Ethernet

[中文]

Overview

ESP-IDF provides a set of consistent and flexible APIs to support both internal Ethernet MAC (EMAC) controller and external SPI-Ethernet modules.

This programming guide is split into the following sections:

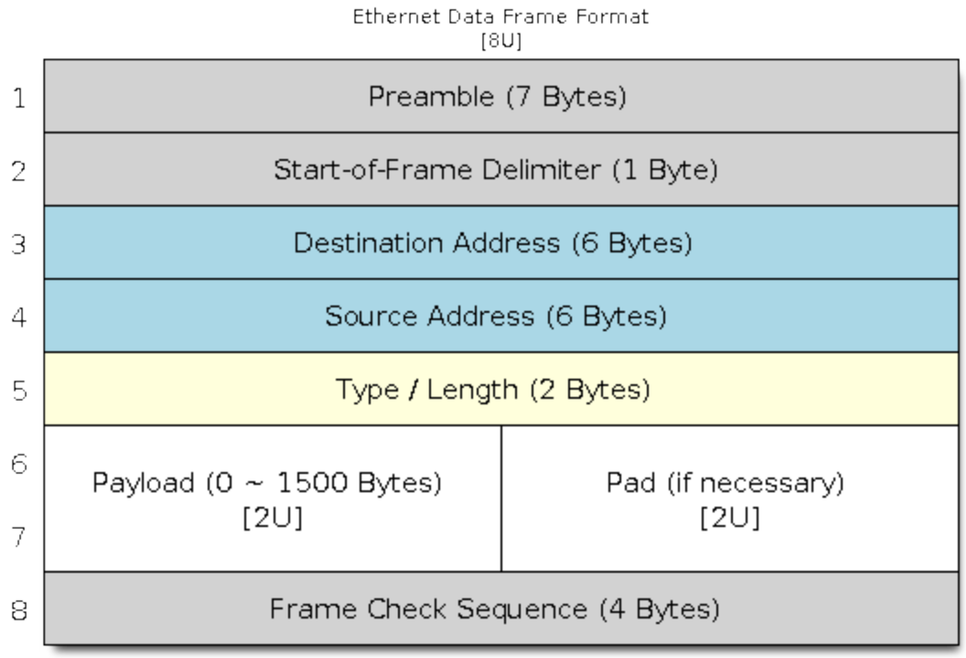
1. Basic Ethernet Concepts
2. Configure MAC and PHY
3. Connect Driver to TCP/IP Stack
4. Misc Control of Ethernet Driver

Basic Ethernet Concepts

Ethernet is an asynchronous Carrier Sense Multiple Access with Collision Detect (CSMA/CD) protocol/interface. It is generally not well suited for low-power applications. However, with ubiquitous deployment, internet connectivity, high data rates, and limitless-range expandability, Ethernet can accommodate nearly all wired communications.

Normal IEEE 802.3 compliant Ethernet frames are between 64 and 1518 bytes in length. They are made up of five or six different fields: a destination MAC address (DA), a source MAC address (SA), a type/length field, a data payload, an optional padding field and a Cyclic Redundancy Check (CRC). Additionally, when transmitted on the Ethernet medium, a 7-byte preamble field and Start-of-Frame (SOF) delimiter byte are appended to the beginning of the Ethernet packet.

Thus the traffic on the twist-pair cabling appears as shown below:



Ethernet Data Frame Format

Preamble and Start-of-Frame Delimiter

The preamble contains seven bytes of `55H`. It allows the receiver to lock onto the stream of data before the actual frame arrives.

The Start-of-Frame Delimiter (SFD) is a binary sequence `10101011` (as seen on the physical medium). It is sometimes considered to be part of the preamble.

When transmitting and receiving data, the preamble and SFD bytes will be automatically generated or stripped from the packets.

Destination Address

The destination address field contains a 6-byte length MAC address of the device that the packet is directed to. If the Least Significant bit in the first byte of the MAC address is set, the address is a multicast destination. For example, 01-00-00-00-F0-00 and 33-45-67-89-AB-CD are multi-cast addresses, while 00-00-00-00-F0-00 and 32-45-67-89-AB-CD are not.

Packets with multi-cast destination addresses are designed to arrive and be important to a selected group of Ethernet nodes. If the destination address field is the reserved multicast address, i.e., FF-FF-FF-FF-FF-FF, the packet is a broadcast packet and it will be directed to everyone sharing the network. If the Least Significant bit in the first byte of the MAC address is clear, the address is a unicast address and will be designed for usage by only the addressed node.

Normally the EMAC controller incorporates receive filters which can be used to discard or accept packets with multi-cast, broadcast and/or unicast destination addresses. When transmitting packets, the host controller is responsible for writing the desired destination address into the transmit buffer.

Source Address

The source address field contains a 6-byte length MAC address of the node which created the Ethernet packet. Users of Ethernet must generate a unique MAC address for each controller used. MAC addresses consist of two portions. The first three bytes are known as the

Organizationally Unique Identifier (OUI). OUIs are distributed by the IEEE. The last three bytes are address bytes at the discretion of the company that purchased the OUI. For more information about MAC Address used in ESP-IDF, please see MAC Address Allocation.

When transmitting packets, the assigned source MAC address must be written into the transmit buffer by the host controller.

Type/Length

The type/length field is a 2-byte field. If the value in this field is <= 1500 (decimal), it is considered a length field and it specifies the amount of non-padding data which follows in the data field. If the value is >= 1536, it represents the protocol the following packet data belongs to. The followings are the most common type values:

- IPv4 = 0800H
- IPv6 = 86DDH
- ARP = 0806H

Users implementing proprietary networks may choose to treat this field as a length field, while applications implementing protocols such as the Internet Protocol (IP) or Address Resolution Protocol (ARP), should program this field with the appropriate type defined by the protocol's specification when transmitting packets.

Payload

The payload field is a variable length field, anywhere from 0 to 1500 bytes. Larger data packets violates Ethernet standards and will be dropped by most Ethernet nodes.

This field contains the client data, such as an IP datagram.

Padding and FCS

The padding field is a variable length field added to meet the IEEE 802.3 specification requirements when small data payloads are used.

The DA, SA, type, payload, and padding of an Ethernet packet must be no smaller than 60 bytes in total. If the required 4-byte FCS field is added, packets must be no smaller than 64 bytes. If the payload field is less than 46-byte long, a padding field is required.

The FCS field is a 4-byte field that contains an industry-standard 32-bit CRC calculated with the data from the DA, SA, type, payload, and padding fields. Given the complexity of calculating a CRC, the hardware normally automatically generates a valid CRC and transmit it. Otherwise, the host controller must generate the CRC and place it in the transmit buffer.

Normally, the host controller does not need to concern itself with padding and the CRC which the hardware EMAC will also be able to automatically generate when transmitting and verify when receiving. However, the padding and CRC fields will be written into the receive buffer when packets arrive, so they may be evaluated by the host controller if needed.

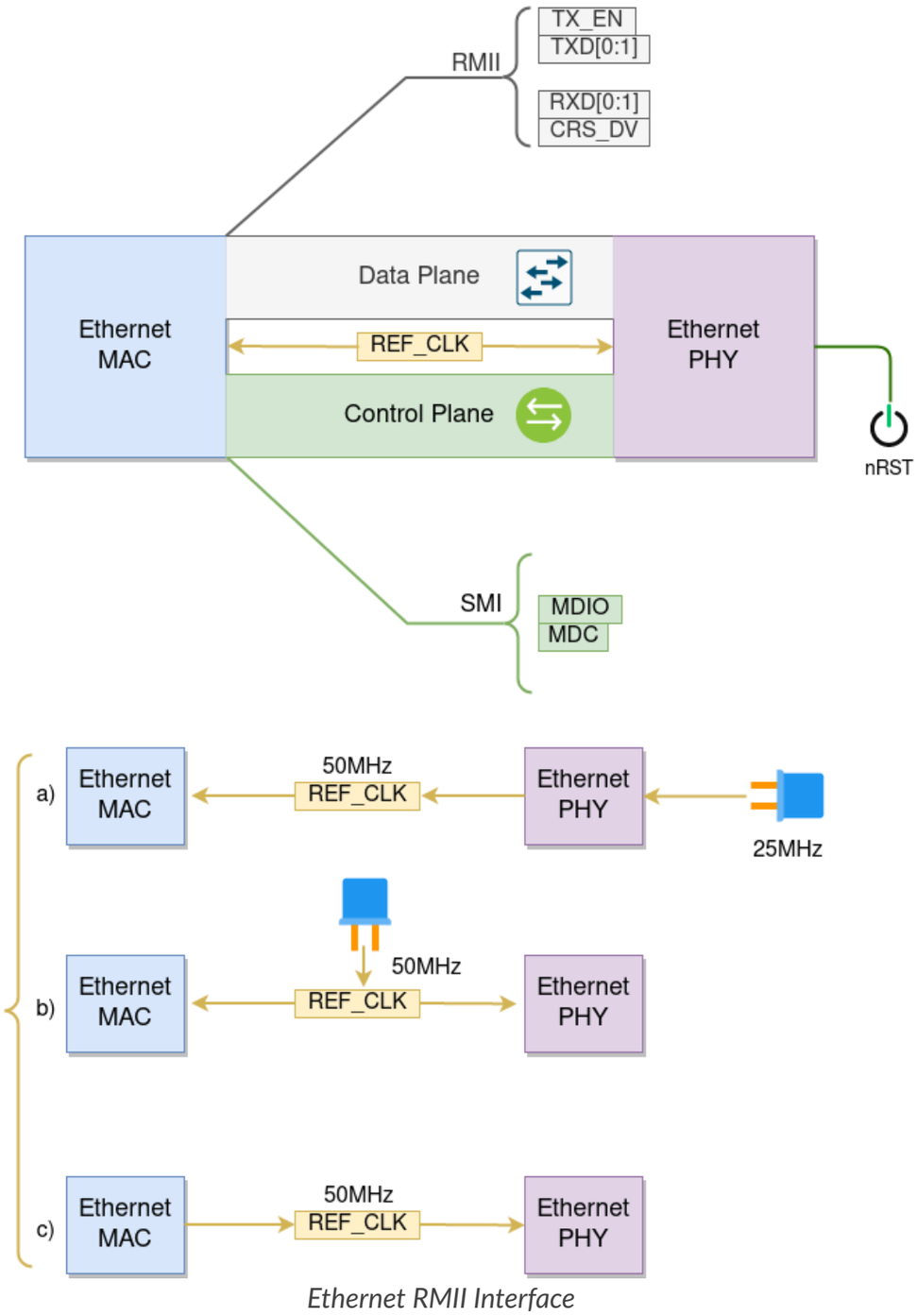
Note

Besides the basic data frame described above, there are two other common frame types in 10/100 Mbps Ethernet: control frames and VLAN-tagged frames. They are not supported in ESP-IDF.

Configure MAC and PHY

The Ethernet driver is composed of two parts: MAC and PHY.

The communication between MAC and PHY can have diverse choices: **MII** (Media Independent Interface), **RMII** (Reduced Media Independent Interface), etc.



Ethernet RMII Interface

One of the obvious differences between MII and RMII is signal consumption. MII usually costs up to 18 signals, while the RMII interface can reduce the consumption to 9.

In RMII mode, both the receiver and transmitter signals are referenced to the `REF_CLK`. **REF_CLK must be stable during any access to PHY and MAC**. Generally, there are three ways to generate the `REF_CLK` depending on the PHY device in your design:

- Some PHY chips can derive the `REF_CLK` from its externally connected 25 MHz crystal oscillator (as seen the option **a** in the picture). In this case, you should select `CONFIG_ETH_RMII_CLK_INPUT` in CONFIG_ETH_RMII_CLK_MODE.
- Some PHY chip uses an externally connected 50MHz crystal oscillator or other clock sources, which can also be used as the `REF_CLK` for the MAC side (as seen the option **b** in the picture). In this case, you still need to select `CONFIG_ETH_RMII_CLK_INPUT` in CONFIG_ETH_RMII_CLK_MODE.

- Some EMAC controllers can generate the `REF_CLK` using an internal high-precision PLL (as seen the option **c** in the picture). In this case, you should select `CONFIG_ETH_RMII_CLK_OUTPUT` in CONFIG_ETH_RMII_CLK_MODE.

Note

`REF_CLK` is configured via Project Configuration as described above by default. However, it can be overwritten from user application code by appropriately setting `eth_esp32_emac_config_t::interface` and `eth_esp32_emac_config_t::clock_config` members. See `emac_rmii_clock_mode_t` and `emac_rmii_clock_gpio_t` for more details.

Warning

If the RMII clock mode is selected to `CONFIG_ETH_RMII_CLK_OUTPUT`, then `GPIO0` can be used to output the `REF_CLK` signal. See CONFIG_ETH_RMII_CLK_OUTPUT_GPIO0 for more information.

What is more, if you are not using PSRAM in your design, GPIO16 and GPIO17 are also available to output the reference clock. See CONFIG_ETH_RMII_CLK_OUT_GPIO for more information.

If the RMII clock mode is selected to `CONFIG_ETH_RMII_CLK_INPUT`, then `GPIO0` is the only choice to input the `REF_CLK` signal. Please note that `GPIO0` is also an important strapping GPIO on ESP32. If GPIO0 samples a low level during power-up, ESP32 will go into download mode. The system will get halted until a manually reset. The workaround for this issue is disabling the `REF_CLK` in hardware by default so that the strapping pin is not interfered by other signals in the boot stage. Then, re-enable the `REF_CLK` in the Ethernet driver installation stage.

The ways to disable the `REF_CLK` signal can be:

- Disable or power down the crystal oscillator (as the case **b** in the picture).
- Force the PHY device to reset status (as the case **a** in the picture). **This could fail for some PHY device** (i.e., it still outputs signals to GPIO0 even in reset state).

No matter which RMII clock mode you select, you really need to take care of the signal integrity of REF_CLK in your hardware design! Keep the trace as short as possible. Keep it away from RF devices and inductor elements.

Note

ESP-IDF only supports the RMII interface (i.e., always select `CONFIG_ETH_PHY_INTERFACE_RMII` in the Kconfig option CONFIG_ETH_PHY_INTERFACE).

Signals used in the data plane are fixed to specific GPIOs via MUX, they can not be modified to other GPIOs. Signals used in the control plane can be routed to any free GPIOs via Matrix. Please refer to ESP32-Ethernet-Kit for hardware design example.

You need to set up the necessary parameters for MAC and PHY respectively based on your Ethernet board design, and then combine the two together to complete the driver installation.

Configuration for MAC is described in `eth_mac_config_t`, including:

- `eth_mac_config_t::sw_reset_timeout_ms`: software reset timeout value, in milliseconds. Typically, MAC reset should be finished within 100 ms.
- `eth_mac_config_t::rx_task_stack_size` and `eth_mac_config_t::rx_task_prio`: the MAC driver creates a dedicated task to process incoming packets. These two parameters are used to set the stack size and priority of the task.
- `eth_mac_config_t::flags`: specifying extra features that the MAC driver should have, it could be useful in some special situations. The value of this field can be OR'd with macros prefixed with `ETH_MAC_FLAG_`. For example, if the MAC driver should work when the cache is disabled, then you should configure this field with `ETH_MAC_FLAG_WORK_WITH_CACHE_DISABLE`.
- `eth_esp32_emac_config_t::smi_mdc_gpio_num` and `eth_esp32_emac_config_t::smi_mdio_gpio_num`: the GPIO number used to connect the SMI signals.
- `eth_esp32_emac_config_t::interface`: configuration of MAC Data interface to PHY (MII/RMII).
- `eth_esp32_emac_config_t::clock_config`: configuration of EMAC Interface clock (`REF_CLK` mode and GPIO number in case of RMII).

Configuration for PHY is described in `eth_phy_config_t`, including:

- `eth_phy_config_t::phy_addr`: multiple PHY devices can share the same SMI bus, so each PHY needs a unique address. Usually, this address is configured during hardware design by pulling up/down some PHY strapping pins. You can set the value from `0` to `15` based on your Ethernet board. Especially, if the SMI bus is shared by only one PHY device, setting this value to `-1` can enable the driver to detect the PHY address automatically.
- `eth_phy_config_t::reset_timeout_ms`: reset timeout value, in milliseconds. Typically, PHY reset should be finished within 100 ms.
- `eth_phy_config_t::autonego_timeout_ms`: auto-negotiation timeout value, in milliseconds. The Ethernet driver starts negotiation with the peer Ethernet node automatically, to determine to duplex and speed mode. This value usually depends on the ability of the PHY device on your board.
- `eth_phy_config_t::reset_gpio_num`: if your board also connects the PHY reset pin to one of the GPIO, then set it here. Otherwise, set this field to `-1`.

ESP-IDF provides a default configuration for MAC and PHY in macro `ETH_MAC_DEFAULT_CONFIG` and `ETH_PHY_DEFAULT_CONFIG`.

Create MAC and PHY Instance

The Ethernet driver is implemented in an Object-Oriented style. Any operation on MAC and PHY should be based on the instance of the two.

Internal EMAC + External PHY

```
eth_mac_config_t mac_config = ETH_MAC_DEFAULT_CONFIG();                     // apply default
common MAC configuration
eth_esp32_emac_config_t esp32_emac_config = ETH_ESP32_EMAC_DEFAULT_CONFIG(); // apply default
vendor-specific MAC configuration
esp32_emac_config.smi_mdc_gpio_num = CONFIG_EXAMPLE_ETH_MDC_GPIO;           // alter the GPIO
used for MDC signal
esp32_emac_config.smi_mdio_gpio_num = CONFIG_EXAMPLE_ETH_MDIO_GPIO;         // alter the GPIO
used for MDIO signal
esp_eth_mac_t *mac = esp_eth_mac_new_esp32(&esp32_emac_config, &mac_config); // create MAC
instance

eth_phy_config_t phy_config = ETH_PHY_DEFAULT_CONFIG();      // apply default PHY configuration
phy_config.phy_addr = CONFIG_EXAMPLE_ETH_PHY_ADDR;           // alter the PHY address according to
your board design
phy_config.reset_gpio_num = CONFIG_EXAMPLE_ETH_PHY_RST_GPIO; // alter the GPIO used for PHY reset
esp_eth_phy_t *phy = esp_eth_phy_new_ip101(&phy_config);     // create PHY instance
// ESP-IDF officially supports several different Ethernet PHY chip driver
// esp_eth_phy_t *phy = esp_eth_phy_new_rtl8201(&phy_config);
// esp_eth_phy_t *phy = esp_eth_phy_new_lan8720(&phy_config);
// esp_eth_phy_t *phy = esp_eth_phy_new_dp83848(&phy_config);
```

Optional Runtime MAC Clock Configuration

EMAC `REF_CLK` can be optionally configured from the user application code.

```
eth_esp32_emac_config_t esp32_emac_config = ETH_ESP32_EMAC_DEFAULT_CONFIG(); // apply default
vendor-specific MAC configuration

// ...

esp32_emac_config.interface = EMAC_DATA_INTERFACE_RMII;                     // alter EMAC Data
Interface
esp32_emac_config.clock_config.rmii.clock_mode = EMAC_CLK_OUT;              // select EMAC
REF_CLK mode
esp32_emac_config.clock_config.rmii.clock_gpio = EMAC_CLK_OUT_GPIO;         // select GPIO number
used to input/output EMAC REF_CLK
esp_eth_mac_t *mac = esp_eth_mac_new_esp32(&esp32_emac_config, &mac_config); // create MAC
instance
```

SPI-Ethernet Module

```
eth_mac_config_t mac_config = ETH_MAC_DEFAULT_CONFIG();      // apply default common MAC
configuration
eth_phy_config_t phy_config = ETH_PHY_DEFAULT_CONFIG();      // apply default PHY configuration
phy_config.phy_addr = CONFIG_EXAMPLE_ETH_PHY_ADDR;           // alter the PHY address according to
your board design
phy_config.reset_gpio_num = CONFIG_EXAMPLE_ETH_PHY_RST_GPIO; // alter the GPIO used for PHY reset
// Install GPIO interrupt service (as the SPI-Ethernet module is interrupt-driven)
gpio_install_isr_service(0);
// SPI bus configuration
spi_device_handle_t spi_handle = NULL;
spi_bus_config_t buscfg = {
    .miso_io_num = CONFIG_EXAMPLE_ETH_SPI_MISO_GPIO,
    .mosi_io_num = CONFIG_EXAMPLE_ETH_SPI_MOSI_GPIO,
    .sclk_io_num = CONFIG_EXAMPLE_ETH_SPI_SCLK_GPIO,
    .quadwp_io_num = -1,
    .quadhd_io_num = -1,
};
ESP_ERROR_CHECK(spi_bus_initialize(CONFIG_EXAMPLE_ETH_SPI_HOST, &buscfg, 1));
// Configure SPI device
spi_device_interface_config_t spi_devcfg = {
    .mode = 0,
    .clock_speed_hz = CONFIG_EXAMPLE_ETH_SPI_CLOCK_MHZ * 1000 * 1000,
    .spics_io_num = CONFIG_EXAMPLE_ETH_SPI_CS_GPIO,
    .queue_size = 20
};
/* dm9051 ethernet driver is based on spi driver */
eth_dm9051_config_t dm9051_config = ETH_DM9051_DEFAULT_CONFIG(CONFIG_EXAMPLE_ETH_SPI_HOST,
&spi_devcfg);
dm9051_config.int_gpio_num = CONFIG_EXAMPLE_ETH_SPI_INT_GPIO;
esp_eth_mac_t *mac = esp_eth_mac_new_dm9051(&dm9051_config, &mac_config);
esp_eth_phy_t *phy = esp_eth_phy_new_dm9051(&phy_config);
```

Note

- When creating MAC and PHY instances for SPI-Ethernet modules (e.g., DM9051), the constructor function must have the same suffix (e.g., *esp_eth_mac_new_dm9051* and *esp_eth_phy_new_dm9051*). This is because we don not have other choices but the integrated PHY.
- The SPI device configuration (i.e., *spi_device_interface_config_t*) may slightly differ for other Ethernet modules or to meet SPI timing on specific PCB. Please check out your module's specs and the examples in ESP-IDF.

Install Driver

To install the Ethernet driver, we need to combine the instance of MAC and PHY and set some additional high-level configurations (i.e., not specific to either MAC or PHY) in `esp_eth_config_t`:

- `esp_eth_config_t::mac`: instance that created from MAC generator (e.g., `esp_eth_mac_new_esp32()`).
- `esp_eth_config_t::phy`: instance that created from PHY generator (e.g., `esp_eth_phy_new_ip101()`).
- `esp_eth_config_t::check_link_period_ms`: Ethernet driver starts an OS timer to check the link status periodically, this field is used to set the interval, in milliseconds.
- `esp_eth_config_t::stack_input`: In most Ethernet IoT applications, any Ethernet frame received by a driver should be passed to the upper layer (e.g., TCP/IP stack). This field is set to a function that is responsible to deal with the incoming frames. You can even update this field at runtime via function `esp_eth_update_input_path()` after driver installation.

- `esp_eth_config_t::on_lowlevel_init_done` and `esp_eth_config_t::on_lowlevel_deinit_done`: These two fields are used to specify the hooks which get invoked when low-level hardware has been initialized or de-initialized.

ESP-IDF provides a default configuration for driver installation in macro `ETH_DEFAULT_CONFIG`.

```
esp_eth_config_t config = ETH_DEFAULT_CONFIG(mac, phy); // apply default driver configuration
esp_eth_handle_t eth_handle = NULL; // after the driver is installed, we will get the handle of the driver
esp_eth_driver_install(&config, &eth_handle); // install driver
```

The Ethernet driver also includes an event-driven model, which sends useful and important events to user space. We need to initialize the event loop before installing the Ethernet driver. For more information about event-driven programming, please refer to ESP Event.

```
/** Event handler for Ethernet events */
static void eth_event_handler(void *arg, esp_event_base_t event_base,
                              int32_t event_id, void *event_data)
{
    uint8_t mac_addr[6] = {0};
    /* we can get the ethernet driver handle from event data */
    esp_eth_handle_t eth_handle = *(esp_eth_handle_t *)event_data;

    switch (event_id) {
    case ETHERNET_EVENT_CONNECTED:
        esp_eth_ioctl(eth_handle, ETH_CMD_G_MAC_ADDR, mac_addr);
        ESP_LOGI(TAG, "Ethernet Link Up");
        ESP_LOGI(TAG, "Ethernet HW Addr %02x:%02x:%02x:%02x:%02x:%02x",
                 mac_addr[0], mac_addr[1], mac_addr[2], mac_addr[3], mac_addr[4], mac_addr[5]);
        break;
    case ETHERNET_EVENT_DISCONNECTED:
        ESP_LOGI(TAG, "Ethernet Link Down");
        break;
    case ETHERNET_EVENT_START:
        ESP_LOGI(TAG, "Ethernet Started");
        break;
    case ETHERNET_EVENT_STOP:
        ESP_LOGI(TAG, "Ethernet Stopped");
        break;
    default:
        break;
    }
}

esp_event_loop_create_default(); // create a default event loop that runs in the background
esp_event_handler_register(ETH_EVENT, ESP_EVENT_ANY_ID, &eth_event_handler, NULL); // register Ethernet event handler (to deal with user-specific stuff when events like link up/down happened)
```

Start Ethernet Driver

After driver installation, we can start Ethernet immediately.

```
esp_eth_start(eth_handle); // start Ethernet driver state machine
```

Connect Driver to TCP/IP Stack

Up until now, we have installed the Ethernet driver. From the view of OSI (Open System Interconnection), we are still on level 2 (i.e., Data Link Layer). While we can detect link up and down events and gain MAC address in user space, it is infeasible to obtain the IP address, let

alone send an HTTP request. The TCP/IP stack used in ESP-IDF is called LwIP. For more information about it, please refer to LwIP.

To connect the Ethernet driver to TCP/IP stack, follow these three steps:

1. Create a network interface for the Ethernet driver
2. Attach the network interface to the Ethernet driver
3. Register IP event handlers

For more information about the network interface, please refer to Network Interface.

```
/** Event handler for IP_EVENT_ETH_GOT_IP */
static void got_ip_event_handler(void *arg, esp_event_base_t event_base,
                                 int32_t event_id, void *event_data)
{
    ip_event_got_ip_t *event = (ip_event_got_ip_t *) event_data;
    const esp_netif_ip_info_t *ip_info = &event->ip_info;

    ESP_LOGI(TAG, "Ethernet Got IP Address");
    ESP_LOGI(TAG, "~~~~~~~~~~~");
    ESP_LOGI(TAG, "ETHIP:" IPSTR, IP2STR(&ip_info->ip));
    ESP_LOGI(TAG, "ETHMASK:" IPSTR, IP2STR(&ip_info->netmask));
    ESP_LOGI(TAG, "ETHGW:" IPSTR, IP2STR(&ip_info->gw));
    ESP_LOGI(TAG, "~~~~~~~~~~~");
}

esp_netif_init()); // Initialize TCP/IP network interface (should be called only once in
application)
esp_netif_config_t cfg = ESP_NETIF_DEFAULT_ETH(); // apply default network interface configuration
for Ethernet
esp_netif_t *eth_netif = esp_netif_new(&cfg); // create network interface for Ethernet driver

esp_netif_attach(eth_netif, esp_eth_new_netif_glue(eth_handle)); // attach Ethernet driver to
TCP/IP stack
esp_event_handler_register(IP_EVENT, IP_EVENT_ETH_GOT_IP, &got_ip_event_handler, NULL); //
register user defined IP event handlers
esp_eth_start(eth_handle); // start Ethernet driver state machine
```

Warning

It is recommended to fully initialize the Ethernet driver and network interface before registering the user's Ethernet/IP event handlers, i.e., register the event handlers as the last thing prior to starting the Ethernet driver. Such an approach ensures that Ethernet/IP events get executed first by the Ethernet driver or network interface so the system is in the expected state when executing the user's handlers.

Misc Control of Ethernet Driver

The following functions should only be invoked after the Ethernet driver has been installed.

- Stop Ethernet driver: `esp_eth_stop()`
- Update Ethernet data input path: `esp_eth_update_input_path()`
- Misc get/set of Ethernet driver attributes: `esp_eth_ioctl()`

```
/* get MAC address */
uint8_t mac_addr[6];
memset(mac_addr, 0, sizeof(mac_addr));
esp_eth_ioctl(eth_handle, ETH_CMD_G_MAC_ADDR, mac_addr);
ESP_LOGI(TAG, "Ethernet MAC Address: %02x:%02x:%02x:%02x:%02x:%02x",
         mac_addr[0], mac_addr[1], mac_addr[2], mac_addr[3], mac_addr[4], mac_addr[5]);

/* get PHY address */
int phy_addr = -1;
esp_eth_ioctl(eth_handle, ETH_CMD_G_PHY_ADDR, &phy_addr);
ESP_LOGI(TAG, "Ethernet PHY Address: %d", phy_addr);
```

Flow Control

Ethernet on MCU usually has a limitation in the number of frames it can handle during network congestion, because of the limitation in RAM size. A sending station might be transmitting data faster than the peer end can accept it. The ethernet flow control mechanism allows the receiving node to signal the sender requesting the suspension of transmissions until the receiver catches up. The magic behind that is the pause frame, which was defined in IEEE 802.3x.

Pause frame is a special Ethernet frame used to carry the pause command, whose EtherType field is `0x8808`, with the Control opcode set to `0x0001`. Only stations configured for full-duplex operation may send pause frames. When a station wishes to pause the other end of a link, it sends a pause frame to the 48-bit reserved multicast address of `01-80-C2-00-00-01`. The pause frame also includes the period of pause time being requested, in the form of a two-byte integer, ranging from `0` to `65535`.

After the Ethernet driver installation, the flow control feature is disabled by default. You can enable it by:

```
bool flow_ctrl_enable = true;
esp_eth_ioctl(eth_handle, ETH_CMD_S_FLOW_CTRL, &flow_ctrl_enable);
```

One thing that should be kept in mind is that the pause frame ability is advertised to the peer end by PHY during auto-negotiation. The Ethernet driver sends a pause frame only when both sides of the link support it.

Application Examples

- Ethernet basic example: ethernet/basic
- Ethernet iperf example: ethernet/iperf
- Ethernet to Wi-Fi AP "router": network/eth2ap
- Wi-Fi station to Ethernet "bridge": network/sta2eth
- Most protocol examples should also work for Ethernet: protocols

Advanced Topics

Custom PHY Driver

There are multiple PHY manufacturers with wide portfolios of chips available. The ESP-IDF already supports several PHY chips however one can easily get to a point where none of them satisfies the user's actual needs due to price, features, stock availability, etc.

Luckily, a management interface between EMAC and PHY is standardized by IEEE 802.3 in Section 22.2.4 Management Functions. It defines provisions of the so-called "MII Management Interface" to control the PHY and gather status from the PHY. A set of management registers is defined to control chip behavior, link properties, auto-negotiation configuration, etc. This basic management functionality is addressed by esp_eth/src/esp_eth_phy_802_3.c in ESP-IDF and so it makes the creation of a new custom PHY chip driver quite a simple task.

Note

Always consult with PHY datasheet since some PHY chips may not comply with IEEE 802.3, Section 22.2.4. It does not mean you are not able to create a custom PHY driver, but it just requires more effort. You will have to define all PHY management functions.

The majority of PHY management functionality required by the ESP-IDF Ethernet driver is covered by the esp_eth/src/esp_eth_phy_802_3.c. However, the following may require developing chip-specific management functions:

- Link status which is almost always chip-specific
- Chip initialization, even though not strictly required, should be customized to at least ensure that the expected chip is used
- Chip-specific features configuration

Steps to create a custom PHY driver:

1. Define vendor-specific registry layout based on the PHY datasheet. See esp_eth/src/esp_eth_phy_ip101.c as an example.
2. Prepare derived PHY management object info structure which:
    - must contain at least parent IEEE 802.3 `phy_802_3_t` object
    - optionally contain additional variables needed to support non-IEEE 802.3 or customized functionality. See esp_eth/src/esp_eth_phy_ksz80xx.c as an example.
3. Define chip-specific management call-back functions.
4. Initialize parent IEEE 802.3 object and re-assign chip-specific management call-back functions.

Once you finish the new custom PHY driver implementation, consider sharing it among other users via IDF Component Registry.

API Reference

Header File

- components/esp_eth/include/esp_eth.h
- This header file can be included with:

```
#include "esp_eth.h"
```

- This header file is a part of the API provided by the `esp_eth` component. To declare that your component depends on `esp_eth`, add the following to your CMakeLists.txt:

```
REQUIRES esp_eth
```

or

```
PRIV_REQUIRES esp_eth
```

Header File

- components/esp_eth/include/esp_eth_driver.h
- This header file can be included with:

```
#include "esp_eth_driver.h"
```

- This header file is a part of the API provided by the `esp_eth` component. To declare that your component depends on `esp_eth`, add the following to your CMakeLists.txt:

```
REQUIRES esp_eth
```

or

```
PRIV_REQUIRES esp_eth
```

Functions

esp_err_t **esp_eth_driver_install**(*const* esp_eth_config_t *config, esp_eth_handle_t *out_hdl)

Install Ethernet driver.

Parameters:
- **config** -- **[in]** configuration of the Ethernet driver
- **out_hdl** -- **[out]** handle of Ethernet driver

Returns:
- ESP_OK: install esp_eth driver successfully
- ESP_ERR_INVALID_ARG: install esp_eth driver failed because of some invalid argument
- ESP_ERR_NO_MEM: install esp_eth driver failed because there's no memory for driver
- ESP_FAIL: install esp_eth driver failed because some other error occurred

esp_err_t **esp_eth_driver_uninstall**(esp_eth_handle_t hdl)

Uninstall Ethernet driver.

Note

It's not recommended to uninstall Ethernet driver unless it won't get used any more in application code. To uninstall Ethernet driver, you have to make sure, all references to the driver are released. Ethernet driver can only be uninstalled successfully when reference

counter equals to one.

Parameters: **hdl** -- **[in]** handle of Ethernet driver

Returns:

- ESP_OK: uninstall esp_eth driver successfully
- ESP_ERR_INVALID_ARG: uninstall esp_eth driver failed because of some invalid argument
- ESP_ERR_INVALID_STATE: uninstall esp_eth driver failed because it has more than one reference
- ESP_FAIL: uninstall esp_eth driver failed because some other error occurred

esp_err_t **esp_eth_start**(esp_eth_handle_t hdl)

Start Ethernet driver **ONLY** in standalone mode (i.e. without TCP/IP stack)

Note

This API will start driver state machine and internal software timer (for checking link status).

Parameters: **hdl** -- **[in]** handle of Ethernet driver

Returns:

- ESP_OK: start esp_eth driver successfully
- ESP_ERR_INVALID_ARG: start esp_eth driver failed because of some invalid argument
- ESP_ERR_INVALID_STATE: start esp_eth driver failed because driver has started already
- ESP_FAIL: start esp_eth driver failed because some other error occurred

esp_err_t **esp_eth_stop**(esp_eth_handle_t hdl)

Stop Ethernet driver.

Note

This function does the oppsite operation of `esp_eth_start`.

Parameters: **hdl** -- **[in]** handle of Ethernet driver

Returns:

- ESP_OK: stop esp_eth driver successfully
- ESP_ERR_INVALID_ARG: stop esp_eth driver failed because of some invalid argument
- ESP_ERR_INVALID_STATE: stop esp_eth driver failed because driver has not started yet
- ESP_FAIL: stop esp_eth driver failed because some other error occurred

esp_err_t **esp_eth_update_input_path**(esp_eth_handle_t hdl, esp_err_t (*stack_input)(esp_eth_handle_t hdl, uint8_t *buffer, uint32_t length, void *priv), void *priv)

Update Ethernet data input path (i.e. specify where to pass the input buffer)

Note

After install driver, Ethernet still don't know where to deliver the input buffer. In fact, this API registers a callback function which get invoked when Ethernet received new packets.

Parameters:
- **hdl** -- **[in]** handle of Ethernet driver
- **stack_input** -- **[in]** function pointer, which does the actual process on incoming packets
- **priv** -- **[in]** private resource, which gets passed to `stack_input` callback without any modification

Returns:
- ESP_OK: update input path successfully
- ESP_ERR_INVALID_ARG: update input path failed because of some invalid argument
- ESP_FAIL: update input path failed because some other error occurred

esp_err_t esp_eth_transmit(esp_eth_handle_t hdl, void *buf, size_t length)

General Transmit.

Parameters:
- **hdl** -- **[in]** handle of Ethernet driver
- **buf** -- **[in]** buffer of the packet to transfer
- **length** -- **[in]** length of the buffer to transfer

Returns:
- ESP_OK: transmit frame buffer successfully
- ESP_ERR_INVALID_ARG: transmit frame buffer failed because of some invalid argument
- ESP_ERR_INVALID_STATE: invalid driver state (e.i. driver is not started)
- ESP_ERR_TIMEOUT: transmit frame buffer failed because HW was not get available in predefined period
- ESP_FAIL: transmit frame buffer failed because some other error occurred

esp_err_t esp_eth_transmit_vargs(esp_eth_handle_t hdl, uint32_t argc, ...)

Special Transmit with variable number of arguments.

Parameters:
- **hdl** -- **[in]** handle of Ethernet driver
- **argc** -- **[in]** number variable arguments
- **...** -- variable arguments

Returns:
- ESP_OK: transmit successfull
- ESP_ERR_INVALID_STATE: invalid driver state (e.i. driver is not started)
- ESP_ERR_TIMEOUT: transmit frame buffer failed because HW was not get available in predefined period
- ESP_FAIL: transmit frame buffer failed because some other error occurred

esp_err_t esp_eth_ioctl(esp_eth_handle_t hdl, esp_eth_io_cmd_t cmd, void *data)

Misc IO function of Etherent driver.

The following common IO control commands are supported:

- `ETH_CMD_S_MAC_ADDR` sets Ethernet interface MAC address. `data` argument is pointer to MAC address buffer with expected size of 6 bytes.

- `ETH_CMD_G_MAC_ADDR` gets Ethernet interface MAC address. `data` argument is pointer to a buffer to which MAC address is to be copied. The buffer size must be at least 6 bytes.
- `ETH_CMD_S_PHY_ADDR` sets PHY address in range of <0-31>. `data` argument is pointer to memory of uint32_t datatype from where the configuration option is read.
- `ETH_CMD_G_PHY_ADDR` gets PHY address. `data` argument is pointer to memory of uint32_t datatype to which the PHY address is to be stored.
- `ETH_CMD_S_AUTONEGO` enables or disables Ethernet link speed and duplex mode autonegotiation. `data` argument is pointer to memory of bool datatype from which the configuration option is read. Preconditions: Ethernet driver needs to be stopped.
- `ETH_CMD_G_AUTONEGO` gets current configuration of the Ethernet link speed and duplex mode autonegotiation. `data` argument is pointer to memory of bool datatype to which the current configuration is to be stored.
- `ETH_CMD_S_SPEED` sets the Ethernet link speed. `data` argument is pointer to memory of eth_speed_t datatype from which the configuration option is read. Preconditions: Ethernet driver needs to be stopped and auto-negotiation disabled.
- `ETH_CMD_G_SPEED` gets current Ethernet link speed. `data` argument is pointer to memory of eth_speed_t datatype to which the speed is to be stored.
- `ETH_CMD_S_PROMISCUOUS` sets/resets Ethernet interface promiscuous mode. `data` argument is pointer to memory of bool datatype from which the configuration option is read.
- `ETH_CMD_S_FLOW_CTRL` sets/resets Ethernet interface flow control. `data` argument is pointer to memory of bool datatype from which the configuration option is read.
- `ETH_CMD_S_DUPLEX_MODE` sets the Ethernet duplex mode. `data` argument is pointer to memory of eth_duplex_t datatype from which the configuration option is read. Preconditions: Ethernet driver needs to be stopped and auto-negotiation disabled.
- `ETH_CMD_G_DUPLEX_MODE` gets current Ethernet link duplex mode. `data` argument is pointer to memory of eth_duplex_t datatype to which the duplex mode is to be stored.
- `ETH_CMD_S_PHY_LOOPBACK` sets/resets PHY to/from loopback mode. `data` argument is pointer to memory of bool datatype from which the configuration option is read.

- Note that additional control commands may be available for specific MAC or PHY chips. Please consult specific MAC or PHY documentation or driver code.

Parameters:

- **hdl** -- **[in]** handle of Ethernet driver
- **cmd** -- **[in]** IO control command
- **data** -- **[inout]** address of data for `set` command or address where to store the data when used with `get` command

Returns:

- ESP_OK: process io command successfully
- ESP_ERR_INVALID_ARG: process io command failed because of some invalid argument
- ESP_FAIL: process io command failed because some other error occurred
- ESP_ERR_NOT_SUPPORTED: requested feature is not supported

esp_err_t **esp_eth_increase_reference**(esp_eth_handle_t hdl)

Increase Ethernet driver reference.

Note

Ethernet driver handle can be obtained by os timer, netif, etc. It's dangerous when thread A is using Ethernet but thread B uninstall the driver. Using reference counter can prevent such risk, but care should be taken, when you obtain Ethernet driver, this API must be invoked so that the driver won't be uninstalled during your using time.

Parameters: **hdl** -- **[in]** handle of Ethernet driver

Returns:

- ESP_OK: increase reference successfully
- ESP_ERR_INVALID_ARG: increase reference failed because of some invalid argument

esp_err_t **esp_eth_decrease_reference**(esp_eth_handle_t hdl)

Decrease Ethernet driver reference.

Parameters: **hdl** -- **[in]** handle of Ethernet driver

Returns:

- ESP_OK: increase reference successfully
- ESP_ERR_INVALID_ARG: increase reference failed because of some invalid argument

Structures

struct **esp_eth_config_t**

Configuration of Ethernet driver.

Public Members

esp_eth_mac_t ***mac**

Ethernet MAC object.

esp_eth_phy_t ***phy**

Ethernet PHY object.

uint32_t **check_link_period_ms**

Period time of checking Ethernet link status.

esp_err_t (***stack_input**)(esp_eth_handle_t eth_handle, uint8_t *buffer, uint32_t length, void *priv)

Input frame buffer to user's stack.

Param eth_handle: **[in]** handle of Ethernet driver

Param buffer: **[in]** frame buffer that will get input to upper stack

Param length: **[in]** length of the frame buffer

Return:

- ESP_OK: input frame buffer to upper stack successfully
- ESP_FAIL: error occurred when inputting buffer to upper stack

esp_err_t (***on_lowlevel_init_done**)(esp_eth_handle_t eth_handle)

Callback function invoked when lowlevel initialization is finished.

Param eth_handle: **[in]** handle of Ethernet driver

Return:

- ESP_OK: process extra lowlevel initialization successfully
- ESP_FAIL: error occurred when processing extra lowlevel initialization

esp_err_t (*on_lowlevel_deinit_done)(esp_eth_handle_t eth_handle)

Callback function invoked when lowlevel deinitialization is finished.

Param eth_handle: **[in]** handle of Ethernet driver

Return:

- ESP_OK: process extra lowlevel deinitialization successfully
- ESP_FAIL: error occurred when processing extra lowlevel deinitialization

esp_err_t (*read_phy_reg)(esp_eth_handle_t eth_handle, uint32_t phy_addr, uint32_t phy_reg, uint32_t *reg_value)

Read PHY register.

Note

Usually the PHY register read/write function is provided by MAC (SMI interface), but if the PHY device is managed by other interface (e.g. I2C), then user needs to implement the corresponding read/write. Setting this to NULL means your PHY device is managed by MAC's SMI interface.

Param eth_handle: **[in]** handle of Ethernet driver

Param phy_addr: **[in]** PHY chip address (0~31)

Param phy_reg: **[in]** PHY register index code

Param reg_value: **[out]** PHY register value

Return:

- ESP_OK: read PHY register successfully
- ESP_ERR_INVALID_ARG: read PHY register failed because of invalid argument
- ESP_ERR_TIMEOUT: read PHY register failed because of timeout
- ESP_FAIL: read PHY register failed because some other error occurred

esp_err_t (*write_phy_reg)(esp_eth_handle_t eth_handle, uint32_t phy_addr, uint32_t phy_reg, uint32_t reg_value)

Write PHY register.

Note

Usually the PHY register read/write function is provided by MAC (SMI interface), but if the PHY device is managed by other interface (e.g. I2C), then user needs to implement the corresponding read/write. Setting this to NULL means your PHY device is managed by MAC's SMI interface.

Param eth_handle: **[in]** handle of Ethernet driver

Param phy_addr: **[in]** PHY chip address (0~31)

Param phy_reg: **[in]** PHY register index code

Param reg_value: **[in]** PHY register value

Return:

- ESP_OK: write PHY register successfully

- ESP_ERR_INVALID_ARG: read PHY register failed because of invalid argument
- ESP_ERR_TIMEOUT: write PHY register failed because of timeout
- ESP_FAIL: write PHY register failed because some other error occurred

struct **esp_eth_phy_reg_rw_data_t**

Data structure to Read/Write PHY register via ioctl API.

Public Members

uint32_t **reg_addr**

PHY register address

uint32_t ***reg_value_p**

Pointer to a memory where the register value is read/written

Macros

ETH_DEFAULT_CONFIG(emac, ephy)

Default configuration for Ethernet driver.

Type Definitions

typedef void ***esp_eth_handle_t**

Handle of Ethernet driver.

Enumerations

enum **esp_eth_io_cmd_t**

Command list for ioctl API.

Values:

enumerator **ETH_CMD_G_MAC_ADDR**

Get MAC address

enumerator **ETH_CMD_S_MAC_ADDR**

Set MAC address

enumerator **ETH_CMD_G_PHY_ADDR**

Get PHY address

enumerator **ETH_CMD_S_PHY_ADDR**

Set PHY address

enumerator **ETH_CMD_G_AUTONEGO**

Get PHY Auto Negotiation

enumerator **ETH_CMD_S_AUTONEGO**

Set PHY Auto Negotiation

enumerator **ETH_CMD_G_SPEED**

Get Speed

enumerator **ETH_CMD_S_SPEED**

Set Speed

enumerator **ETH_CMD_S_PROMISCUOUS**

Set promiscuous mode

enumerator **ETH_CMD_S_FLOW_CTRL**

Set flow control

enumerator **ETH_CMD_G_DUPLEX_MODE**

Get Duplex mode

enumerator **ETH_CMD_S_DUPLEX_MODE**

Set Duplex mode

enumerator **ETH_CMD_S_PHY_LOOPBACK**

Set PHY loopback

enumerator **ETH_CMD_READ_PHY_REG**

Read PHY register

enumerator **ETH_CMD_WRITE_PHY_REG**

Write PHY register

enumerator **ETH_CMD_CUSTOM_MAC_CMDS**

enumerator **ETH_CMD_CUSTOM_PHY_CMDS**

Header File

- components/esp_eth/include/esp_eth_com.h
- This header file can be included with:

```
#include "esp_eth_com.h"
```

- This header file is a part of the API provided by the `esp_eth` component. To declare that your component depends on `esp_eth`, add the following to your CMakeLists.txt:

```
REQUIRES esp_eth
```

or

```
PRIV_REQUIRES esp_eth
```

Structures

struct esp_eth_mediator_s

Ethernet mediator.

Public Members

esp_err_t (***phy_reg_read**)(esp_eth_mediator_t *eth, uint32_t phy_addr, uint32_t phy_reg, uint32_t *reg_value)

Read PHY register.

Param eth: **[in]** mediator of Ethernet driver

Param phy_addr: **[in]** PHY Chip address (0~31)

Param phy_reg: **[in]** PHY register index code

Param reg_value: **[out]** PHY register value

Return:

- ESP_OK: read PHY register successfully
- ESP_FAIL: read PHY register failed because some error occurred

esp_err_t (***phy_reg_write**)(esp_eth_mediator_t *eth, uint32_t phy_addr, uint32_t phy_reg, uint32_t reg_value)

Write PHY register.

Param eth: **[in]** mediator of Ethernet driver

Param phy_addr: **[in]** PHY Chip address (0~31)

Param phy_reg: **[in]** PHY register index code

Param reg_value: **[in]** PHY register value

Return:

- ESP_OK: write PHY register successfully
- ESP_FAIL: write PHY register failed because some error occurred

esp_err_t (***stack_input**)(esp_eth_mediator_t *eth, uint8_t *buffer, uint32_t length)

Deliver packet to upper stack.

Param eth: **[in]** mediator of Ethernet driver

Param buffer: **[in]** packet buffer

Param length: **[in]** length of the packet

Return:

- ESP_OK: deliver packet to upper stack successfully

- ESP_FAIL: deliver packet failed because some error occurred

esp_err_t (*on_state_changed)(esp_eth_mediator_t *eth, esp_eth_state_t state, void *args)

Callback on Ethernet state changed.

Param eth: [in] mediator of Ethernet driver

Param state: [in] new state

Param args: [in] optional argument for the new state

Return:

- ESP_OK: process the new state successfully
- ESP_FAIL: process the new state failed because some error occurred

Type Definitions

typedef struct esp_eth_mediator_s **esp_eth_mediator_t**

Ethernet mediator.

Enumerations

enum **esp_eth_state_t**

Ethernet driver state.

Values:

enumerator **ETH_STATE_LLINIT**

Lowlevel init done

enumerator **ETH_STATE_DEINIT**

Deinit done

enumerator **ETH_STATE_LINK**

Link status changed

enumerator **ETH_STATE_SPEED**

Speed updated

enumerator **ETH_STATE_DUPLEX**

Duplex updated

enumerator **ETH_STATE_PAUSE**

Pause ability updated

enum **eth_event_t**

Ethernet event declarations.

Values:

enumerator **ETHERNET_EVENT_START**

Ethernet driver start

enumerator **ETHERNET_EVENT_STOP**

Ethernet driver stop

enumerator **ETHERNET_EVENT_CONNECTED**

Ethernet got a valid link

enumerator **ETHERNET_EVENT_DISCONNECTED**

Ethernet lost a valid link

Header File

- components/esp_eth/include/esp_eth_mac.h
- This header file can be included with:

```
#include "esp_eth_mac.h"
```

- This header file is a part of the API provided by the `esp_eth` component. To declare that your component depends on `esp_eth`, add the following to your CMakeLists.txt:

```
REQUIRES esp_eth
```

or

```
PRIV_REQUIRES esp_eth
```

Functions

esp_eth_mac_t ***esp_eth_mac_new_esp32**(*const* eth_esp32_emac_config_t *esp32_config, *const* eth_mac_config_t *config)*

Create ESP32 Ethernet MAC instance.

Parameters:
- **esp32_config** -- EMAC specific configuration
- **config** -- Ethernet MAC configuration

Returns:
- instance: create MAC instance successfully
- NULL: create MAC instance failed because some error occurred

Unions

union **eth_mac_clock_config_t**

#include <esp_eth_mac.h>
Ethernet MAC Clock Configuration.

Public Members

struct eth_mac_clock_config_t::[anonymous] **mii**

EMAC MII Clock Configuration

emac_rmii_clock_mode_t **clock_mode**

RMII Clock Mode Configuration

emac_rmii_clock_gpio_t **clock_gpio**

RMII Clock GPIO Configuration

struct eth_mac_clock_config_t::[anonymous] **rmii**

EMAC RMII Clock Configuration

Structures

struct **esp_eth_mac_s**

Ethernet MAC.

Public Members

esp_err_t (***set_mediator**)(esp_eth_mac_t *mac, esp_eth_mediator_t *eth)

Set mediator for Ethernet MAC.

Param mac: **[in]** Ethernet MAC instance

Param eth: **[in]** Ethernet mediator

Return:

- ESP_OK: set mediator for Ethernet MAC successfully
- ESP_ERR_INVALID_ARG: set mediator for Ethernet MAC failed because of invalid argument

esp_err_t (***init**)(esp_eth_mac_t *mac)

Initialize Ethernet MAC.

Param mac: **[in]** Ethernet MAC instance

Return:

- ESP_OK: initialize Ethernet MAC successfully
- ESP_ERR_TIMEOUT: initialize Ethernet MAC failed because of timeout
- ESP_FAIL: initialize Ethernet MAC failed because some other error occurred

esp_err_t (***deinit**)(esp_eth_mac_t *mac)

Deinitialize Ethernet MAC.

Param mac: **[in]** Ethernet MAC instance

Return:

- ESP_OK: deinitialize Ethernet MAC successfully
- ESP_FAIL: deinitialize Ethernet MAC failed because some error occurred

esp_err_t (***start**)(esp_eth_mac_t *mac)

Start Ethernet MAC.

Param mac: **[in]** Ethernet MAC instance

Return:

- ESP_OK: start Ethernet MAC successfully
- ESP_FAIL: start Ethernet MAC failed because some other error occurred

esp_err_t (***stop**)(esp_eth_mac_t *mac)

Stop Ethernet MAC.

Param mac: **[in]** Ethernet MAC instance

Return:

- ESP_OK: stop Ethernet MAC successfully
- ESP_FAIL: stop Ethernet MAC failed because some error occurred

esp_err_t (***transmit**)(esp_eth_mac_t *mac, uint8_t *buf, uint32_t length)

Transmit packet from Ethernet MAC.

Note

Returned error codes may differ for each specific MAC chip.

Param mac: **[in]** Ethernet MAC instance

Param buf: **[in]** packet buffer to transmit

Param length: **[in]** length of packet

Return:

- ESP_OK: transmit packet successfully
- ESP_ERR_INVALID_SIZE: number of actually sent bytes differs to expected
- ESP_FAIL: transmit packet failed because some other error occurred

esp_err_t (***transmit_vargs**)(esp_eth_mac_t *mac, uint32_t argc, va_list args)

Transmit packet from Ethernet MAC constructed with special parameters at Layer2.

Note

Typical intended use case is to make possible to construct a frame from multiple higher layer buffers without a need of buffer reallocations. However, other use cases are not limited.

Note

Returned error codes may differ for each specific MAC chip.

Param mac: **[in]** Ethernet MAC instance

Param argc: **[in]** number variable arguments

Param args: **[in]** variable arguments

Return:

- ESP_OK: transmit packet successfully
- ESP_ERR_INVALID_SIZE: number of actually sent bytes differs to expected

- ESP_FAIL: transmit packet failed because some other error occurred

esp_err_t (*receive)(esp_eth_mac_t *mac, uint8_t *buf, uint32_t *length)

Receive packet from Ethernet MAC.

Note

Memory of buf is allocated in the Layer2, make sure it get free after process.

Note

Before this function got invoked, the value of "length" should set by user, equals the size of buffer. After the function returned, the value of "length" means the real length of received data.

Param mac: **[in]** Ethernet MAC instance

Param buf: **[out]** packet buffer which will preserve the received frame

Param length: **[out]** length of the received packet

Return:

- ESP_OK: receive packet successfully
- ESP_ERR_INVALID_ARG: receive packet failed because of invalid argument
- ESP_ERR_INVALID_SIZE: input buffer size is not enough to hold the incoming data. in this case, value of returned "length" indicates the real size of incoming data.
- ESP_FAIL: receive packet failed because some other error occurred

esp_err_t (*read_phy_reg)(esp_eth_mac_t *mac, uint32_t phy_addr, uint32_t phy_reg, uint32_t *reg_value)

Read PHY register.

Param mac: **[in]** Ethernet MAC instance

Param phy_addr: **[in]** PHY chip address (0~31)

Param phy_reg: **[in]** PHY register index code

Param reg_value: **[out]** PHY register value

Return:

- ESP_OK: read PHY register successfully
- ESP_ERR_INVALID_ARG: read PHY register failed because of invalid argument
- ESP_ERR_INVALID_STATE: read PHY register failed because of wrong state of MAC
- ESP_ERR_TIMEOUT: read PHY register failed because of timeout
- ESP_FAIL: read PHY register failed because some other error occurred

esp_err_t (*write_phy_reg)(esp_eth_mac_t *mac, uint32_t phy_addr, uint32_t phy_reg, uint32_t reg_value)

Write PHY register.

Param mac: **[in]** Ethernet MAC instance

Param phy_addr: **[in]** PHY chip address (0~31)

Param phy_reg: **[in]** PHY register index code

Param reg_value: **[in]** PHY register value

Return:

- ESP_OK: write PHY register successfully
- ESP_ERR_INVALID_STATE: write PHY register failed because of wrong state of MAC
- ESP_ERR_TIMEOUT: write PHY register failed because of timeout
- ESP_FAIL: write PHY register failed because some other error occurred

esp_err_t (*set_addr)(esp_eth_mac_t *mac, uint8_t *addr)

Set MAC address.

Param mac: **[in]** Ethernet MAC instance

Param addr: **[in]** MAC address

Return:

- ESP_OK: set MAC address successfully
- ESP_ERR_INVALID_ARG: set MAC address failed because of invalid argument
- ESP_FAIL: set MAC address failed because some other error occurred

esp_err_t (*get_addr)(esp_eth_mac_t *mac, uint8_t *addr)

Get MAC address.

Param mac: **[in]** Ethernet MAC instance

Param addr: **[out]** MAC address

Return:

- ESP_OK: get MAC address successfully
- ESP_ERR_INVALID_ARG: get MAC address failed because of invalid argument
- ESP_FAIL: get MAC address failed because some other error occurred

esp_err_t (*set_speed)(esp_eth_mac_t *mac, eth_speed_t speed)

Set speed of MAC.

Param ma:c: **[in]** Ethernet MAC instance

Param speed: **[in]** MAC speed

Return:

- ESP_OK: set MAC speed successfully
- ESP_ERR_INVALID_ARG: set MAC speed failed because of invalid argument
- ESP_FAIL: set MAC speed failed because some other error occurred

esp_err_t (*set_duplex)(esp_eth_mac_t *mac, eth_duplex_t duplex)

Set duplex mode of MAC.

Param mac: **[in]** Ethernet MAC instance

Param duplex: **[in]** MAC duplex

Return:

- ESP_OK: set MAC duplex mode successfully
- ESP_ERR_INVALID_ARG: set MAC duplex failed because of invalid argument
- ESP_FAIL: set MAC duplex failed because some other error occurred

esp_err_t (*set_link)(esp_eth_mac_t *mac, eth_link_t link)

Set link status of MAC.

Param mac: **[in]** Ethernet MAC instance

Param link: **[in]** Link status

Return:

- ESP_OK: set link status successfully
- ESP_ERR_INVALID_ARG: set link status failed because of invalid argument
- ESP_FAIL: set link status failed because some other error occurred

esp_err_t (*set_promiscuous)(esp_eth_mac_t *mac, bool enable)

Set promiscuous of MAC.

Param mac: **[in]** Ethernet MAC instance

Param enable: **[in]** set true to enable promiscuous mode; set false to disable promiscuous mode

Return:

- ESP_OK: set promiscuous mode successfully
- ESP_FAIL: set promiscuous mode failed because some error occurred

esp_err_t (*enable_flow_ctrl)(esp_eth_mac_t *mac, bool enable)

Enable flow control on MAC layer or not.

Param mac: **[in]** Ethernet MAC instance

Param enable: **[in]** set true to enable flow control; set false to disable flow control

Return:

- ESP_OK: set flow control successfully
- ESP_FAIL: set flow control failed because some error occurred

esp_err_t (*set_peer_pause_ability)(esp_eth_mac_t *mac, uint32_t ability)

Set the PAUSE ability of peer node.

Param mac: **[in]** Ethernet MAC instance

Param ability: **[in]** zero indicates that pause function is supported by link partner; non-zero indicates that pause function is not supported by link partner

Return:

- ESP_OK: set peer pause ability successfully
- ESP_FAIL: set peer pause ability failed because some error occurred

esp_err_t (*custom_ioctl)(esp_eth_mac_t *mac, uint32_t cmd, void *data)

Custom IO function of MAC driver. This function is intended to extend common options of esp_eth_ioctl to cover specifics of MAC chip.

Note

This function may not be assigned when the MAC chip supports only most common set of configuration options.

Param mac: **[in]** Ethernet MAC instance

Param cmd: **[in]** IO control command

Param data: **[inout]** address of data for `set` command or address where to store the data when used with `get` command

Return:

- ESP_OK: process io command successfully
- ESP_ERR_INVALID_ARG: process io command failed because of some invalid argument
- ESP_FAIL: process io command failed because some other error occurred
- ESP_ERR_NOT_SUPPORTED: requested feature is not supported

esp_err_t (*del)(esp_eth_mac_t *mac)

Free memory of Ethernet MAC.

Param mac: **[in]** Ethernet MAC instance

Return:

- ESP_OK: free Ethernet MAC instance successfully
- ESP_FAIL: free Ethernet MAC instance failed because some error occurred

struct eth_mac_config_t

Configuration of Ethernet MAC object.

Public Members

uint32_t sw_reset_timeout_ms

Software reset timeout value (Unit: ms)

uint32_t rx_task_stack_size

Stack size of the receive task

uint32_t rx_task_prio

Priority of the receive task

uint32_t flags

Flags that specify extra capability for mac driver

struct `eth_esp32_emac_config_t`

EMAC specific configuration.

Public Members

int **smi_mdc_gpio_num**

SMI MDC GPIO number, set to -1 could bypass the SMI GPIO configuration

int **smi_mdio_gpio_num**

SMI MDIO GPIO number, set to -1 could bypass the SMI GPIO configuration

eth_data_interface_t **interface**

EMAC Data interface to PHY (MII/RMII)

eth_mac_clock_config_t **clock_config**

EMAC Interface clock configuration

eth_mac_dma_burst_len_t **dma_burst_len**

EMAC DMA burst length for both Tx and Rx

struct `eth_spi_custom_driver_config_t`

Custom SPI Driver Configuration. This structure declares configuration and callback functions to access Ethernet SPI module via user's custom SPI driver.

Public Members

void ***config**

Custom driver specific configuration data used by `init()` function.

> **Note**
>
> Type and its content is fully under user's control

void *(***init**)(*const* void *spi_config)

Custom driver SPI Initialization.

> **Note**
>
> return type and its content is fully under user's control

Param spi_config: [in] Custom driver specific configuration

Return:

- spi_ctx: when initialization is successful, a pointer to context structure holding all variables needed for subsequent SPI access operations (e.g. SPI bus identification, mutexes, etc.)
- NULL: driver initialization failed

esp_err_t (***deinit**)(void *spi_ctx)

Custom driver De-initialization.

Param spi_ctx: **[in]** a pointer to driver specific context structure

Return:

- ESP_OK: driver de-initialization was successful
- ESP_FAIL: driver de-initialization failed
- any other failure codes are allowed to be used to provide failure isolation

esp_err_t (***read**)(void *spi_ctx, uint32_t cmd, uint32_t addr, void *data, uint32_t data_len)

Custom driver SPI read.

Note

The read function is responsible to construct command, address and data fields of the SPI frame in format expected by particular SPI Ethernet module

Param spi_ctx: **[in]** a pointer to driver specific context structure

Param cmd: **[in]** command

Param addr: **[in]** register address

Param data: **[out]** read data

Param data_len: **[in]** read data length in bytes

Return:

- ESP_OK: read was successful
- ESP_FAIL: read failed
- any other failure codes are allowed to be used to provide failure isolation

esp_err_t (***write**)(void *spi_ctx, uint32_t cmd, uint32_t addr, *const* void *data, uint32_t data_len)

Custom driver SPI write.

Note

The write function is responsible to construct command, address and data fields of the SPI frame in format expected by particular SPI Ethernet module

Param spi_ctx: **[in]** a pointer to driver specific context structure

Param cmd: **[in]** command

Param addr: **[in]** register address

Param data: **[in]** data to write

Param data_len: **[in]** length of data to write in bytes

Return:

- ESP_OK: write was successful
- ESP_FAIL: write failed
- any other failure codes are allowed to be used to provide failure isolation

Macros

ETH_MAC_FLAG_WORK_WITH_CACHE_DISABLE

MAC driver can work when cache is disabled

ETH_MAC_FLAG_PIN_TO_CORE

Pin MAC task to the CPU core where driver installation happened

ETH_MAC_DEFAULT_CONFIG()

Default configuration for Ethernet MAC object.

ETH_ESP32_EMAC_DEFAULT_CONFIG()

Default ESP32's EMAC specific configuration.

ETH_DEFAULT_SPI

Default configuration of the custom SPI driver. Internal ESP-IDF SPI Master driver is used by default.

Type Definitions

typedef struct esp_eth_mac_s **esp_eth_mac_t**

Ethernet MAC.

Enumerations

enum **emac_rmii_clock_mode_t**

RMII Clock Mode Options.

Values:

enumerator **EMAC_CLK_DEFAULT**

Default values configured using Kconfig are going to be used when "Default" selected.

enumerator **EMAC_CLK_EXT_IN**

Input RMII Clock from external. EMAC Clock GPIO number needs to be configured when this option is selected.

Note

MAC will get RMII clock from outside. Note that ESP32 only supports GPIO0 to input the RMII clock.

enumerator **EMAC_CLK_OUT**

Output RMII Clock from internal APLL Clock. EMAC Clock GPIO number needs to be configured when this option is selected.

enum **emac_rmii_clock_gpio_t**

RMII Clock GPIO number Options.

Values:

enumerator **EMAC_CLK_IN_GPIO**

MAC will get RMII clock from outside at this GPIO.

Note

ESP32 only supports GPIO0 to input the RMII clock.

enumerator **EMAC_APPL_CLK_OUT_GPIO**

Output RMII Clock from internal APLL Clock available at GPIO0.

Note

GPIO0 can be set to output a pre-divided PLL clock (test only!). Enabling this option will configure GPIO0 to output a 50MHz clock. In fact this clock doesn't have directly relationship with EMAC peripheral. Sometimes this clock won't work well with your PHY chip. You might need to add some extra devices after GPIO0 (e.g. inverter). Note that outputting RMII clock on GPIO0 is an experimental practice. If you want the Ethernet to work with WiFi, don't select GPIO0 output mode for stability.

enumerator **EMAC_CLK_OUT_GPIO**

Output RMII Clock from internal APLL Clock available at GPIO16.

enumerator **EMAC_CLK_OUT_180_GPIO**

Inverted Output RMII Clock from internal APLL Clock available at GPIO17.

Header File

- components/esp_eth/include/esp_eth_phy.h
- This header file can be included with:

```
#include "esp_eth_phy.h"
```

- This header file is a part of the API provided by the `esp_eth` component. To declare that your component depends on `esp_eth`, add the following to your CMakeLists.txt:

```
REQUIRES esp_eth
```

or

```
PRIV_REQUIRES esp_eth
```

Functions

esp_eth_phy_t ***esp_eth_phy_new_ip101**(*const* eth_phy_config_t *config)

Create a PHY instance of IP101.

Parameters: **config** -- **[in]** configuration of PHY

Returns:

- instance: create PHY instance successfully
- NULL: create PHY instance failed because some error occurred

esp_eth_phy_t *esp_eth_phy_new_rtl8201(const eth_phy_config_t *config)

Create a PHY instance of RTL8201.

Parameters: **config** -- **[in]** configuration of PHY

Returns:

- instance: create PHY instance successfully
- NULL: create PHY instance failed because some error occurred

esp_eth_phy_t *esp_eth_phy_new_lan87xx(const eth_phy_config_t *config)

Create a PHY instance of LAN87xx.

Parameters: **config** -- **[in]** configuration of PHY

Returns:

- instance: create PHY instance successfully
- NULL: create PHY instance failed because some error occurred

esp_eth_phy_t *esp_eth_phy_new_dp83848(const eth_phy_config_t *config)

Create a PHY instance of DP83848.

Parameters: **config** -- **[in]** configuration of PHY

Returns:

- instance: create PHY instance successfully
- NULL: create PHY instance failed because some error occurred

esp_eth_phy_t *esp_eth_phy_new_ksz80xx(const eth_phy_config_t *config)

Create a PHY instance of KSZ80xx.

The phy model from the KSZ80xx series is detected automatically. If the driver is unable to detect a supported model, `NULL` is returned.

Currently, the following models are supported: KSZ8001, KSZ8021, KSZ8031, KSZ8041, KSZ8051, KSZ8061, KSZ8081, KSZ8091

Parameters: **config** -- **[in]** configuration of PHY

Returns:

- instance: create PHY instance successfully
- NULL: create PHY instance failed because some error occurred

Structures

struct esp_eth_phy_s

Ethernet PHY.

Public Members

esp_err_t (*set_mediator)(esp_eth_phy_t *phy, esp_eth_mediator_t *mediator)

Set mediator for PHY.

Param phy: **[in]** Ethernet PHY instance

Param mediator: **[in]** mediator of Ethernet driver

Return:

- ESP_OK: set mediator for Ethernet PHY instance successfully

- ESP_ERR_INVALID_ARG: set mediator for Ethernet PHY instance failed because of some invalid arguments

esp_err_t (*reset)(esp_eth_phy_t *phy)

Software Reset Ethernet PHY.

Param phy: **[in]** Ethernet PHY instance

Return:
- ESP_OK: reset Ethernet PHY successfully
- ESP_FAIL: reset Ethernet PHY failed because some error occurred

esp_err_t (*reset_hw)(esp_eth_phy_t *phy)

Hardware Reset Ethernet PHY.

Note

Hardware reset is mostly done by pull down and up PHY's nRST pin

Param phy: **[in]** Ethernet PHY instance

Return:
- ESP_OK: reset Ethernet PHY successfully
- ESP_FAIL: reset Ethernet PHY failed because some error occurred

esp_err_t (*init)(esp_eth_phy_t *phy)

Initialize Ethernet PHY.

Param phy: **[in]** Ethernet PHY instance

Return:
- ESP_OK: initialize Ethernet PHY successfully
- ESP_FAIL: initialize Ethernet PHY failed because some error occurred

esp_err_t (*deinit)(esp_eth_phy_t *phy)

Deinitialize Ethernet PHY.

Param phy: **[in]** Ethernet PHY instance

Return:
- ESP_OK: deinitialize Ethernet PHY successfully
- ESP_FAIL: deinitialize Ethernet PHY failed because some error occurred

esp_err_t (*autonego_ctrl)(esp_eth_phy_t *phy, eth_phy_autoneg_cmd_t cmd, bool *autonego_en_stat)

Configure auto negotiation.

Param phy: **[in]** Ethernet PHY instance

Param cmd: **[in]** Configuration command, it is possible to Enable (restart), Disable or get current status of PHY auto negotiation

Param autonego_en_stat: **[out]** Address where to store current status of auto negotiation configuration

Return:

- ESP_OK: restart auto negotiation successfully
- ESP_FAIL: restart auto negotiation failed because some error occurred
- ESP_ERR_INVALID_ARG: invalid command

`esp_err_t (*get_link)(esp_eth_phy_t *phy)`

Get Ethernet PHY link status.

Param phy: **[in]** Ethernet PHY instance

Return:

- ESP_OK: get Ethernet PHY link status successfully
- ESP_FAIL: get Ethernet PHY link status failed because some error occurred

`esp_err_t (*pwrctl)(esp_eth_phy_t *phy, bool enable)`

Power control of Ethernet PHY.

Param phy: **[in]** Ethernet PHY instance

Param enable: **[in]** set true to power on Ethernet PHY; ser false to power off Ethernet PHY

Return:

- ESP_OK: control Ethernet PHY power successfully
- ESP_FAIL: control Ethernet PHY power failed because some error occurred

`esp_err_t (*set_addr)(esp_eth_phy_t *phy, uint32_t addr)`

Set PHY chip address.

Param phy: **[in]** Ethernet PHY instance

Param addr: **[in]** PHY chip address

Return:

- ESP_OK: set Ethernet PHY address successfully
- ESP_FAIL: set Ethernet PHY address failed because some error occurred

`esp_err_t (*get_addr)(esp_eth_phy_t *phy, uint32_t *addr)`

Get PHY chip address.

Param phy: **[in]** Ethernet PHY instance

Param addr: **[out]** PHY chip address

Return:

- ESP_OK: get Ethernet PHY address successfully
- ESP_ERR_INVALID_ARG: get Ethernet PHY address failed because of invalid argument

`esp_err_t (*advertise_pause_ability)(esp_eth_phy_t *phy, uint32_t ability)`

Advertise pause function supported by MAC layer.

Param phy: **[in]** Ethernet PHY instance

Param addr: **[out]** Pause ability

Return:

- ESP_OK: Advertise pause ability successfully
- ESP_ERR_INVALID_ARG: Advertise pause ability failed because of invalid argument

esp_err_t (***loopback**)(esp_eth_phy_t *phy, bool enable)

Sets the PHY to loopback mode.

Param phy: **[in]** Ethernet PHY instance

Param enable: **[in]** enables or disables PHY loopback

Return:

- ESP_OK: PHY instance loopback mode has been configured successfully
- ESP_FAIL: PHY instance loopback configuration failed because some error occurred

esp_err_t (***set_speed**)(esp_eth_phy_t *phy, eth_speed_t speed)

Sets PHY speed mode.

Note

Autonegotiation feature needs to be disabled prior to calling this function for the new setting to be applied

Param phy: **[in]** Ethernet PHY instance

Param speed: **[in]** Speed mode to be set

Return:

- ESP_OK: PHY instance speed mode has been configured successfully
- ESP_FAIL: PHY instance speed mode configuration failed because some error occurred

esp_err_t (***set_duplex**)(esp_eth_phy_t *phy, eth_duplex_t duplex)

Sets PHY duplex mode.

Note

Autonegotiation feature needs to be disabled prior to calling this function for the new setting to be applied

Param phy: **[in]** Ethernet PHY instance

Param duplex: **[in]** Duplex mode to be set

Return:

- ESP_OK: PHY instance duplex mode has been configured successfully
- ESP_FAIL: PHY instance duplex mode configuration failed because some error occurred

esp_err_t (***custom_ioctl**)(esp_eth_phy_t *phy, uint32_t cmd, void *data)

Custom IO function of PHY driver. This function is intended to extend common options of esp_eth_ioctl to cover specifics of PHY chip.

Note

This function may not be assigned when the PHY chip supports only most common set of configuration options.

Param phy: **[in]** Ethernet PHY instance

Param cmd: **[in]** IO control command

Param data: **[inout]** address of data for `set` command or address where to store the data when used with `get` command

Return:

- ESP_OK: process io command successfully
- ESP_ERR_INVALID_ARG: process io command failed because of some invalid argument
- ESP_FAIL: process io command failed because some other error occurred
- ESP_ERR_NOT_SUPPORTED: requested feature is not supported

esp_err_t (***del**)(esp_eth_phy_t *phy)

Free memory of Ethernet PHY instance.

Param phy: **[in]** Ethernet PHY instance

Return:

- ESP_OK: free PHY instance successfully
- ESP_FAIL: free PHY instance failed because some error occurred

struct **eth_phy_config_t**

Ethernet PHY configuration.

Public Members

int32_t **phy_addr**

PHY address, set -1 to enable PHY address detection at initialization stage

uint32_t **reset_timeout_ms**

Reset timeout value (Unit: ms)

uint32_t **autonego_timeout_ms**

Auto-negotiation timeout value (Unit: ms)

int **reset_gpio_num**

Reset GPIO number, -1 means no hardware reset

Macros

ESP_ETH_PHY_ADDR_AUTO

ETH_PHY_DEFAULT_CONFIG()

Default configuration for Ethernet PHY object.

Type Definitions

typedef struct esp_eth_phy_s **esp_eth_phy_t**

Ethernet PHY.

Enumerations

enum **eth_phy_autoneg_cmd_t**

Auto-negotiation controll commands.

Values:

enumerator **ESP_ETH_PHY_AUTONEGO_RESTART**

enumerator **ESP_ETH_PHY_AUTONEGO_EN**

enumerator **ESP_ETH_PHY_AUTONEGO_DIS**

enumerator **ESP_ETH_PHY_AUTONEGO_G_STAT**

Header File

- components/esp_eth/include/esp_eth_phy_802_3.h
- This header file can be included with:

```
#include "esp_eth_phy_802_3.h"
```

- This header file is a part of the API provided by the `esp_eth` component. To declare that your component depends on `esp_eth`, add the following to your CMakeLists.txt:

```
REQUIRES esp_eth
```

or

```
PRIV_REQUIRES esp_eth
```

Functions

esp_err_t **esp_eth_phy_802_3_set_mediator**(phy_802_3_t *phy_802_3, esp_eth_mediator_t *eth)

Set Ethernet mediator.

Parameters:
- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **eth** -- Ethernet mediator pointer

Returns:
- ESP_OK: Ethermet mediator set successfuly
- ESP_ERR_INVALID_ARG: if `eth` is `NULL`

esp_err_t **esp_eth_phy_802_3_reset**(phy_802_3_t *phy_802_3)

Reset PHY.

Parameters: **phy_802_3** -- IEEE 802.3 PHY object infostructure

Returns:

- ESP_OK: Ethernet PHY reset successfuly
- ESP_FAIL: reset Ethernet PHY failed because some error occured

esp_err_t **esp_eth_phy_802_3_autonego_ctrl**(phy_802_3_t *phy_802_3, eth_phy_autoneg_cmd_t cmd, bool *autonego_en_stat)

Control autonegotiation mode of Ethernet PHY.

Parameters:

- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **cmd** -- autonegotiation command enumeration
- **autonego_en_stat** -- **[out]** autonegotiation enabled flag

Returns:

- ESP_OK: Ethernet PHY autonegotiation configured successfuly
- ESP_FAIL: Ethernet PHY autonegotiation configuration fail because some error occured
- ESP_ERR_INVALID_ARG: invalid value of `cmd`

esp_err_t **esp_eth_phy_802_3_pwrctl**(phy_802_3_t *phy_802_3, bool enable)

Power control of Ethernet PHY.

Parameters:

- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **enable** -- set true to power ON Ethernet PHY; set false to power OFF Ethernet PHY

Returns:

- ESP_OK: Ethernet PHY power down mode set successfuly
- ESP_FAIL: Ethernet PHY power up or power down failed because some error occured

esp_err_t **esp_eth_phy_802_3_set_addr**(phy_802_3_t *phy_802_3, uint32_t addr)

Set Ethernet PHY address.

Parameters:

- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **addr** -- new PHY address

Returns:

- ESP_OK: Ethernet PHY address set

esp_err_t **esp_eth_phy_802_3_get_addr**(phy_802_3_t *phy_802_3, uint32_t *addr)

Get Ethernet PHY address.

Parameters:

- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **addr** -- **[out]** Ethernet PHY address

Returns:

- ESP_OK: Ethernet PHY address read successfuly
- ESP_ERR_INVALID_ARG: `addr` pointer is `NULL`

esp_err_t **esp_eth_phy_802_3_advertise_pause_ability**(phy_802_3_t *phy_802_3, uint32_t ability)

Advertise pause function ability.

Parameters:
- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **ability** -- enable or disable pause ability

Returns:
- ESP_OK: pause ability set successfuly
- ESP_FAIL: Advertise pause function ability failed because some error occured

esp_err_t **esp_eth_phy_802_3_loopback**(phy_802_3_t *phy_802_3, bool enable)

Set Ethernet PHY loopback mode.

Parameters:
- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **enable** -- set true to enable loopback; set false to disable loopback

Returns:
- ESP_OK: Ethernet PHY loopback mode set successfuly
- ESP_FAIL: Ethernet PHY loopback configuration failed because some error occured

esp_err_t **esp_eth_phy_802_3_set_speed**(phy_802_3_t *phy_802_3, eth_speed_t speed)

Set Ethernet PHY speed.

Parameters:
- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **speed** -- new speed of Ethernet PHY link

Returns:
- ESP_OK: Ethernet PHY speed set successfuly
- ESP_FAIL: Set Ethernet PHY speed failed because some error occured

esp_err_t **esp_eth_phy_802_3_set_duplex**(phy_802_3_t *phy_802_3, eth_duplex_t duplex)

Set Ethernet PHY duplex mode.

Parameters:
- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **duplex** -- new duplex mode for Ethernet PHY link

Returns:
- ESP_OK: Ethernet PHY duplex mode set successfuly
- ESP_ERR_INVALID_STATE: unable to set duplex mode to Half if loopback is enabled
- ESP_FAIL: Set Ethernet PHY duplex mode failed because some error occured

esp_err_t **esp_eth_phy_802_3_init**(phy_802_3_t *phy_802_3)

Initialize Ethernet PHY.

Parameters: **phy_802_3** -- IEEE 802.3 PHY object infostructure

Returns:
- ESP_OK: Ethernet PHY initialized successfuly

esp_err_t **esp_eth_phy_802_3_deinit**(phy_802_3_t *phy_802_3)

Power off Eternet PHY.

Parameters: **phy_802_3** -- IEEE 802.3 PHY object infostructure

Returns:

- ESP_OK: Ethernet PHY powered off successfuly

esp_err_t **esp_eth_phy_802_3_del**(phy_802_3_t *phy_802_3)

Delete Ethernet PHY infostructure.

Parameters: **phy_802_3** -- IEEE 802.3 PHY object infostructure

Returns:

- ESP_OK: Ethrnet PHY infostructure deleted

esp_err_t **esp_eth_phy_802_3_reset_hw**(phy_802_3_t *phy_802_3, uint32_t reset_assert_us)

Performs hardware reset with specific reset pin assertion time.

Parameters:

- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **reset_assert_us** -- Hardware reset pin assertion time

Returns:

- ESP_OK: reset Ethernet PHY successfully

esp_err_t **esp_eth_phy_802_3_detect_phy_addr**(esp_eth_mediator_t *eth, int *detected_addr)

Detect PHY address.

Parameters:

- **eth** -- Mediator of Ethernet driver
- **detected_addr** -- **[out]** a valid address after detection

Returns:

- ESP_OK: detect phy address successfully
- ESP_ERR_INVALID_ARG: invalid parameter
- ESP_ERR_NOT_FOUND: can't detect any PHY device
- ESP_FAIL: detect phy address failed because some error occurred

esp_err_t **esp_eth_phy_802_3_basic_phy_init**(phy_802_3_t *phy_802_3)

Performs basic PHY chip initialization.

Note

It should be called as the first function in PHY specific driver instance

Parameters: **phy_802_3** -- IEEE 802.3 PHY object infostructure

Returns:

- ESP_OK: initialized Ethernet PHY successfully
- ESP_FAIL: initialization of Ethernet PHY failed because some error occurred
- ESP_ERR_INVALID_ARG: invalid argument
- ESP_ERR_NOT_FOUND: PHY device not detected
- ESP_ERR_TIMEOUT: MII Management read/write operation timeout
- ESP_ERR_INVALID_STATE: PHY is in invalid state to perform requested operation

esp_err_t **esp_eth_phy_802_3_basic_phy_deinit**(phy_802_3_t *phy_802_3)

Performs basic PHY chip de-initialization.

Note

It should be called as the last function in PHY specific driver instance

Parameters: **phy_802_3** -- IEEE 802.3 PHY object infostructure

Returns:

- ESP_OK: de-initialized Ethernet PHY successfully
- ESP_FAIL: de-initialization of Ethernet PHY failed because some error occurred
- ESP_ERR_TIMEOUT: MII Management read/write operation timeout
- ESP_ERR_INVALID_STATE: PHY is in invalid state to perform requested operation

esp_err_t **esp_eth_phy_802_3_read_oui**(phy_802_3_t *phy_802_3, uint32_t *oui)

Reads raw content of OUI field.

Parameters:

- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **oui** -- **[out]** OUI value

Returns:

- ESP_OK: OUI field read successfully
- ESP_FAIL: OUI field read failed because some error occurred
- ESP_ERR_INVALID_ARG: invalid `oui` argument
- ESP_ERR_TIMEOUT: MII Management read/write operation timeout
- ESP_ERR_INVALID_STATE: PHY is in invalid state to perform requested operation

esp_err_t **esp_eth_phy_802_3_read_manufac_info**(phy_802_3_t *phy_802_3, uint8_t *model, uint8_t *rev)

Reads manufacturer's model and revision number.

Parameters:

- **phy_802_3** -- IEEE 802.3 PHY object infostructure
- **model** -- **[out]** Manufacturer's model number (can be NULL when not required)
- **rev** -- **[out]** Manufacturer's revision number (can be NULL when not required)

Returns:

- ESP_OK: Manufacturer's info read successfully
- ESP_FAIL: Manufacturer's info read failed because some error occurred
- ESP_ERR_TIMEOUT: MII Management read/write operation timeout
- ESP_ERR_INVALID_STATE: PHY is in invalid state to perform requested operation

inline phy_802_3_t ***esp_eth_phy_into_phy_802_3**(esp_eth_phy_t *phy)

Returns address to parent IEEE 802.3 PHY object infostructure.

Parameters: **phy** -- Ethernet PHY instance

Returns: phy_802_3_t*

- address to parent IEEE 802.3 PHY object infostructure

esp_err_t **esp_eth_phy_802_3_obj_config_init**(phy_802_3_t *phy_802_3, *const* eth_phy_config_t *config)

Initializes configuration of parent IEEE 802.3 PHY object infostructure.

Parameters:
- **phy_802_3** -- Address to IEEE 802.3 PHY object infostructure
- **config** -- Configuration of the IEEE 802.3 PHY object

Returns:
- ESP_OK: configuration initialized successfully
- ESP_ERR_INVALID_ARG: invalid `config` argument

Structures

struct **phy_802_3_t**

IEEE 802.3 PHY object infostructure.

Public Members

esp_eth_phy_t **parent**

Parent Ethernet PHY instance

esp_eth_mediator_t ***eth**

Mediator of Ethernet driver

int **addr**

PHY address

uint32_t **reset_timeout_ms**

Reset timeout value (Unit: ms)

uint32_t **autonego_timeout_ms**

Auto-negotiation timeout value (Unit: ms)

eth_link_t **link_status**

Current Link status

int **reset_gpio_num**

Reset GPIO number, -1 means no hardware reset

Header File

- components/esp_eth/include/esp_eth_netif_glue.h
- This header file can be included with:

```
#include "esp_eth_netif_glue.h"
```

- This header file is a part of the API provided by the `esp_eth` component. To declare that your component depends on `esp_eth`, add the following to your CMakeLists.txt:

```
REQUIRES esp_eth
```

or

```
PRIV_REQUIRES esp_eth
```

Functions

esp_eth_netif_glue_handle_t **esp_eth_new_netif_glue**(esp_eth_handle_t eth_hdl)

Create a netif glue for Ethernet driver.

> **Note**
>
> netif glue is used to attach io driver to TCP/IP netif

Parameters: **eth_hdl** -- Ethernet driver handle

Returns: glue object, which inherits esp_netif_driver_base_t

esp_err_t **esp_eth_del_netif_glue**(esp_eth_netif_glue_handle_t eth_netif_glue)

Delete netif glue of Ethernet driver.

Parameters: **eth_netif_glue** -- netif glue

Returns: -ESP_OK: delete netif glue successfully

Type Definitions

typedef struct esp_eth_netif_glue_t ***esp_eth_netif_glue_handle_t**

Handle of netif glue - an intermediate layer between netif and Ethernet driver.