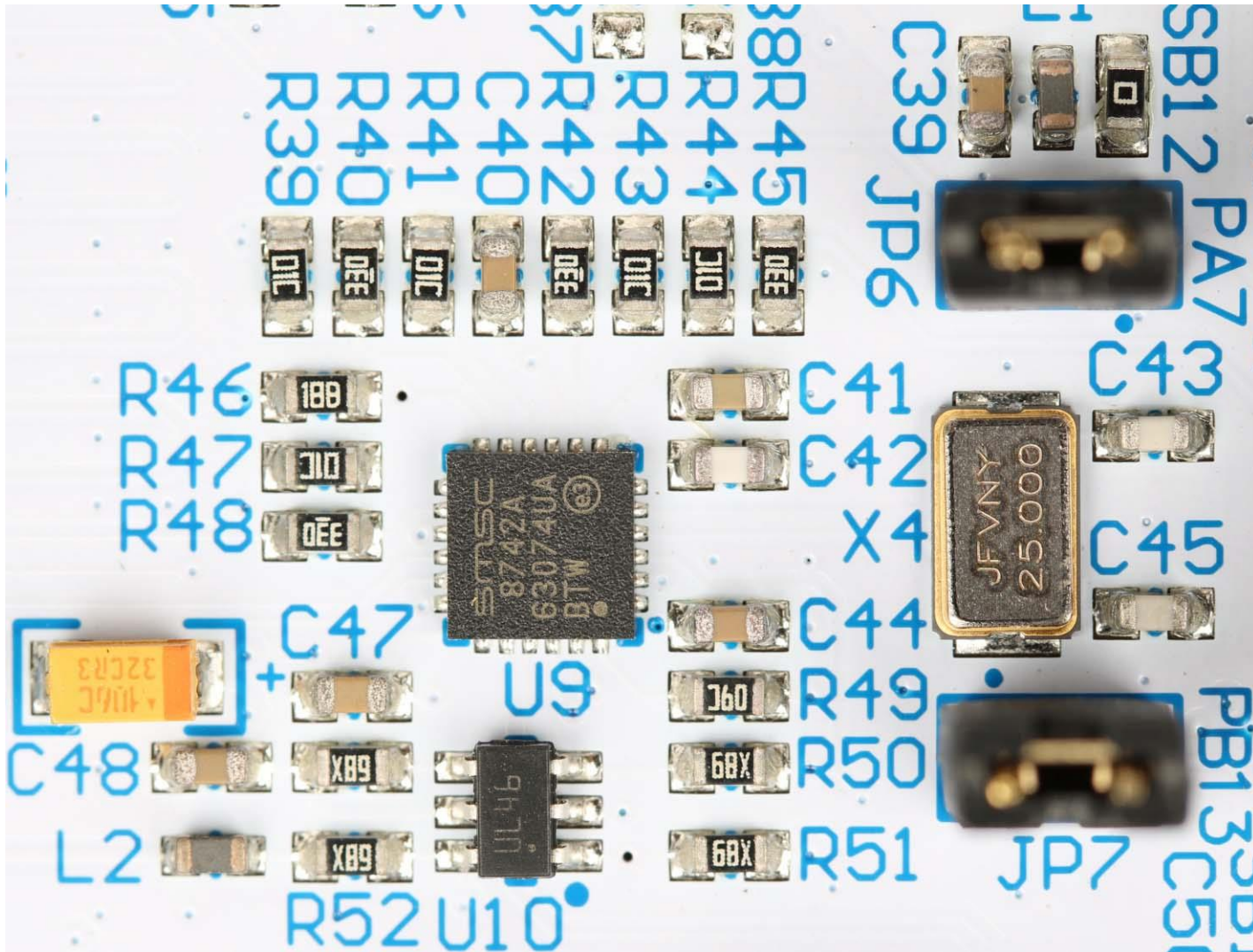
Easy TCP/IP for IoT

Hardware - NUCLEO-F767ZI: Ethernet Module - LAN8742A



Easy TCP/IP for IoT

Hardware - **NUCLEO-F767ZI**: Ethernet Module



Easy TCP/IP for IoT

Hardware - NUCLEO-F767ZI: Ethernet Module

ETH Mode and Configuration

Mode

Mode

☐ Activate Rx Err signal

Configuration

Reset Configuration

☒ Parameter Settings ☒ Advanced Parameters ☒ User Constants ☒ NVIC Settings ☒ GPIO Settings

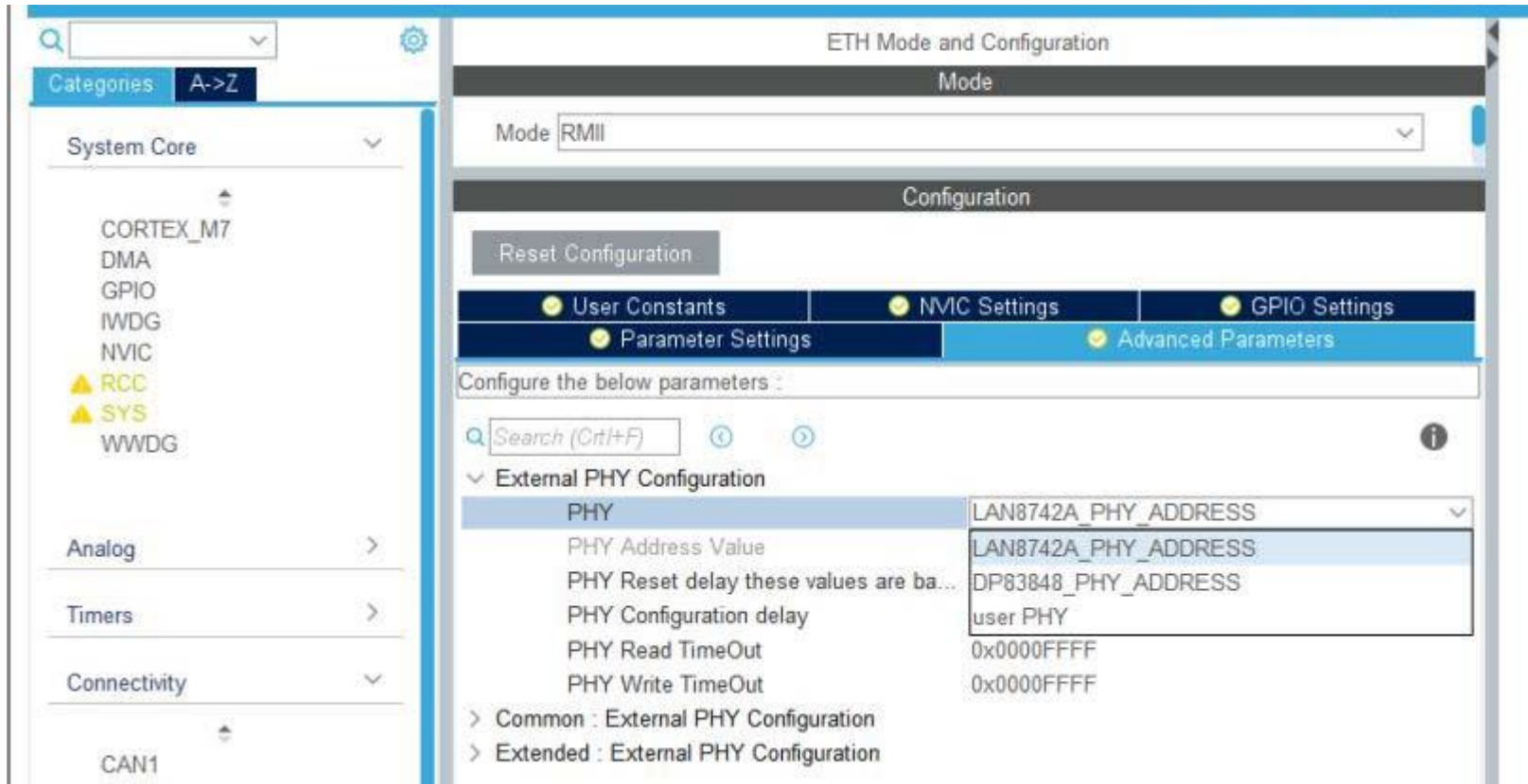
Search Signals

☐ Show only Modified Pins

Pin Name	Signal on Pin	GPIO output I...	GPIO mode	GPIO Pull-up/...	Maximum out...	Fast Mode	User Label	Modified
PA1	ETH_REF_CLK	n/a	Alternate Fun...	No pull-up and...	Very High	n/a	RMII_REF_CL...	<input checked="" type="checkbox"/>
PA2	ETH_MDIO	n/a	Alternate Fun...	No pull-up and...	Very High	n/a	RMII_MDIO [L...	<input checked="" type="checkbox"/>
PA7	ETH_CRS_DV	n/a	Alternate Fun...	No pull-up and...	Very High	n/a	RMII_CRS_D...	<input checked="" type="checkbox"/>
PB13	ETH_TXD1	n/a	Alternate Fun...	No pull-up and...	Very High	n/a	RMII_TXD1 [L...	<input checked="" type="checkbox"/>
PC1	ETH_MDC	n/a	Alternate Fun...	No pull-up and...	Very High	n/a	RMII_MDC [L...	<input checked="" type="checkbox"/>
PC4	ETH_RXD0	n/a	Alternate Fun...	No pull-up and...	Very High	n/a	RMII_RXD0 [L...	<input checked="" type="checkbox"/>
PC5	ETH_RXD1	n/a	Alternate Fun...	No pull-up and...	Very High	n/a	RMII_RXD1 [L...	<input checked="" type="checkbox"/>
PG11	ETH_TX_EN	n/a	Alternate Fun...	No pull-up and...	Very High	n/a	RMII_TX_EN [...	<input checked="" type="checkbox"/>
PG13	ETH_TXD0	n/a	Alternate Fun...	No pull-up and...	Very High	n/a	RMII_TXD0 [L...	<input checked="" type="checkbox"/>

Easy TCP/IP for IoT

Hardware - NUCLEO-F767ZI: Ethernet Module



Easy TCP/IP for IoT

Hardware - NUCLEO-F767ZI: Ethernet Module

ETH Mode and Configuration

Mode

Mode

☐ Activate Rx Err signal

Configuration

Reset Configuration

Parameter Settings Advanced Parameters User Constants NVM Settings GPIO Settings

Configure the below parameters :

Search (Ctrl+F) ⏪ ⏩ ⓘ

- Advanced : Ethernet Media Configuration
 - Auto Negotiation Enabled
- General : Ethernet Configuration
 - Ethernet MAC Address 00:80:E1:00:00:00
 - PHY Address 0
- Ethernet Basic Configuration
 - Rx Mode Polling Mode
 - TX IP Header Checksum Computation By hardware

Easy TCP/IP for IoT

Firmware - NUCLEO-F767ZI: lwIP Module-DHCP Disabled

LWIP Mode and Configuration

Mode

☒ Enabled

Configuration

Reset Configuration

<input checked="" type="checkbox"/> SNTP	<input checked="" type="checkbox"/> MDNS/TFTP	<input checked="" type="checkbox"/> Perf/Checks	<input checked="" type="checkbox"/> Statistics	<input checked="" type="checkbox"/> Checksum	<input checked="" type="checkbox"/> Debug	<input checked="" type="checkbox"/> User Constants
<input checked="" type="checkbox"/> General Settings	<input checked="" type="checkbox"/> Key Options	<input checked="" type="checkbox"/> PPP	<input checked="" type="checkbox"/> IPv6	<input checked="" type="checkbox"/> HTTPD	<input checked="" type="checkbox"/> SNMP	

Configure the below parameters :

▼ LwIP Version

LwIP Version (Version of LwIP supported by CubeMX ** CubeM... 2.0.3)

▼ IPv4 - DHCP Options

LWIP_DHCP (DHCP Module) Disabled

▼ IP Address Settings

IP_ADDRESS (IP Address) 192.168.010.010

NETMASK_ADDRESS (Netmask Address) 255.255.255.000

GATEWAY_ADDRESS (Gateway Address) 192.168.010.001

▼ RTOS Dependency

WITH_RTOS (Use FREERTOS ** CubeMX specific **) Disabled

▼ Protocols Options

LWIP_ICMP (ICMP Module Activation) Enabled

LWIP_IGMP (IGMP Module) Disabled

LWIP_DNS (DNS Module) Disabled

LWIP_UDP (UDP Module) Enabled

MEMP_NUM_UDP_PCB (Number of UDP Connections) 4

LWIP_TCP (TCP Module) Enabled

MEMP_NUM_TCP_PCB (Number of TCP Connections) 5

Easy TCP/IP for IoT

Firmware - NUCLEO-F767ZI: lwIP Module-DHCP Disabled

```
/**
 * LwIP initialization function
 */
void MX_LWIP_Init(void)
{
    /* IP addresses initialization */
    IP_ADDRESS[0] = 192;
    IP_ADDRESS[1] = 168;
    IP_ADDRESS[2] = 10;
    IP_ADDRESS[3] = 10;
    NETMASK_ADDRESS[0] = 255;
    NETMASK_ADDRESS[1] = 255;
    NETMASK_ADDRESS[2] = 255;
    NETMASK_ADDRESS[3] = 0;
    GATEWAY_ADDRESS[0] = 192;
    GATEWAY_ADDRESS[1] = 168;
    GATEWAY_ADDRESS[2] = 10;
    GATEWAY_ADDRESS[3] = 1;

    /* Initialize the LwIP stack without RTOS */
    lwip_init();

    /* IP addresses initialization without DHCP (IPv4) */
    IP4_ADDR(&ipaddr, IP_ADDRESS[0], IP_ADDRESS[1], IP_ADDRESS[2], IP_ADDRESS[3]);
    IP4_ADDR(&netmask, NETMASK_ADDRESS[0], NETMASK_ADDRESS[1], NETMASK_ADDRESS[2], NETMASK_ADDRESS[3]);
    IP4_ADDR(&gw, GATEWAY_ADDRESS[0], GATEWAY_ADDRESS[1], GATEWAY_ADDRESS[2], GATEWAY_ADDRESS[3]);
}
```

Easy TCP/IP for IoT

Firmware - NUCLEO-F767ZI: lwIP Module-DHCP Enabled

LWIP Mode and Configuration

Mode

☒ Enabled

Configuration

Reset Configuration

<input checked="" type="checkbox"/> MDNS/TFTP	<input checked="" type="checkbox"/> Perf/Checks	<input checked="" type="checkbox"/> Statistics	<input checked="" type="checkbox"/> Checksum	<input checked="" type="checkbox"/> Debug	<input checked="" type="checkbox"/> User Constants
<input checked="" type="checkbox"/> General Settings	<input checked="" type="checkbox"/> Key Options	<input checked="" type="checkbox"/> PPP	<input checked="" type="checkbox"/> IPv6	<input checked="" type="checkbox"/> HTTPD	<input checked="" type="checkbox"/> SNMP
<input checked="" type="checkbox"/> SNTP					

Configure the below parameters :

- ▼ LwIP Version
 - LwIP Version (Version of LwIP supported by Cube... 2.0.3
- ▼ IPv4 - DHCP Options
 - LWIP_DHCP (DHCP Module) Enabled
- ▼ RTOS Dependency
 - WITH_RTOS (Use FREERTOS ** CubeMX specifi... Disabled
- ▼ Protocols Options
 - LWIP_ICMP (ICMP Module Activation) Enabled
 - LWIP_IGMP (IGMP Module) Disabled
 - LWIP_DNS (DNS Module) Disabled
 - LWIP_UDP (UDP Module) Enabled
 - MEMP_NUM_UDP_PCB (Number of UDP Conne... 4
 - LWIP_TCP (TCP Module) Enabled
 - MEMP_NUM_TCP_PCB (Number of TCP Connec... 5

Easy TCP/IP for IoT

Firmware - NUCLEO-F767ZI: lwIP Module-DHCP Enabled

```
/**
 * LwIP initialization function
 */
void MX_LWIP_Init(void)
{
    /* Initilialize the LwIP stack without RTOS */
    lwip_init();

    /* IP addresses initialization with DHCP (IPv4) */
    ipaddr.addr = 0;
    netmask.addr = 0;
    gw.addr = 0;

    /* add the network interface (IPv4/IPv6) without RTOS */
    netif_add(&gnetif, &ipaddr, &netmask, &gw, NULL, &ethernetif_init, &ethernet_input);

    /* Registers the default network interface */
    netif_set_default(&gnetif);

    if (netif_is_link_up(&gnetif))
    {
        /* When the netif is fully configured this function must be called */
        netif_set_up(&gnetif);
    }
    else
    {
        /* When the netif link is down this function must be called */
        netif_set_down(&gnetif);
    }

    /* Start DHCP negotiation for a network interface (IPv4) */
    dhcp_start(&gnetif);
}
```


Easy TCP/IP for IoT

Firmware - NUCLEO-F767ZI: lwIP Module-DHCP Enabled

```
uint32_t addr;
extern struct netif gnetif;
//*****
/* PRINTF
//*****
int fputc(int ch, FILE *f)
{
    HAL_UART_Transmit(&huart3, (uint8_t *)&ch, 1, 0xFFFF);
    return ch;
}
```

Easy TCP/IP for IoT

Firmware - NUCLEO-F767ZI: lwIP Module-DHCP Enabled

```
int main(void)
{
    /* Reset of all peripherals, Initializes the Flash interface and the Systick. */
    HAL_Init();
    /* Configure the system clock */
    SystemClock_Config();
    /* Initialize all configured peripherals */
    MX_GPIO_Init();
    MX_USART3_UART_Init();
    MX_USB_OTG_FS_PCD_Init();
    MX_LWIP_Init();
    /* USER CODE BEGIN 2 */

    /* USER CODE END 2 */

    /* Infinite loop */
    /* USER CODE BEGIN WHILE */
    while (1)
    {
        MX_LWIP_Process();
        if(dhcp_supplied_address(&gnetif) )
        {
            printf("BOUND\r\n");
            addr = gnetif.ip_addr.addr;
        }
    }
}
```

Easy TCP/IP for IoT

Firmware - NUCLEO-F767ZI: lwIP Module-DHCP Enabled

BOUND

BOUND

BOUND

BOUND

BOUND

BOUND

BOUND

BOUND

BOUND

BOUND

Watch 1		
Name	Value	Type
gnetif	0x20000564 &gnetif	struct netif
next	0x00000000	struct netif *
ip_addr	0x20000568	struct ip4_addr
addr	0x6A0AA8C0	uint
netmask	0x2000056C	struct ip4_addr
addr	0x00FFFFFF	uint
gw	0x20000570	struct ip4_addr
addr	0x010AA8C0	uint
input	0x08005011 ethernet_i...	char f(struct pbuf *,str...
output	0x08004869 etharp_ou...	char f(struct netif *,str...
linkoutput	0x08006589 low_level_...	char f(struct netif *,str...
state	0x00000000	void *
[0]	0x00000000	void
client_data	0x20000584	void *[1]
rs_count	0x03	uchar
mtu	0x05DC	ushort
hwaddr_len	0x06	uchar
hwaddr	0x2000058D ""	uchar[6]
[0]	0x00	uchar
[1]	0x80 '€'	uchar
[2]	0xE1 'á'	uchar
[3]	0x00	uchar
[4]	0x00	uchar
[5]	0x00	uchar
flags	0x0F	uchar
name	0x20000594 "st"	uchar[2]
num	0x00	uchar
(null)	<cannot evaluate>	uchar
addr	0x6A0AA8C0	uint
<Enter expression>		

Easy TCP/IP for IoT

Firmware - NUCLEO-F767ZI: lwIP Module-DHCP Enabled

```
Microsoft Windows [Version 10.0.17763.737]
(c) 2018 Microsoft Corporation. All rights reserved.

C:\Users\fred>ping 192.168.10.106

Pinging 192.168.10.106 with 32 bytes of data:
Reply from 192.168.10.106: bytes=32 time<1ms TTL=255
Reply from 192.168.10.106: bytes=32 time<1ms TTL=255
Reply from 192.168.10.106: bytes=32 time<1ms TTL=255
Reply from 192.168.10.106: bytes=32 time<1ms TTL=255

Ping statistics for 192.168.10.106:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\fred>_
```

Easy TCP/IP for IoT

Firmware - NUCLEO-F767ZI: lwIP Module-DHCP Enabled

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
6	0.5191...	192.168.10.1	239.255.255.250	SSDP	4...	NOTIFY * HTTP/1.1
7	0.6236...	192.168.10.1	239.255.255.250	SSDP	4...	NOTIFY * HTTP/1.1
8	0.7273...	192.168.10.1	239.255.255.250	SSDP	4...	NOTIFY * HTTP/1.1
9	1.0266...	192.168.10.100	192.168.10.106	ICMP	74	Echo (ping) request id=0x0001, seq=67/17152, ttl=128 (reply in 12)
10	1.0272...	Stmicroe_00:00:00	Broadcast	ARP	60	Who has 192.168.10.100? Tell 192.168.10.106
11	1.0272...	Elitegro_f1:4f:36	Stmicroe_00:00:00	ARP	42	192.168.10.100 is at 94:c6:91:f1:4f:36
12	1.0279...	192.168.10.106	192.168.10.100	ICMP	74	Echo (ping) reply id=0x0001, seq=67/17152, ttl=255 (request in 9)
13	2.0289...	192.168.10.100	192.168.10.106	ICMP	74	Echo (ping) request id=0x0001, seq=68/17408, ttl=128 (reply in 14)
14	2.0297...	192.168.10.106	192.168.10.100	ICMP	74	Echo (ping) reply id=0x0001, seq=68/17408, ttl=255 (request in 13)
15	3.0323...	192.168.10.100	192.168.10.106	ICMP	74	Echo (ping) request id=0x0001, seq=69/17664, ttl=128 (reply in 16)
16	3.0333...	192.168.10.106	192.168.10.100	ICMP	74	Echo (ping) reply id=0x0001, seq=69/17664, ttl=255 (request in 15)
17	4.0366...	192.168.10.100	192.168.10.106	ICMP	74	Echo (ping) request id=0x0001, seq=70/17920, ttl=128 (reply in 18)
18	4.0376...	192.168.10.106	192.168.10.100	ICMP	74	Echo (ping) reply id=0x0001, seq=70/17920, ttl=255 (request in 17)
19	5.5734...	Elitegro_f1:4f:36	Stmicroe_00:00:00	ARP	42	Who has 192.168.10.106? Tell 192.168.10.100
20	5.5741...	Stmicroe_00:00:00	Elitegro_f1:4f:36	ARP	60	192.168.10.106 is at 00:80:e1:00:00:00

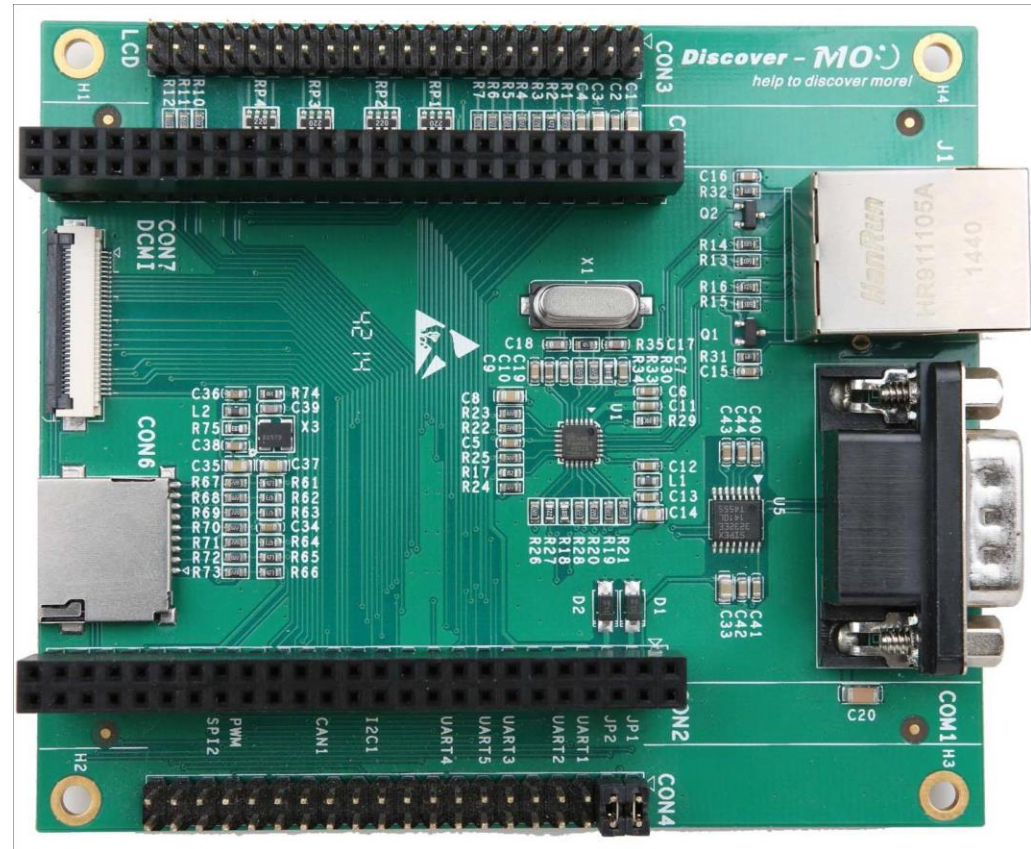
> Frame 17: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0
> Ethernet II, Src: Elitegro_f1:4f:36 (94:c6:91:f1:4f:36), Dst: Stmicroe_00:00:00 (00:80:e1:00:00:00)
> Internet Protocol Version 4, Src: 192.168.10.100, Dst: 192.168.10.106
> Internet Control Message Protocol

Bytes	0-5: Address (eth.addr)
0000	00 80 e1 00 00 00
0010	94 c6 91 f1 4f 36
0020	00 00 c0 a8 0a 64
0030	c0 a8 0a 6a 08 00
0040	4d 15 00 01 00 46

Packets: 20 - Displayed: 20 (100.0%) Profile: Default

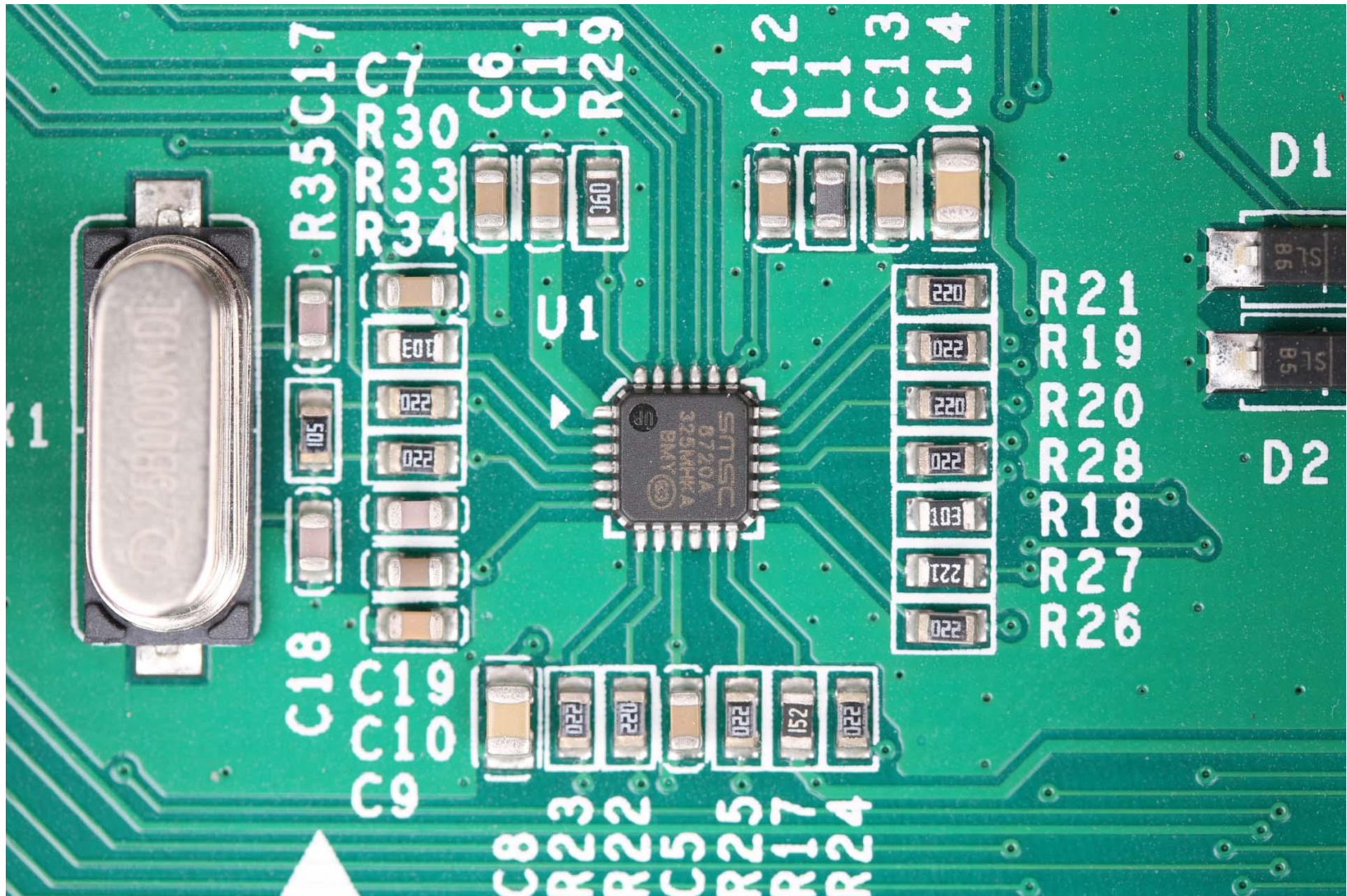
Easy TCP/IP for IoT

Hardware - STM32F4-Discovery

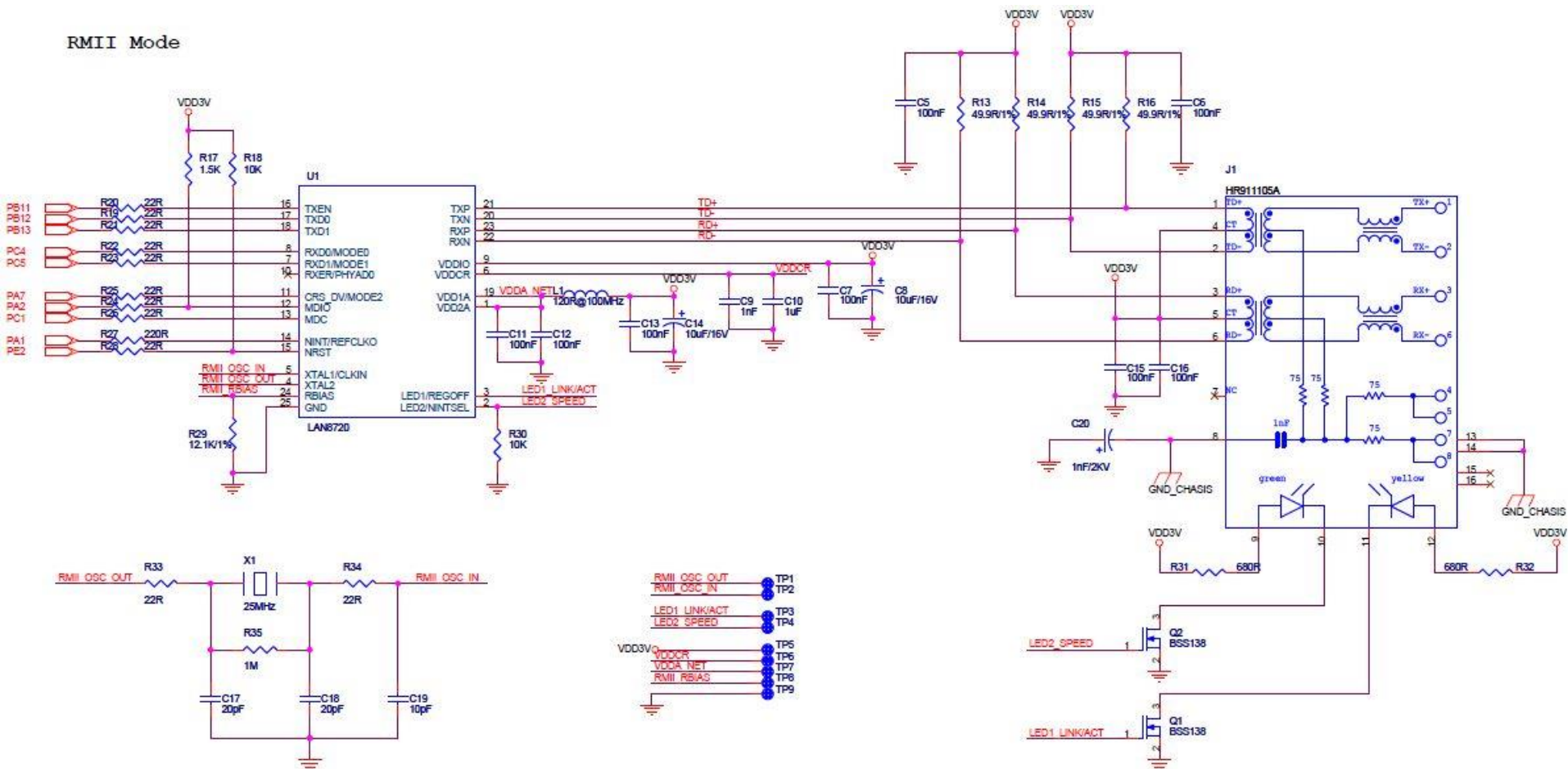


Easy TCP/IP for IoT

Hardware - **STMF4-Discovery**: Ethernet Module - LAN8720



Hardware - STMF4-Discovery: Ethernet Module - LAN8720



Easy TCP/IP for IoT

Hardware - STM4-Discovery: Ethernet Module

ETH Mode and Configuration

Mode

Mode

☐ Activate Rx Err signal

Configuration

Reset Configuration

✓ Parameter Settings | ✓ Advanced Parameters | ✓ User Constants | ✓ NVIC Settings | ✓ GPIO Settings

Configure the below parameters :

✓ Advanced : Ethernet Media Configuration

Auto Negotiation	Enabled
------------------	---------

✓ General : Ethernet Configuration

Ethernet MAC Address	00:80:E1:00:00:00
PHY Address	0

✓ Ethernet Basic Configuration

Rx Mode	Polling Mode
TX IP Header Checksum Computation	By hardware

Easy TCP/IP for IoT

Firmware - **STM4-Discovery**: lwIP Module - DHCP Disabled

```
Microsoft Windows [Version 10.0.17763.737]
(c) 2018 Microsoft Corporation. All rights reserved.

C:\Users\fred>ping 192.168.10.10

Pinging 192.168.10.10 with 32 bytes of data:
Reply from 192.168.10.10: bytes=32 time=1ms TTL=255
Reply from 192.168.10.10: bytes=32 time<1ms TTL=255
Reply from 192.168.10.10: bytes=32 time<1ms TTL=255
Reply from 192.168.10.10: bytes=32 time<1ms TTL=255

Ping statistics for 192.168.10.10:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 1ms, Average = 0ms

C:\Users\fred>
```

Easy TCP/IP for IoT

Firmware - STM4-Discovery: lwIP Module - DHCP Disabled

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/> Expression...

No.	Time	Source	Destination	Protocol	Length	Info
62	65.012...	192.168.10.1	192.168.10.100	DNS	70	Standard query response 0x66ee Refused A g.live.com
63	67.335...	192.168.10.100	192.168.10.10	ICMP	74	Echo (ping) request id=0x0001, seq=123/31488, ttl=128 (reply in 66)
64	67.336...	Stmicroe_00:00:00	Broadcast	ARP	60	Who has 192.168.10.100? Tell 192.168.10.10
65	67.336...	Elitegro_f1:4f:36	Stmicroe_00:00:00	ARP	42	192.168.10.100 is at 94:c6:91:f1:4f:36
66	67.336...	192.168.10.10	192.168.10.100	ICMP	74	Echo (ping) reply id=0x0001, seq=123/31488, ttl=255 (request in 63)
67	68.338...	192.168.10.100	192.168.10.10	ICMP	74	Echo (ping) request id=0x0001, seq=124/31744, ttl=128 (reply in 68)
68	68.339...	192.168.10.10	192.168.10.100	ICMP	74	Echo (ping) reply id=0x0001, seq=124/31744, ttl=255 (request in 67)
69	69.341...	192.168.10.100	192.168.10.10	ICMP	74	Echo (ping) request id=0x0001, seq=125/32000, ttl=128 (reply in 70)
70	69.342...	192.168.10.10	192.168.10.100	ICMP	74	Echo (ping) reply id=0x0001, seq=125/32000, ttl=255 (request in 69)
71	69.886...	192.168.10.1	239.255.255.250	SSDP	3...	NOTIFY * HTTP/1.1
72	69.989...	192.168.10.1	239.255.255.250	SSDP	3...	NOTIFY * HTTP/1.1
73	69.990...	Elitegro_f1:4f:36	BelkinIn_b7:cb:e0	ARP	42	Who has 192.168.10.1? Tell 192.168.10.100
74	69.991...	BelkinIn_b7:cb:e0	Elitegro_f1:4f:36	ARP	60	192.168.10.1 is at 58:ef:68:b7:cb:e0
75	70.093...	192.168.10.1	239.255.255.250	SSDP	3...	NOTIFY * HTTP/1.1
76	70.197...	192.168.10.1	239.255.255.250	SSDP	3...	NOTIFY * HTTP/1.1
77	70.201...	192.168.10.1	239.255.255.250	SSDP	3...	NOTIFY * HTTP/1.1

> Frame 1: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0
> Ethernet II, Src: Elitegro_f1:4f:36 (94:c6:91:f1:4f:36), Dst: BelkinIn_b7:cb:e0 (58:ef:68:b7:cb:e0)
> Internet Protocol Version 4, Src: 192.168.10.100, Dst: 192.168.10.1
> User Datagram Protocol, Src Port: 54350, Dst Port: 53
> Domain Name System (query)

Offset	Hex	ASCII
0000	58 ef 68 b7 cb e0 94 c6 91 f1 4f 36 08 00 45 00	X·h·...·06·E·
0010	00 38 e5 fe 00 00 80 11 00 00 c0 a8 0a 64 c0 a8	·8·...·d·
0020	0a 01 d4 4e 00 35 00 24 95 eb 36 e4 01 00 00 01	·N·5·\$·6·...·
0030	00 00 00 00 00 00 01 67 04 6c 69 76 65 03 63 6f	·...·g·live·co
0040	6d 00 00 01 00 01	m·...·

wireshark_Ethernet_20191012133316_a00700.pcapng Packets: 120 · Displayed: 120 (100.0%) Profile: Default

Easy TCP/IP for IoT

Day 4 Summary

