M030G SPI 模擬MDIO 波形

NuMicro® 32位系列微控制器范例代码介绍

文件信息

应用简述	本范例代码使用 M030G SPI 接口仿真 MDIO 波形用以控制以太网络 PHY(IP101GR)。
BSP 版本	M029G_M030G_M031G_Series_BSP_CMSIS_V3.03.000
开发平台	NuMaker-M030GTD V1.1

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1. 概述

本范例代码使用 M030G SPI 接口来仿真 MDIO 波形用以控制以太网络 PHY。

大多数 NuMicro® 家族微控制器不支持 MDIO 接口，本范例代码提供一种存取以太网络 PHY 的解决方案，可广泛应用于 NuMicro® 家族微控制器。

本范例代码需另接外部硬件模块，包含一九旸电子的以太网络 PHY(IP101GR)。

1.1 原理

以下将重点介绍如何透过 SPI 接口来仿真 MDIO 波形。M030G 扮演 SPI 主机; IP101GR 扮演 SPI 从机。

1.1.1 MDIO 资料格式

MDIO 数据格式如图 1-1 所示，字段说明如表 1-1 所示。

Preamble	ST	OP	PHY_ADR	REG_ADR	TA	DATA
32-bit	2-bit	2-bit	5-bit	5-bit	2-bit	16-bit

图 1-1 MDIO 数据格式

字段	数据宽度	说明
Preamble	32-bit	32 个连续 2’1
ST	2-bit	帧开始标志 2’01
OP	2-bit	操作码 01 = 写操作 10 = 读操作
PHY_ADR	5-bit	PHY 地址
REG_ADR	5-bit	寄存器地址
TA	2-bit	状态转换时间
DATA	16-bit	MDIO 资料

表 1-1 MDIO 数据字段介绍

由于 MDIO 是双向数据线，故需将 SPI_MOSI 引脚、SPI_MISO 引脚和 MDIO 引脚连接在一起以实现此功能。在读操作中，程序必须先将 SPI_MOSI 引脚配置为 GPIO 输入模式，才能读取数据。图 1-3 与图 1-4 分别描述 SPI 接口仿真 MDIO 写操作与读操作的程序流程。图 1-2 描述终端机人机界面操作流程。

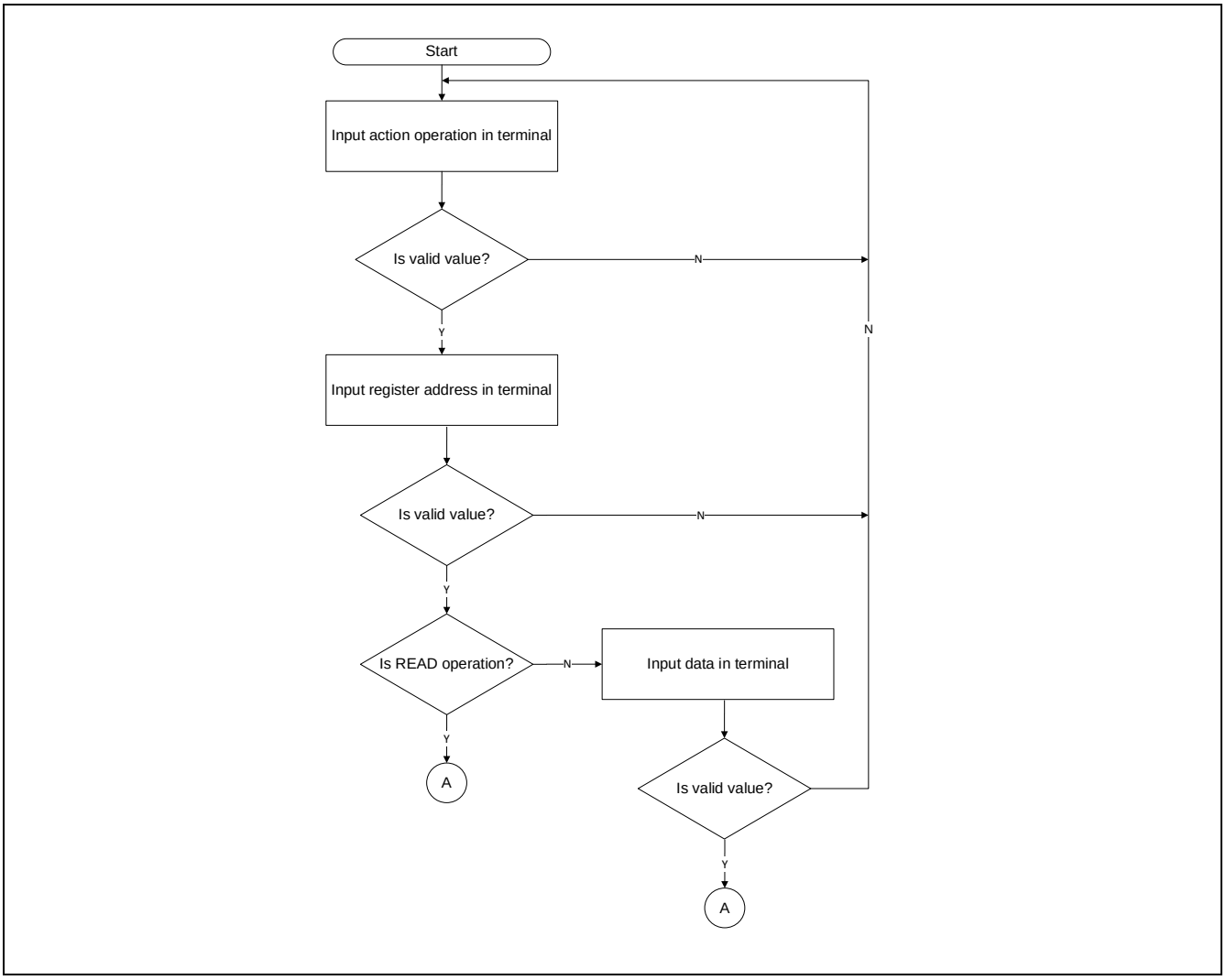

图 1-2 终端机人机接口操作流程

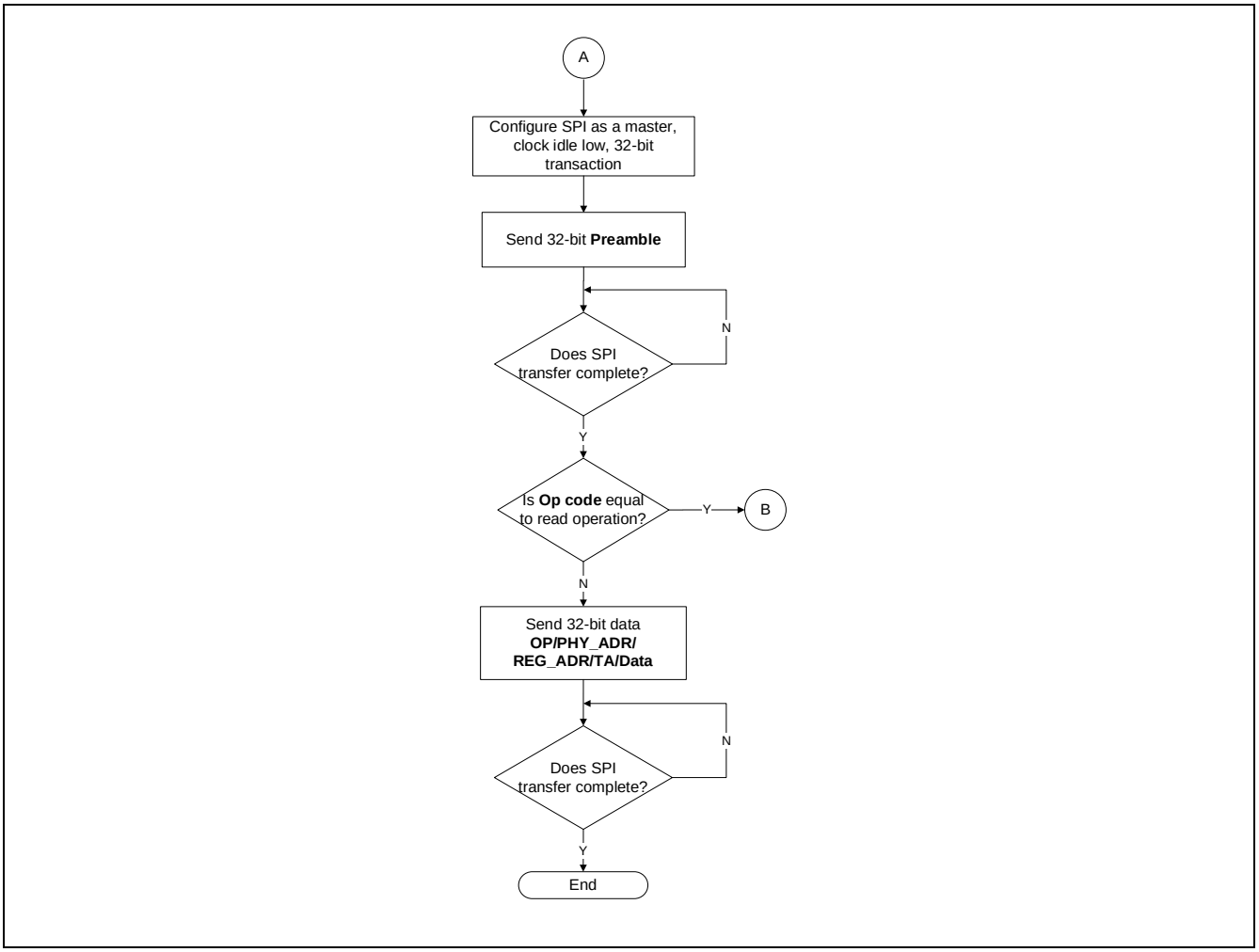

图 1-3 SPI 模拟 MDIO 写操作流程图

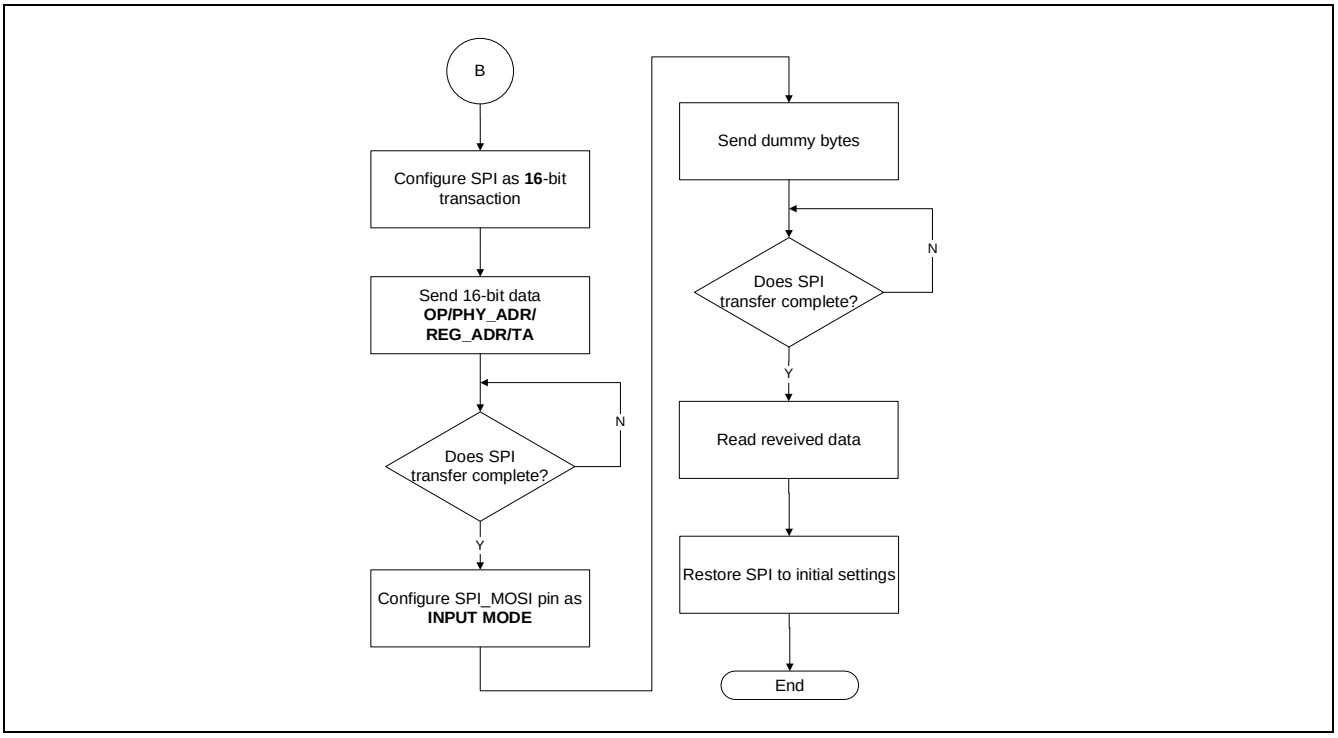

图 1-4 SPI 模拟 MDIO 读操作流程图

1.2 执行結果

开启计算机终端机软件，设置 UART 传输速度为 115200 bps，无校验位，数据长度为 8 位，停止位长度为 1 位。执行程序后，终端机显示操作指示。

图 1-5 终端机屏幕截图

本范例代码执行结果如图 1-6 与图 1-7 所示，分别对应 MDIO 写操作和读操作波形。演示将寄存器 0x04 配置为 0x0001 并进行验证。

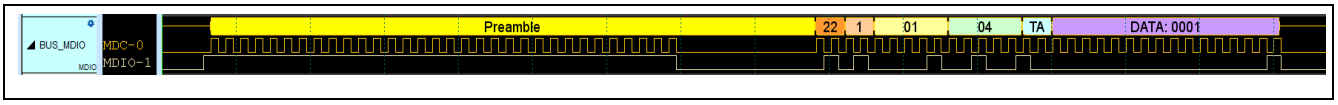

图 1-6 MDIO 写操作波形

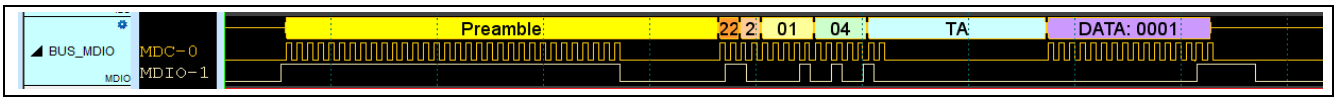

图 1-7 MDIO 读操作波形

2. 代码介绍

初始化 SPI 接口，代码位于 *spi_transfer.c*。

```
void SPI_Init(void)
{
    /* Set IP clock divider. SPI clock rate = 1MHz */
    SPI_Open(SPI0, SPI_MASTER, SPI_MODE_0, 32, SPI_CLK_FREQ);

    /* Enable the automatic hardware slave select function. Select the SS pin and
       configure as low-active. */
    SPI_EnableAutoSS(SPI0, SPI_SS, SPI_SS_ACTIVE_LOW);
}
```

初始化系统后，透过 SPI 接口仿真 MDIO 波形。代码位于 spi_transfer.c。

写操作

- 传送 32 位 Preamble。
- 传送 *MDIO_temp*，包含 ST (2 位)、opcode(2 位)、PHY 地址(5 位)、寄存器地址(5 位)、TA (2 位) 与 Data(16 位)。

读操作

- 传送 32 位 Preamble。
- 设定 SPI 接口数据宽度为 16 位与传送 *MDIO_temp*，包含 ST (2 位)、opcode(2 位)、PHY 地址(5 位)、寄存器地址(5 位) 与 TA (2 位) 组成。
- 设定 SPI_MOSI 引脚为 GPIO input 模式来接收数据。
- 接收完毕后，需重新设定 SPI 接口为初始设定。

```
MDIO_RES SPI_MDIO_RW(unsigned char rw, unsigned char phy_addr, unsigned char reg_addr,
unsigned int w_data, unsigned int *r_data)
{
    unsigned int MDIO_temp = 0;
    /* Checking parameters validation */
    if (rw > 0x02)
        return RW_ERROR;

    if (phy_addr > MDIO_PHY_MAX)
        return phy_ERROR;

    if ((rw == MDIO_OP_W) && (w_data > W_DATA_MAX))
        return w_data_ERROR;
```

```
    if ((rw == MDIO_OP_R) && (w_data != W_DATA_MAX))
        return r_data_ERROR;

    /* Clear SPI FIFO */
    SPI_ClearTxFIFO(SPI0);
    SPI_ClearRxFIFO(SPI0);

    /* Prepare the MDIO package with 32-bit data, including 2-bit ST, 2-bit Op code,
     5-bit PHY address, 5-bit Register address, 2-bit TA and 16-bit Data */
    MDIO_temp = (MDIO_ST_CAUSE_22 << MDIO_ST_OFFSET) | (rw << MDIO_OP_OFFSET) |
                (phy_addr << MDIO_PHY_OFFSET) | (reg_addr << MDIO_REG_OFFSET) |
                (MDIO_TA << MDIO_TA_OFFSET) | w_data;

    /* READ operation with 16-bit data, including 2-bit ST, 2-bit Op code,
    5-bit PHY address and 5-bit Register address */
    if (rw == MDIO_OP_R)
        MDIO_temp = (MDIO_temp >> 16) & 0xFFFF;

    /* Send 32-bit preamble */
    SPI_WRITE_TX(SPI0, 0xffffffff);
    /* Check SPI0 busy status */
    while (SPI_IS_BUSY(SPI0));

    /* READ operation with 16-bit data, including 2-bit ST, 2-bit Op code,
    5-bit PHY address, 5-bit Register address and 2-bit TA*/
    /* WRITE operation with 32-bit data, including 2-bit ST, 2-bit Op code,
    5-bit PHY address, 5-bit Register address, 2-bit TA and 16-bit Data */
    if (rw == MDIO_OP_R)
        SPI_SET_DATA_WIDTH(SPI0, 16);

    SPI_WRITE_TX(SPI0, MDIO_temp);
    /* Check SPI0 busy status */
    while (SPI_IS_BUSY(SPI0));

    /* Read data from Ethernet PHY */
    if (rw == MDIO_OP_R){
        /* Configure PA0(MOSI) as input mode for receiving data */
        SYS->GPA_MFPL = (SYS->GPA_MFPL & ~(SYS_GPA_MFPL_PA0MFP_Msk)) |
                        (SYS_GPA_MFPL_PA0MFP_GPIO);
        GPIO_SetMode(PA, BIT0, GPIO_MODE_INPUT);

        SPI_ClearRxFIFO(SPI0);
        /* Send dummy data for receiving data */
        SPI_WRITE_TX(SPI0, 0xFFFF);
        /* Check SPI0 busy status */
        while (SPI_IS_BUSY(SPI0));
        /* Read received data */
        r_data[reg_addr] = SPI_READ_RX(SPI0);

        /* Restore to initial settings */
        SYS->GPA_MFPL = (SYS->GPA_MFPL & ~(SYS_GPA_MFPL_PA0MFP_Msk)) |
                        (SYS_GPA_MFPL_PA0MFP_SPI0_MOSI);
        SPI_SET_DATA_WIDTH(SPI0, 32) ;
    }
    return PASS;
}
```

3. 软件与硬件需求

3.1 软件需求

- BSP 版本
  - M029G_M030G_M031G_Series_BSP_CMSIS_V3.03.000
- IDE 版本
  - Keil uVersion 5.38

3.2 硬件需求

- 电路组件
  - NuMaker-M030GTD V1.1
- 线路示意图
  - 将 SPI_MOSI (PA.0) pin 脚与 SPI_MISO (PA.1) pin 脚连接到 Ethernet PHY 的 MDIO pin 脚; SPI_CLK (PA.2) pin 脚连接到 Ethernet PHY 的 MDC pin 脚用存取 Ethernet PHY 寄存器。
  - 连接 4.7 k 欧姆的上拉电阻于 MDIO pin 脚。

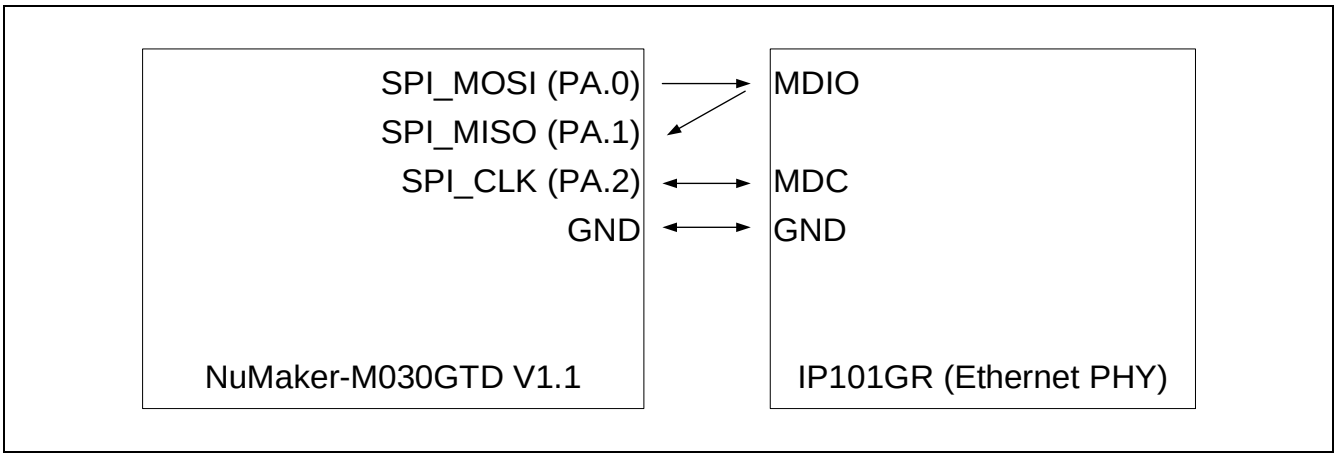

图 3-1 引脚连接图

4. 目录信息

EC_M030G_SPI_Emulate_MDIO _V1.00	
Library	Sample code header and source files
CMSIS	Cortex® Microcontroller Software Interface Standard (CMSIS) by Arm® Corp.
Device	CMSIS compliant device header file
StdDriver	All peripheral driver header and source files
SampleCode	
ExampleCode	
Project	Source file of example code

图 4-1 目录信息

5. 范例程序执行

1. 根据目录信息章节进入 ExampleCode 路径中的 KEIL 文件夹，双击 *M030G_SPI_Emulate_MDIO.uvprojx*。
2. 进入编译模式界面
   - 编译
   - 下载代码至内存
   - 进入 / 离开仿真模式
3. 进入仿真模式界面
   - 执行代码

6. 修订纪录

Date	Revision	Description
2024.07.02	1.00	初始发布。

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