

# Synchronized Teaching Mode – ESP-NOW

## Synchronized Teaching Mode – ESP-NOW

The robotic arm firmware includes built-in support for **ESP-NOW**, allowing multiple arms to mirror each other's movements in real time.

With this feature, you can set up **one-to-one** or **one-to-many** synchronized control without any router, hotspot, or external network.

Simply power on the arms, configure the host and followers, and synchronized teaching works immediately.

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### What Is ESP-NOW? (Quick Overview)

ESP-NOW is a lightweight, low-latency wireless protocol developed by Espressif. It uses the Wi-Fi physical layer but does **not** require a Wi-Fi network.

Key advantages:

1. **Ultra-low latency** — millisecond-level response, ideal for real-time motion sync.
  2. **No router required** — devices communicate directly, even without Internet.
  3. **Low power consumption** — suitable for battery-powered robots.
  4. **Simple API & reliable performance** — stable transmission, long range (up to 100+ meters depending on environment).
  5. **Flexible networking** — supports one-to-one or broadcast (one-to-many).
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## ESP-NOW Broadcast Synchronization

To get started, you'll need **at least two robotic arms**:

- One configured as the **Leader (Host)**

- Others configured as **Followers**

After powering on, each arm's OLED displays:

```
STA:  
MAC:FC:01:2C:DA:5F:FC  
ESP-NOW <OFF>  
BRD Leader <OFF>
```

Explanation:

- **STA:** shows the router-assigned IP (blank if STA mode is not configured)
- **MAC:** the device's unique MAC address  
(your value will differ; needed if you want followers to accept commands only from a specific host)
- **ESP-NOW <OFF>:** ESP-NOW reception disabled
- **BRD Leader <OFF>:** broadcasting of joint data is disabled

## Configuring the Host (Leader)

### 1. Long-press **UP** on the 5-way switch

- The buzzer beeps
- RGB LED flashes yellow
- Torque lock is released (you can move the arm by hand)

Do not move the arm excessively—followers will snap to this pose once paired.

OLED display now shows:

```
TorqueLock <OFF>  
Leader BRD <OFF>
```

longPress-L: ON  
longPress-R: OFF

1. **Long-press LEFT** to enable broadcasting of joint positions

OLED updates to:

TorqueLock <OFF>  
Leader BRD <ON>  
longPress-L: ON  
longPress-R: OFF

1. To stop broadcasting: **long-press RIGHT**
2. To re-enable torque lock: **long-press DOWN**

Host setup is complete.

## Configuring the Followers

### Important Safety Warning

**Upon enabling ESP-NOW reception, the follower arm will move quickly—either to its home pose or to match the host's pose.**

**Keep clear of fragile objects, the robot's workspace, and children.**

### Step 1 — Enable ESP-NOW Reception (Known MAC Mode)

Long-press **LEFT**:

The arm moves to its initial pose and enters "Known MAC" mode.

STA:  
MAC:FC:01:2C:DA:5F:FC  
ESP-NOW <ON> KnownMAC  
BRD Leader <OFF>

In this mode, the follower accepts commands **only from MAC addresses added to its Peer List.**

## Step 2 — Enable Broadcast Reception

Long-press **LEFT** again:

The arm instantly mirrors the host's pose and enters broadcast mode:

```
STA:  
MAC:FC:01:2C:DA:5F:FC  
ESP-NOW <ON> BRD MAC  
BRD Leader <OFF>
```

Long-press **LEFT** repeatedly to toggle between:

- **Known MAC mode**
- **Broadcast mode**

To disable ESP-NOW reception: **long-press RIGHT**

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## Assigning a Specific Host to a Follower

If you want a follower to respond **only** to a designated host:

1. Record the **MAC address** of the host.
2. Use any JSON command method (Web App, UART, HTTP, etc.) to send the following to the follower:

```
{"T":414,"mac":"FC:01:2C:DA:5F:FC"}
```

Replace the MAC address with your host's actual MAC.

OLED will then show:

```
STA:  
MAC:FC:01:2C:DA:5F:FC  
ESP-NOW <ON> KnownMAC  
BRD Leader <OFF>
```

Indicating the follower only accepts commands from the specified host.

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## Automatically Loading the Host MAC on Boot

If you want the follower to automatically load the host MAC every time it powers on, write the command into its boot mission:

```
{"T":303,"name":"boot","json":{"T":414,"mac":"FC:01:2C:DA:5F:FC"}}
```

Now the follower will always trust this host after rebooting.