

MQTT + JSON 通信协议规范

文档信息

项目	说明
版本	V1.1
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说明	本协议由原 TCP 645 协议迁移而来，功能一一对应，数据格式采用 JSON（对齐《控制器通信协议 2026 版 Ver2.15》）
适用设备	单灯控制器、智能开关、三相计量等系列产品

1. 概述

1.1 通信方式对比

原 TCP 协议	新 MQTT 协议
TCP 长连接	MQTT 3.1.1 / 3.1
645 二进制帧	JSON 文本
平台 ↔ 设备 点对点	发布/订阅模式
心跳 30 秒	MQTT 自带 Keep-Alive + 业务心跳

1.2 设计原则

- **功能对等**：新协议覆盖原 TCP 协议全部功能
- **JSON 格式**：便于解析、调试和跨平台集成
- **请求-响应**：通过 `msgId` 关联请求与响应
- 每条命令均有完整的请求格式和响应格式

2. MQTT 主题规划

2.0 MQTT 连接参数（默认）

- **Broker**：`mqtt://wsd.jh-iot.cn:1883`
- **协议版本**：MQTT 3.1.1（建议）
- **KeepAlive**：建议 120s（参考 `app_demo_mqtt.c`），业务心跳仍按本协议 30s 上报
- **QoS 建议**：命令/响应 QoS0；上报类 QoS0 或 QoS0（视平台可靠性要求）

2.1 主题定义

主题	方向	说明
device/{product}/{imei}/cmd	平台→设备	平台下发给指定设备的命令
device/{product}/{imei}/rsp	设备→平台	设备对命令的响应
device/{product}/{imei}/report	设备→平台	设备主动上报（心跳、事件等）

占位符说明： {product}=产品线(switch/dimmer/meter3p), {imei}=设备IMEI(15位)

2.2 设备订阅与发布

- 设备订阅： device/{product}/{imei}/cmd
- 设备发布： device/{product}/{imei}/rsp、 device/{product}/{imei}/report

3. 通用消息格式

3.1 请求格式（平台下发 / 设备上报）

```
{
  "msgId": "唯一标识",
  "ts": 1704067200000,
  "cmd": "命令名",
  "data": { }
}
```

字段	类型	必填	说明
msgId	string	是	消息唯一标识，响应必须回传相同值
ts	number	否	时间戳，毫秒
cmd	string	是	命令名称
data	object	是	命令数据体，无数据时可为 {}

3.2 响应格式（设备回复平台）

```
{
  "msgId": "对应请求的msgId",
  "ts": 1704067200000,
  "cmd": "rsp",
  "reqCmd": "下发时的命令名",
  "code": 0,
  "msg": "success",
  "data": { }
}
```

字段	类型	必填	说明
msgId	string	是	必须与请求的 msgId 一致
ts	number	否	响应时间戳
cmd	string	是	固定为 "rsp"
reqCmd	string	是	下发时的 cmd，与请求中的 cmd 一致，用于对应是哪条命令的响应
code	number	是	0=成功，非0=失败
msg	string	是	结果描述
data	object	是	返回数据，无数据时可为 {}

3.3 错误码

code	说明
0	成功
-1	参数错误
-2	设备忙
-3	不支持
-4	内部错误

4. 命令详细说明

以下每条命令均按请求与响应格式描述，并附完整示例。

4.1 登录 (login / login_ack)

原 TCP 对应： CMD_LOGIN (0x12)，设备发送登入请求，平台回复 0xAA 表示允许上线

说明： 由设备发起登录请求，平台回复是否允许登入。

设备发起登录请求

方向： 设备 → 平台

主题： device/{product}/{imei}/report

```
{
  "msgId": "dev-login-001",
  "ts": 1704067200000,
  "cmd": "login",
  "data": {
    "imei": "861234567890123",
    "iccid": "89860123456789012345"
  }
}
```

data 字段	类型	说明
imei	string	设备 IMEI, 15 位
iccid	string	SIM 卡 ICCID, 可选

平台回复是否允许

方向：平台 → 设备

主题：device/{product}/{imei}/cmd

```
{
  "msgId": "dev-login-001",
  "ts": 1704067200100,
  "cmd": "login_ack",
  "data": {
    "allow": true
  }
}
```

data 字段	类型	说明
allow	boolean	true=允许登入, false=拒绝

说明：设备收到 allow: true 后开始按周期发送心跳；收到 allow: false 则不发送心跳，可选择重试或断开。

示例

设备问：请求登入

```
{"msgId":"dev-login-001","ts":1704067200000,"cmd":"login","data":{
  "imei":"861234567890123","iccid":"89860123456789012345"}}
```

平台答：允许登入

```
{"msgId":"dev-login-001","ts":1704067200100,"cmd":"login_ack","data":{"allow":true}}
```

平台答：拒绝登入

```
{"msgId": "dev-login-001", "ts": 1704067200100, "cmd": "login_ack", "data": {"allow": false}}
```

4.2 心跳 (heartbeat / heartbeat_ack)

原 TCP 对应: CMD_HEARTBEAT (0x11)、CMD_HEARTBEAT_REP (0x91)

4.2.1 设备心跳上报 (设备 → 平台)

方向: 设备 → 平台

主题: device/{product}/{imei}/report

周期: 30 秒

设备上报:

```
{
  "msgId": "dev-hb-1704067200",
  "ts": 1704067200000,
  "cmd": "heartbeat",
  "data": {
    "relay": [true, false, false],
    "csq": 25,
    "iccid": "89860123456789012345",
    "swVer": "ML307_BKZQ_V1.2.7",
    "voltage": 225.5,
    "temperature": 32,
    "phaseStatus": 0,
    "meter": {
      "voltage": 220.1,
      "current": 1.23,
      "power": 265.5,
      "powerFactor": 0.98,
      "energy": 1234.56
    }
  }
}
```

data 字段	类型	说明
relay	array[bool]	继电器状态 [R1,R2,R3], true=吸合
csq	number	信号强度 0~31
iccid	string	SIM 卡 ICCID
swVer	string	软件版本号
voltage	number	电源电压(V)
temperature	number	温度(℃)
phaseStatus	number	三相缺相状态, 0=正常

data 字段	类型	说明
meter	object	计量参数，无计量芯片可省略
meter.voltage	number	电压 V
meter.current	number	电流 A
meter.power	number	有功功率 W
meter.powerFactor	number	功率因数
meter.energy	number	累计电量 kWh

示例：

```
{"msgId": "dev-hb-1704067200", "ts": 1704067200000, "cmd": "heartbeat", "data": {"relay": [true, false, false], "csq": 25, "iccid": "89860123456789012345", "swVer": "ML307_BKZQ_V1.2.7", "voltage": 225.5, "temperature": 32, "phaseStatus": 0, "meter": {"voltage": 220.1, "current": 1.23, "power": 265.5, "powerFactor": 0.98, "energy": 1234.56}}}
```

4.2.2 心跳回复（平台 → 设备）

方向：平台 → 设备

主题：device/{product}/{imei}/cmd

说明：平台收到心跳后回复，设备收到后重置超时计时器，无需设备再回复。

平台下发：

```
{
  "msgId": "plat-hb-ack-001",
  "ts": 1704067200100,
  "cmd": "heartbeat_ack",
  "data": {}
}
```

示例：

```
{"msgId": "plat-hb-ack-001", "ts": 1704067200100, "cmd": "heartbeat_ack", "data": {}}
```

4.3 继电器控制 (relay_ctrl)

原 TCP 对应：CMD_RELAY1_CTRL (0x21) / CMD_RELAY2_CTRL (0x22) / CMD_RELAY3_CTRL (0x23)

方向：平台 → 设备（下发），设备 → 平台（响应）

平台下发

主题: `device/{product}/{imei}/cmd`

```
{
  "msgId": "plat-relay-001",
  "ts": 1704067200000,
  "cmd": "relay_ctrl",
  "data": {
    "index": 0,
    "state": true
  }
}
```

data 字段	类型	说明
index	number	继电器索引 0/1/2
state	boolean	true=吸合, false=断开

设备响应

主题: `device/{product}/{imei}/rsp`

成功:

```
{
  "msgId": "plat-relay-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "relay_ctrl",
  "code": 0,
  "msg": "success",
  "data": {
    "index": 0,
    "state": true
  }
}
```

失败:

```
{
  "msgId": "plat-relay-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "relay_ctrl",
  "code": -1,
  "msg": "param error",
  "data": {}
}
```

示例

平台问：打开继电器0

```
{ "msgId": "plat-relay-001", "ts": 1704067200000, "cmd": "relay_ctrl", "data": { "index": 0, "state": true } }
```

设备答：成功

```
{ "msgId": "plat-relay-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "relay_ctrl", "code": 0, "msg": "success", "data": { "index": 0, "state": true } }
```

4.4 查询继电器状态 (query_relay)

原 TCP 对应： CMD_QUERY_RELAY (0x13)

平台下发

```
{ "msgId": "plat-query-relay-001", "ts": 1704067200000, "cmd": "query_relay", "data": {} }
```

设备响应

成功:

```
{ "msgId": "plat-query-relay-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "query_relay", "code": 0, "msg": "success", "data": { "relay": [true, false, false] } }
```

data 字段	类型	说明
relay	array[bool]	[R1,R2,R3] 状态, true=吸合

示例

平台问：

```
{"msgId": "plat-query-relay-001", "ts": 1704067200000, "cmd": "query_relay", "data": {}}
```

设备答：

```
{"msgId": "plat-query-relay-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "query_relay", "code": 0, "msg": "success", "data": {"relay": [true, false, false]}}
```

4.5 点动模式 (relay_pulse)

原 TCP 对应： CMD_RELAY_PULSE (0x15)

平台下发

```
{
  "msgId": "plat-pulse-001",
  "ts": 1704067200000,
  "cmd": "relay_pulse",
  "data": {
    "enable": true,
    "pulseTimeMs": 2000
  }
}
```

data 字段	类型	说明
enable	boolean	true=开启点动, false=关闭
pulseTimeMs	number	点动持续时间, 毫秒

设备响应

成功：

```
{
  "msgId": "plat-pulse-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "relay_pulse",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

失败：

```
{
  "msgId": "plat-pulse-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "relay_pulse",
  "code": -1,
  "msg": "param error",
  "data": {}
}
```

示例

平台问：开启点动，时长2秒

```
{"msgId":"plat-pulse-001","ts":1704067200000,"cmd":"relay_pulse","data":
{"enable":true,"pulseTimeMs":2000}}
```

设备答：成功

```
{"msgId":"plat-pulse-001","ts":1704067200100,"cmd":"rsp","reqCmd":"relay_pulse","code":0,"msg":"success","data":
{}}
```

4.6 继电器定时 (relay_timer)

原 TCP 对应： CMD_RELAY1_TIMER (0x31) / CMD_RELAY2_TIMER (0x32) / CMD_RELAY3_TIMER (0x33)

平台下发

```
{
  "msgId": "plat-timer-001",
  "ts": 1704067200000,
  "cmd": "relay_timer",
  "data": {
    "index": 0,
    "enabled": true,
    "hour": 8,
    "minute": 30,
    "second": 0,
    "action": 1,
    "weekMask": 127,
    "relayMask": 1
  }
}
```

data 字段	类型	说明
index	number	定时任务序号

data 字段	类型	说明
enabled	boolean	是否启用
hour	number	时 0~23
minute	number	分 0~59
second	number	秒 0~59
action	number	0=关, 1=开
weekMask	number	周重复, bit0~6=日~六, 127=每天
relayMask	number	继电器掩码, bit0=R1, bit1=R2, bit2=R3

设备响应

成功:

```
{
  "msgId": "plat-timer-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "relay_timer",
  "code": 0,
  "msg": "success",
  "data": {
    "index": 0,
    "enabled": true,
    "hour": 8,
    "minute": 30,
    "second": 0,
    "action": 1,
    "weekMask": 127,
    "relayMask": 1
  }
}
```

失败:

```
{
  "msgId": "plat-timer-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "relay_timer",
  "code": -1,
  "msg": "param error",
  "data": {}
}
```

示例

平台问：设置每天8:30开灯

```
{
  "msgId": "plat-timer-001",
  "ts": 1704067200000,
  "cmd": "relay_timer",
  "data": {
    "index": 0,
    "enabled": true,
    "hour": 8,
    "minute": 30,
    "second": 0,
    "action": 1,
    "weekMask": 127,
    "relayMask": 1
  }
}
```

设备答：成功

```
{
  "msgId": "plat-timer-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "relay_timer",
  "code": 0,
  "msg": "success",
  "data": {
    "index": 0,
    "enabled": true,
    "hour": 8,
    "minute": 30,
    "second": 0,
    "action": 1,
    "weekMask": 127,
    "relayMask": 1
  }
}
```

4.7 循环定时 (loop_timer)

原 TCP 对应： CMD_RELAY_LOOP (0x30)

平台下发

```
{
  "msgId": "plat-loop-001",
  "ts": 1704067200000,
  "cmd": "loop_timer",
  "data": {
    "index": 0,
    "enabled": true,
    "startHour": 8,
    "startMinute": 0,
    "endHour": 18,
    "endMinute": 0,
    "repeat": 1,
    "onHour": 8,
    "onMinute": 0,
    "offHour": 12,
    "offMinute": 0,
    "endState": 0
  }
}
```

data 字段	类型	说明
index	number	循环任务序号 0~99
enabled	boolean	true=启用， false=仅禁用
startHour/Minute	number	循环开始时间
endHour/Minute	number	循环结束时间

data 字段	类型	说明
repeat	number	1=每天, 2=一次
onHour/Minute	number	每次开启时间
offHour/Minute	number	每次关闭时间
endState	number	结束后: 0=默认, 1=开, 2=关

设备响应

成功:

```
{
  "msgId": "plat-loop-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "loop_timer",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

失败:

```
{
  "msgId": "plat-loop-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "loop_timer",
  "code": -1,
  "msg": "invalid index",
  "data": {}
}
```

示例

平台问:

```
{"msgId":"plat-loop-001","ts":1704067200000,"cmd":"loop_timer","data":
{"index":0,"enabled":true,"startHour":8,"startMinute":0,"endHour":18,"endMinute":0,"repeat":
1,"onHour":8,"onMinute":0,"offHour":12,"offMinute":0,"endState":0}}
```

设备答: 成功

```
{"msgId":"plat-loop-001","ts":1704067200100,"cmd":"rsp","reqCmd":"loop_timer","code":0,"msg":"success","data":
{}}
```

4.8 倒计时 (countdown)

原 TCP 对应： CMD_COUNTDOWN_CTRL (0x17)

平台下发

```
{
  "msgId": "plat-cd-001",
  "ts": 1704067200000,
  "cmd": "countdown",
  "data": {
    "state": true,
    "seconds": 60
  }
}
```

data 字段	类型	说明
state	boolean	倒计时期间继电器：true=开， false=关
seconds	number	倒计时秒数

说明： 倒计时结束后恢复倒计时前的继电器状态。

设备响应

成功：

```
{
  "msgId": "plat-cd-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "countdown",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

失败：

```
{
  "msgId": "plat-cd-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "countdown",
  "code": -1,
  "msg": "param error",
  "data": {}
}
```

示例

平台问：继电器开60秒后自动恢复

```
{"msgId": "plat-cd-001", "ts": 1704067200000, "cmd": "countdown", "data": {"state": true, "seconds": 60}}
```

设备答：成功

```
{"msgId": "plat-cd-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "countdown", "code": 0, "msg": "success", "data": {}}
```

4.9 停止倒计时 (countdown_stop)

原 TCP 对应：无独立命令，扩展

平台下发

```
{  
  "msgId": "plat-cd-stop-001",  
  "ts": 1704067200000,  
  "cmd": "countdown_stop",  
  "data": {}  
}
```

设备响应

成功：

```
{  
  "msgId": "plat-cd-stop-001",  
  "ts": 1704067200100,  
  "cmd": "rsp",  
  "reqCmd": "countdown_stop",  
  "code": 0,  
  "msg": "success",  
  "data": {}  
}
```

示例

平台问：

```
{"msgId": "plat-cd-stop-001", "ts": 1704067200000, "cmd": "countdown_stop", "data": {}}
```

设备答：

```
{"msgId": "plat-cd-stop-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "countdown_stop", "code": 0, "msg": "success", "data": {}}
```

4.10 开关锁定 (relay_lock)

原 TCP 对应：CMD_COUNTDOWN_STOP (0x18) 复用为锁定

平台下发

```
{
  "msgId": "plat-lock-001",
  "ts": 1704067200000,
  "cmd": "relay_lock",
  "data": {
    "locked": true
  }
}
```

data 字段	类型	说明
locked	boolean	true=锁定（本地按键失效），false=解锁

设备响应

成功：

```
{
  "msgId": "plat-lock-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "relay_lock",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

示例

平台问：锁定开关

```
{"msgId": "plat-lock-001", "ts": 1704067200000, "cmd": "relay_lock", "data": {"locked": true}}
```

设备答：成功

```
{"msgId": "plat-lock-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "relay_lock", "code": 0, "msg": "success", "data": {}}
```

4.11 上电默认状态 (switch_default)

原 TCP 对应: CMD_SWITCH_DEFAULT (0x19)

平台下发

```
{
  "msgId": "plat-default-001",
  "ts": 1704067200000,
  "cmd": "switch_default",
  "data": {
    "mode": 0
  }
}
```

data 字段	类型	说明
mode	number	0=默认关, 1=默认开, 2=保持上次

设备响应

成功:

```
{
  "msgId": "plat-default-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "switch_default",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

失败:

```
{
  "msgId": "plat-default-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "switch_default",
  "code": -1,
  "msg": "invalid mode",
  "data": {}
}
```

示例

平台问：上电默认关

```
{ "msgId": "plat-default-001", "ts": 1704067200000, "cmd": "switch_default", "data": { "mode": 0 } }
```

设备答：成功

```
{ "msgId": "plat-default-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "default_state", "code": 0, "msg": "success", "data": {} }
```

4.12 本地按键启用 (key_enable)

原 TCP 对应： CMD_KEY_ENABLE (0x40)

平台下发

```
{
  "msgId": "plat-key-001",
  "ts": 1704067200000,
  "cmd": "key_enable",
  "data": {
    "enabled": true
  }
}
```

data 字段	类型	说明
enabled	boolean	true=启用本地按键， false=禁用

设备响应

成功：

```
{
  "msgId": "plat-key-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "key_enable",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

示例

平台问：启用本地按键

```
{"msgId": "plat-key-001", "ts": 1704067200000, "cmd": "key_enable", "data": {"enabled": true}}
```

设备答：成功

```
{"msgId": "plat-key-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "key_enable", "code": 0, "msg": "success", "data": {}}
```

4.13 设置服务器地址 (set_server_addr)

原 TCP 对应： CMD_SET_SERVER_ADDR (0x41)

平台下发

```
{
  "msgId": "plat-server-001",
  "ts": 1704067200000,
  "cmd": "set_server_addr",
  "data": {
    "server": "mqtt.example.com",
    "port": 1883
  }
}
```

data 字段	类型	说明
server	string	MQTT 服务器地址
port	number	端口

设备响应

成功：

```
{
  "msgId": "plat-server-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "set_server_addr",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

失败：

```
{
  "msgId": "plat-server-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "set_server_addr",
  "code": -1,
  "msg": "invalid server or port",
  "data": {}
}
```

示例

平台问：

```
{"msgId":"plat-server-001","ts":1704067200000,"cmd":"set_server_addr","data":
{"server":"mqtt.example.com","port":1883}}
```

设备答：成功

```
{"msgId":"plat-server-001","ts":1704067200100,"cmd":"rsp","reqCmd":"server_cfg","code":0,"msg":"success","data":
{}}
```

4.14 电量同步 (energy_sync)

原 TCP 对应： CMD_ENERGY_SYNC (0x42)

平台下发

```
{
  "msgId": "plat-energy-001",
  "ts": 1704067200000,
  "cmd": "energy_sync",
  "data": {
    "energy": 0.0
  }
}
```

data 字段	类型	说明
energy	number	电量值 kWh, 0 表示清零

设备响应

成功：

```
{
  "msgId": "plat-energy-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "energy_sync",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

示例

平台问：电量清零

```
{"msgId":"plat-energy-001","ts":1704067200000,"cmd":"energy_sync","data":{"energy":0.0}}
```

设备答：成功

```
{"msgId":"plat-energy-001","ts":1704067200100,"cmd":"rsp","reqCmd":"energy_sync","code":0,"msg":"success","data":{}}
```

4.15 恢复出厂 (factory_reset)

原 TCP 对应： CMD_FACTORY_RESET (0x43)

平台下发

```
{
  "msgId": "plat-factory-001",
  "ts": 1704067200000,
  "cmd": "factory_reset",
  "data": {
    "confirm": true
  }
}
```

data 字段	类型	说明
confirm	boolean	必须 true 才执行

恢复内容：清空定时/循环定时、停止倒计时、解锁、默认关、启用按键。

设备响应

成功：

```
{
  "msgId": "plat-factory-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "factory_reset",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

失败（未确认）：

```
{
  "msgId": "plat-factory-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "factory_reset",
  "code": -1,
  "msg": "confirm must be true",
  "data": {}
}
```

示例

平台问：

```
{"msgId":"plat-factory-001","ts":1704067200000,"cmd":"factory_reset","data":
{"confirm":true}}
```

设备答：成功

```
{"msgId":"plat-factory-001","ts":1704067200100,"cmd":"rsp","reqCmd":"factory_reset","code":0,"msg":"success","data":{}}
```

4.16 FOTA 升级 (fota_ctrl)

原 TCP 对应：CMD_FOTA_CTRL (0x25)

平台下发

```
{
  "msgId": "plat-fota-001",
  "ts": 1704067200000,
  "cmd": "fota_ctrl",
  "data": {
    "action": "start"
  }
}
```

data 字段	类型	说明
action	string	"start"=启动升级, "cancel"=取消

设备响应

成功（接受升级）：

```
{
  "msgId": "plat-fota-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "fota_ctrl",
  "code": 0,
  "msg": "success",
  "data": {
    "action": "start"
  }
}
```

成功（取消升级）：

```
{
  "msgId": "plat-fota-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "fota_ctrl",
  "code": 0,
  "msg": "success",
  "data": {
    "action": "cancel"
  }
}
```

失败：

```
{
  "msgId": "plat-fota-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "fota_ctrl",
  "code": -1,
  "msg": "invalid action",
  "data": {}
}
```

示例

平台问：启动升级

```
{"msgId": "plat-fota-001", "ts": 1704067200000, "cmd": "fota_ctrl", "data": {"action": "start"}}
```

设备答：成功

```
{"msgId": "plat-fota-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "fota_ctrl", "code": 0, "msg": "success", "data": {"action": "start"}}
```

4.17 调光控制 (dimmer_ctrl)

原 TCP 对应： CMD_DIMMING_CTRL (0x55)

适用设备： 单灯控制器 (DEVICE_DIMMER)

平台下发

```
{
  "msgId": "plat-dimming-001",
  "ts": 1704067200000,
  "cmd": "dimmer_ctrl",
  "data": {
    "routeMask": 1,
    "level": 58
  }
}
```

data 字段	类型	说明
routeMask	number	路数掩码，bit0=路1，bit1=路2，单路为 1
level	number	调光等级 0~100

说明： 仅保存等级；若对应路继电器已打开，则立即执行调光。

设备响应

成功：

```
{
  "msgId": "plat-dimming-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "dimmer_ctrl",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

失败:

```
{
  "msgId": "plat-dimming-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "dimmer_ctrl",
  "code": -1,
  "msg": "level must be 0~100",
  "data": {}
}
```

示例

平台问: 设置调光58%

```
{"msgId":"plat-dimming-001","ts":1704067200000,"cmd":"dimmer_ctrl","data":
{"routeMask":1,"level":58}}
```

设备答: 成功

```
{"msgId":"plat-dimming-001","ts":1704067200100,"cmd":"rsp","reqCmd":"dimmer_ctrl","code":0,"msg":"success","data":
{}}
```

4.18 调光渐变时间 (dimmer_fade_time)

原 TCP 对应: CMD_DIMMING_FADE_TIME (0x56)

平台下发

```
{
  "msgId": "plat-fade-001",
  "ts": 1704067200000,
  "cmd": "dimmer_fade_time",
  "data": {
    "fadeTime01s": 5
  }
}
```

data 字段	类型	说明
fadeTime01s	number	每步渐变时间，单位 0.1 秒，1~100

设备响应

成功:

```
{
  "msgId": "plat-fade-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "dimmer_fade_time",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

失败:

```
{
  "msgId": "plat-fade-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "dimmer_fade_time",
  "code": -1,
  "msg": "fadeTime01s must be 1~100",
  "data": {}
}
```

示例

平台问: 设置每步500ms

```
{"msgId":"plat-fade-001","ts":1704067200000,"cmd":"dimmer_fade_time","data":
{"fadeTime01s":5}}
```

设备答: 成功

```
{"msgId":"plat-fade-001","ts":1704067200100,"cmd":"rsp","reqCmd":"dimmer_fade","code":0,"msg":"success","data":
{}}
```

4.19 三相计量上报周期 (meter3p_period)

原 TCP 对应: CMD_3P_METER_PERIOD (0x37)

适用设备: 三相计量 (DEVICE_3P_JL)

平台下发

```
{
  "msgId": "plat-3p-period-001",
  "ts": 1704067200000,
  "cmd": "meter3p_period",
  "data": {
    "period": 120
  }
}
```

data 字段	类型	说明
period	number	上报周期，秒，最小 10

设备响应

成功:

```
{
  "msgId": "plat-3p-period-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "meter3p_period",
  "code": 0,
  "msg": "success",
  "data": {
    "period": 120
  }
}
```

失败:

```
{
  "msgId": "plat-3p-period-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "meter3p_period",
  "code": -1,
  "msg": "period must be >= 10",
  "data": {}
}
```

示例

平台问：设置120秒上报

```
{"msgId":"plat-3p-period-001","ts":1704067200000,"cmd":"meter3p_period","data":
{"period":120}}
```

设备答：成功

```
{"msgId": "plat-3p-period-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "meter3p_period", "code": 0, "msg": "success", "data": {"period": 120}}
```

4.20 三相计量数据上报 (meter3p_report)

原 TCP 对应：CMD_3P_METER_REPORT (0x36)

方向：设备 → 平台（设备周期主动上报，无需平台回复）

主题：device/{product}/{imei}/report

设备上报

```
{
  "msgId": "dev-3p-1704067200",
  "ts": 1704067200000,
  "cmd": "meter3p_report",
  "data": {
    "phases": [
      {
        "phase": "A",
        "voltage": 220.1,
        "current": 1.2,
        "power": 260.5,
        "powerFactor": 0.98,
        "energy": 1234.5
      },
      {
        "phase": "B",
        "voltage": 219.8,
        "current": 1.1,
        "power": 240.2,
        "powerFactor": 0.97,
        "energy": 1230.1
      },
      {
        "phase": "C",
        "voltage": 221.0,
        "current": 1.3,
        "power": 280.0,
        "powerFactor": 0.99,
        "energy": 1235.0
      }
    ]
  }
}
```

示例

```
{"msgId": "dev-3p-1704067200", "ts": 1704067200000, "cmd": "meter3p_report", "data": {"phases": [{"phase": "A", "voltage": 220.1, "current": 1.2, "power": 260.5, "powerFactor": 0.98, "energy": 1234.5}, {"phase": "B", "voltage": 219.8, "current": 1.1, "power": 240.2, "powerFactor": 0.97, "energy": 1230.1}, {"phase": "C", "voltage": 221.0, "current": 1.3, "power": 280.0, "powerFactor": 0.99, "energy": 1235.0}]}]}
```

4.21 查询 ICCID (query_iccid)

原 TCP 对应: CMD_QUERY_ICCID (0x26)

平台下发

```
{
  "msgId": "plat-query-iccid-001",
  "ts": 1704067200000,
  "cmd": "query_iccid",
  "data": {}
}
```

设备响应

成功:

```
{
  "msgId": "plat-query-iccid-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "query_iccid",
  "code": 0,
  "msg": "success",
  "data": {
    "iccid": "89860123456789012345"
  }
}
```

示例

平台问:

```
{"msgId": "plat-query-iccid-001", "ts": 1704067200000, "cmd": "query_iccid", "data": {}}
```

设备答:

```
{"msgId": "plat-query-iccid-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "query_iccid", "code": 0, "msg": "success", "data": {"iccid": "89860123456789012345"}}
```

4.22 查询软件版本 (query_sw_ver)

原 TCP 对应: CMD_QUERY_SW_VER (0x27)

平台下发

```
{  
  "msgId": "plat-query-ver-001",  
  "ts": 1704067200000,  
  "cmd": "query_sw_ver",  
  "data": {}  
}
```

设备响应

成功:

```
{  
  "msgId": "plat-query-ver-001",  
  "ts": 1704067200100,  
  "cmd": "rsp",  
  "reqCmd": "query_sw_ver",  
  "code": 0,  
  "msg": "success",  
  "data": {  
    "swVer": "ML307_BKZQ_V1.2.7"  
  }  
}
```

示例

平台问:

```
{"msgId": "plat-query-ver-001", "ts": 1704067200000, "cmd": "query_sw_ver", "data": {}}
```

设备答:

```
{"msgId": "plat-query-ver-001", "ts": 1704067200100, "cmd": "rsp", "reqCmd": "query_sw_ver", "code": 0, "msg": "success", "data": {"swVer": "ML307_BKZQ_V1.2.7"}}
```

4.23 查询 SN (query_sn)

原 TCP 对应: CMD_QUERY_SN (0x28)

平台下发

```
{
  "msgId": "plat-query-sn-001",
  "ts": 1704067200000,
  "cmd": "query_sn",
  "data": {}
}
```

设备响应

成功:

```
{
  "msgId": "plat-query-sn-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "query_sn",
  "code": 0,
  "msg": "success",
  "data": {
    "sn": "SN1234567890"
  }
}
```

示例

平台问:

```
{"msgId":"plat-query-sn-001","ts":1704067200000,"cmd":"query_sn","data":{}}
```

设备答:

```
{"msgId":"plat-query-sn-001","ts":1704067200100,"cmd":"rsp","reqCmd":"query_sn","code":0,"msg":"success","data":{
{"sn":"SN1234567890"}
}}
```

4.24 按键事件上报 (key_event)

原 TCP 对应: CMD_KEY_EVENT (0x16)

方向: 设备 → 平台 (设备主动上报, 无需平台回复)

主题: device/{product}/{imei}/report

设备上报

```
{
  "msgId": "dev-key-1704067200",
  "ts": 1704067200000,
  "cmd": "key_event",
  "data": {
    "relay": [true, false, false]
  }
}
```

data 字段	类型	说明
relay	array[bool]	按键操作后的继电器状态 [R1,R2,R3]

示例

```
{"msgId":"dev-key-1704067200","ts":1704067200000,"cmd":"key_event","data":{"relay":
[true,false,false]}}
```

4.25 掉电上报 (low_power)

原 TCP 对应： LOW_POWER_REPORT (0x14)

方向： 设备 → 平台（设备主动上报，无需平台回复）

主题： device/{product}/{imei}/report

设备上报

```
{
  "msgId": "dev-power-1704067200",
  "ts": 1704067200000,
  "cmd": "low_power",
  "data": {}
}
```

示例

```
{"msgId":"dev-power-1704067200","ts":1704067200000,"cmd":"low_power","data":{}}
```

4.26 继电器多路控制 (relay_multi_ctrl)

原 TCP 对应： 继电器多路控制 (0x50)

说明： 一次性下发多个回路的目标状态，适用于多回路（例如 32 路/多板级）设备。对仅 3 路继电器设备，可选实现；平台应通过设备类型/能力集判断是否使用本命令。

平台下发

```
{
  "msgId": "plat-multi-001",
  "ts": 1704067200000,
  "cmd": "relay_multi_ctrl",
  "data": {
    "bitmask": "00030005",
    "bitWidth": 32,
    "bitOrder": "lsb0"
  }
}
```

data 字段	类型	说明
bitmask	string	继电器目标状态位图，16 进制字符串（建议固定 8 字节=32bit：8 个 hex 字符），每一位对应一个继电器通道，1=合闸，0=拉闸
bitWidth	number	位宽（建议 32），用于平台校验长度
bitOrder	string	固定位序约定：lsb0 表示最低位(bit0)对应继电器 1（与 TCP 协议“按位计算”一致）

TCP 示例 00 03 00 05 表示合闸：1、3、17、18，其余拉闸；对应 bitmask="00030005"（按大端展示 hex 字符串）。

设备响应

```
{
  "msgId": "plat-multi-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "relay_multi_ctrl",
  "code": 0,
  "msg": "success",
  "data": {
    "bitmask": "00030005"
  }
}
```

4.27 流程模式开关 (flow_mode)

原 TCP 对应：流程模式开关 (0x51)

平台下发

```
{
  "msgId": "plat-flowmode-001",
  "ts": 1704067200000,
  "cmd": "flow_mode",
  "data": {
    "enabled": true
  }
}
```

data 字段	类型	说明
enabled	boolean	true=开启流程模式, false=关闭

设备响应

```
{
  "msgId": "plat-flowmode-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "flow_mode",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

4.28 编辑流程 (flow_edit)

原 TCP 对应：编辑流程（0x52）

说明：一个设备最多支持 10 个流程；每个流程最多 80 个步骤。流程的启停由 flow_run 控制。

平台下发

```
{
  "msgId": "plat-flowedit-001",
  "ts": 1704067200000,
  "cmd": "flow_edit",
  "data": {
    "flowId": 1,
    "enabled": true,
    "startCond": 1,
    "stopCond": 0,
    "steps": [
      { "stepNo": 3, "type": 1, "value": 2 },
      { "stepNo": 4, "type": 3, "value": 1005 },
      { "stepNo": 5, "type": 4, "value": 2 }
    ]
  }
}
```

```
}

```

data 字段	类型	说明
flowId	number	流程编号 1~10
enabled	boolean	true=使能该流程，false=失能
startCond	number	启动条件：1=X01 有效；2=X02 有效；255(0xFF)=无条件
stopCond	number	停止条件：0=X00 有效；3=X03 有效；255(0xFF)=无条件
steps	array	步骤数组
steps[].stepNo	number	步骤号 0~49（与 TCP “步骤号”一致）
steps[].type	number	步骤类型：1=打开继电器；2=关闭继电器；3=等待时间；4=等待信号；5=等信号跳转步骤
steps[].value	number/object	与 type 对应的参数，见下表

steps[].value 约定：

type	value 类型	说明
1/2	number	继电器编号 0~31
3	number	等待时间，单位 0.1s（例如 1005 表示 100.5 秒）
4	number	信号编号 0~31
5	object	{ "signal": 3, "jumpTo": 10, "timeout01s": 1005 }

设备响应

```
{
  "msgId": "plat-flowedit-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "flow_edit",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

4.29 流程执行开关 (flow_run)

原 TCP 对应：流程执行开关（0x53）

平台下发

```
{
  "msgId": "plat-flowrun-001",
  "ts": 1704067200000,
  "cmd": "flow_run",
  "data": {
    "flowId": 1,
    "mode": "loop"
  }
}
```

data 字段	类型	说明
flowId	number	流程编号 1~10
mode	string	"loop"=循环执行; "once"=单次执行; "stop"=停止

设备响应

```
{
  "msgId": "plat-flowrun-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "flow_run",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

4.30 流程状态上报 (flow_status)

原 TCP 对应： 流程状态上报 (0x54)

方向： 设备 → 平台（周期上报，建议 15 秒一次；无需平台回复）

```
{
  "msgId": "dev-flow-1704067200",
  "ts": 1704067200000,
  "cmd": "flow_status",
  "data": {
    "flowId": 1,
    "stepNo": 10
  }
}
```

4.31 设置输出脉冲数 (pulse_out)

原 TCP 对应： 设置输出脉冲数（0x57）

平台下发

```
{
  "msgId": "plat-pulseout-001",
  "ts": 1704067200000,
  "cmd": "pulse_out",
  "data": {
    "count": 99
  }
}
```

data 字段	类型	说明
count	number	输出脉冲数（单位 1）， 范围按设备能力（TCP 示例为 99）

设备响应

```
{
  "msgId": "plat-pulseout-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "pulse_out",
  "code": 0,
  "msg": "success",
  "data": { "count": 99 }
}
```

4.32 温度阈值设置 / 超限上报 (temp_alarm_cfg / temp_alarm)

原 TCP 对应： 温度阈值设置及温度超限上报（0x58）

4.32.1 平台下发阈值配置 (temp_alarm_cfg)

```
{
  "msgId": "plat-tcfg-001",
  "ts": 1704067200000,
  "cmd": "temp_alarm_cfg",
  "data": {
    "enabled": true,
    "threshold": 80.0
  }
}
```

data 字段	类型	说明
enabled	boolean	true=使能温度报警；false=失能
thresholdC	number	阈值温度(°C)，分辨率 0.1°C

4.32.2 设备响应（对配置命令）

```
{
  "msgId": "plat-tcfg-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "temp_alarm_cfg",
  "code": 0,
  "msg": "success",
  "data": { "enabled": true, "thresholdC": 80.0 }
}
```

4.32.3 设备主动上报超限（temp_alarm）

```
{
  "msgId": "dev-talarm-1704067200",
  "ts": 1704067200000,
  "cmd": "temp_alarm",
  "data": {
    "type": "over",
    "thresholdC": 80.0,
    "currentC": 31.2
  }
}
```

data 字段	类型	说明
type	string	"over" =超限触发（TCP 中标记 0x01）；可扩展 "recover" =恢复
thresholdC	number	配置阈值
currentC	number	当前温度

4.33 过流阈值设置 / 超限上报 (oc_alarm_cfg / oc_alarm)

原 TCP 对应：过流设置及过流超限上报（0x59）

平台下发

```
{
  "msgId": "plat-ocfg-001",
  "ts": 1704067200000,
  "cmd": "oc_alarm_cfg",
  "data": {
    "enabled": true,
    "thresholdA": 80.0
  }
}
```

设备响应

```
{
  "msgId": "plat-ocfg-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "oc_alarm_cfg",
  "code": 0,
  "msg": "success",
  "data": { "enabled": true, "thresholdA": 80.0 }
}
```

设备主动上报 (oc_alarm)

```
{
  "msgId": "dev-ocalarm-1704067200",
  "ts": 1704067200000,
  "cmd": "oc_alarm",
  "data": {
    "type": "over",
    "thresholdA": 80.0,
    "currentA": 31.2
  }
}
```

4.34 过欠压阈值设置 / 超限上报 (ovuv_alarm_cfg / ovuv_alarm)

原 TCP 对应：过欠压设置及过欠压超限上报 (0x60)

平台下发

```
{
  "msgId": "plat-vcfg-001",
  "ts": 1704067200000,
  "cmd": "ovuv_alarm_cfg",
  "data": {
    "enabled": true,
    "overV": 260.5,
    "underV": 160.5
  }
}
```

设备响应

```
{
  "msgId": "plat-vcfg-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "ovuv_alarm_cfg",
  "code": 0,
  "msg": "success",
  "data": { "enabled": true, "overV": 260.5, "underV": 160.5 }
}
```

设备主动上报 (ovuv_alarm)

```
{
  "msgId": "dev-valarm-1704067200",
  "ts": 1704067200000,
  "cmd": "ovuv_alarm",
  "data": {
    "type": "overV",
    "overV": 260.5,
    "underV": 160.5,
    "currentV": 220.5
  }
}
```

type	说明
overV	过压 (TCP 超限类型 0x01)
underV	欠压 (TCP 超限类型 0x02)
none	无过欠压 (TCP 超限类型 0x00, 可用于恢复上报)

4.35 设备重启 (reboot)

原 TCP 对应：设备重启指令 (0x61)

平台下发

```
{
  "msgId": "plat-reboot-001",
  "ts": 1704067200000,
  "cmd": "reboot",
  "data": {
    "confirm": true
  }
}
```

data 字段	类型	说明
confirm	boolean	必须 true 才执行重启

设备响应

```
{
  "msgId": "plat-reboot-001",
  "ts": 1704067200100,
  "cmd": "rsp",
  "reqCmd": "reboot",
  "code": 0,
  "msg": "success",
  "data": {}
}
```

5. 命令对照表（完整）

原 TCP 命令码	命令名称	MQTT cmd	方向	是否有设备响应
0x11	心跳	heartbeat	设备→平台	否（平台发 heartbeat_ack）
0x91	心跳回复	heartbeat_ack	平台→设备	否
0x12	登入	login / login_ack	设备→平台 (login) → 平台→设备 (login_ack)	是（平台回复 login_ack）
0x13	查询继电器	query_relay	平台→设备	是
0x14	掉电上报	low_power	设备→平台	否
0x15	点动模式	relay_pulse	平台→设备	是

原 TCP 命令码	命令名称	MQTT cmd	方向	是否有设备响应
0x16	按键事件	key_event	设备→平台	否
0x17	倒计时	countdown	平台→设备	是
0x18	开关锁定	relay_lock	平台→设备	是
0x19	默认状态	switch_default	平台→设备	是
0x21/22/23	继电器控制	relay_ctrl	平台→设备	是
0x25	FOTA	fota_ctrl	平台→设备	是
0x26	查询 ICCID	query_iccid	平台→设备	是
0x27	查询版本	query_sw_ver	平台→设备	是
0x28	查询SN	query_sn	平台→设备	是
0x30	循环定时	loop_timer	平台→设备	是
0x31/32/33	单次定时	relay_timer	平台→设备	是
0x36	三相计量上报	meter3p_report	设备→平台	否
0x37	三相计量周期	meter3p_period	平台→设备	是
0x40	按键启用	key_enable	平台→设备	是
0x41	服务器地址	set_server_addr	平台→设备	是
0x42	电量同步	energy_sync	平台→设备	是
0x43	恢复出厂	factory_reset	平台→设备	是
0x50	继电器多路控制	relay_multi_ctrl	平台→设备	是
0x51	流程模式开关	flow_mode	平台→设备	是
0x52	编辑流程	flow_edit	平台→设备	是
0x53	流程执行开关	flow_run	平台→设备	是
0x54	流程状态上报	flow_status	设备→平台	否

原 TCP 命令码	命令名称	MQTT cmd	方向	是否有设备响应
0x55	调光控制	dimmer_ctrl	平台→设备	是
0x56	调光渐变时间	dimmer_fade_time	平台→设备	是
0x57	输出脉冲数	pulse_out	平台→设备	是
0x58	温度阈值/超限	temp_alarm_cfg / temp_alarm	平台→设备 (cfg) / 设备→平台 (alarm)	cfg有响应, alarm无
0x59	过流阈值/超限	oc_alarm_cfg / oc_alarm	平台→设备 (cfg) / 设备→平台 (alarm)	cfg有响应, alarm无
0x60	过欠压阈值/超限	ovuv_alarm_cfg / ovuv_alarm	平台→设备 (cfg) / 设备→平台 (alarm)	cfg有响应, alarm无
0x61	设备重启	reboot	平台→设备	是

6. 开发注意事项

1. **msgId**: 平台下发建议使用 UUID; 设备响应必须回传相同 msgId。
2. **QoS**: QoS0。
3. **JSON 编码**: UTF-8, 避免 BOM。
4. **无响应命令**: `heartbeat` (设备上报)、`heartbeat_ack` (平台下发)、`key_event`、`low_power`、`meter3p_report`、`flow_status`、`temp_alarm`、`oc_alarm`、`ovuv_alarm` 等为单向消息, 不需要对方回复。`login` 由设备发起, 平台必须回复 `login_ack`。
5. **retain**: 本协议数据默认 **retain=false**。如平台对“最后一次状态”有要求, 应由平台侧自行落库; 不建议使用 retain 代替状态存储 (易引入历史脏数据)。
6. **离线判定**: 建议以 MQTT LWT (遗嘱) + 业务心跳超时结合判定; 仅依赖 keepalive 可能导致离线感知不及时。
7. **可选字段**: 设备型号不同时, `data` 中可选字段可省略, 平台需做兼容解析。

文档结束