Here is the **README** file for your **STM32F401RE SPI1 Master Communication** project.

You can save this as **README.md** (for GitHub) or **README.docx** (for a Word document).

**STM32F401RE: SPI1 Master Communication (Sending A-Z Characters)**

This project configures **SPI1 as a Master** on the **STM32F401RE**, sending characters **'A' to 'Z'** to an SPI slave device at **1 MHz**. The **Slave Select (SS) is manually controlled** using GPIO **PA4**.

✅ **SPI1 Configured in Master Mode (Mode 0, CPOL = 0, CPHA = 0)**  
✅ **Sends A-Z Characters over SPI1 (PA5 SCK, PA7 MOSI, PA4 SS)**  
✅ **Baud Rate: 1 MHz (fPCLK / 16)**  
✅ **Manual SS Control for Stable Communication**

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**1. Overview**

* **MCU**: STM32F401RE (Nucleo-F401RE)
* **Communication Protocol**: SPI1 (Serial Peripheral Interface)
* **SPI Mode**: **Master (Mode 0, CPOL = 0, CPHA = 0)**
* **Baud Rate**: **1 MHz (fPCLK / 16)**
* **Data Format**: **8-bit, MSB first**
* **Slave Select (SS) Control**: **Manual (PA4)**

**📏 SPI1 Pin Configuration**

| **Signal** | **STM32F401RE Pin** | **Description** |
| --- | --- | --- |
| **SPI1 SCK (Clock)** | **PA5** | SPI1 Clock Output |
| **SPI1 MOSI (Master Out, Slave In)** | **PA7** | SPI1 Data Output |
| **SPI1 SS (Slave Select)** | **PA4** | Manual Control (GPIO Output) |

**2. Hardware Setup**

**🛠 Wiring for SPI1 Master-Slave Communication**

| **STM32F401RE (Master)** | **SPI Slave Device** |
| --- | --- |
| **PA5 (SCK)** | **SCK** |
| **PA7 (MOSI)** | **MISO** |
| **PA4 (SS)** | **CS/SS** |
| **GND** | **GND** |

**3. Software Explanation**

**🟢 SPI1 Master Initialization**

* **PA5 (SCK) and PA7 (MOSI) configured as SPI Alternate Function (AF5).**
* **PA4 (SS) manually controlled as GPIO Output.**
* **SPI Mode 0 (CPOL = 0, CPHA = 0) ensures correct timing.**
* **Baud rate set to 1 MHz using fPCLK / 16.**

**🟢 SPI1 Data Transmission**

* **SS (PA4) goes LOW before transmitting a character.**
* **Data is written to SPI1->DR, and we wait for the TX buffer to be empty.**
* **SS (PA4) goes HIGH after transmission is complete.**
* **Characters 'A' to 'Z' are continuously sent with a delay of 100ms.**

**🟢 Data Flow**

STM32F401RE (SPI1 Master) → Sends 'A' to 'Z' → SPI Slave Receives Data

**4. Project Structure**

.

├── Inc/

│ └── stm32f4xx.h // CMSIS/Device headers

├── Src/

│ └── main.c // Contains SPI1 Master communication logic

└── README.md // This file

**5. Building and Uploading**

**Using Keil uVision / STM32CubeIDE**

1. **Open Keil uVision or STM32CubeIDE**.
2. **Create a new project** for STM32F401RE.
3. **Copy main.c into the Src/ directory**.
4. **Compile and Flash the project** to **Nucleo-F401RE**.

**6. Usage**

**1️⃣ Flash the code to the STM32F401RE**

* Use **Keil uVision** or **STM32CubeIDE**.

**2️⃣ Connect SPI1 to an SPI Slave Device**

* **Wire PA5, PA7, and PA4 to the SPI slave device.**
* Ensure the **GNDs are connected**.

**3️⃣ Observe SPI1 Transmission**

* Use a **logic analyzer** or **SPI slave device** to capture the SPI signals.
* Ensure the **characters 'A' to 'Z'** are received correctly.

**7. Troubleshooting**

**🔴 No SPI Transmission?**

✅ **Ensure PA5, PA7, and PA4 are correctly connected.**  
✅ **Confirm SPI1 is enabled (SPI1->CR1 |= (1U << 6);).**  
✅ **Check that SS (PA4) is LOW during transmission.**

**⚠️ Wrong Characters Received?**

✅ **Ensure SPI settings match between master & slave.**  
✅ **Check SPI Clock Polarity/Phase (CPOL = 0, CPHA = 0).**

**⏳ Want Faster SPI Speed?**

✅ Change **Baud Rate Prescaler** (SPI1->CR1 |= (0U << 3);) for fPCLK/2.  
✅ Reduce **delay between characters (delayMs(100);).**

**8. License**

This project is licensed under the **MIT License**.  
You are free to **modify, distribute, and use** the code.

**9. References**

📄 [STM32F401RE Datasheet](https://www.st.com/en/microcontrollers-microprocessors/stm32f401re.html)  
📄 [STM32 Reference Manual (RM0368)](https://www.st.com/resource/en/reference_manual/dm00096844.pdf)  
📄 [SPI Programming Guide](https://www.st.com/resource/en/programming_manual/dm00245755.pdf)

**🚀 Summary**

✅ **SPI1 configured as Master (PA5 SCK, PA7 MOSI, PA4 SS).**  
✅ **Sends 'A' to 'Z' over SPI1 at 1 MHz.**  
✅ **Manually controls SS (PA4) for stable SPI communication.**  
✅ **Perfect for interfacing with SPI slave devices.**

📡 **Enjoy SPI communication with STM32F401RE! 🎯**