UM1546
User manual

STEVAL-IHM037V1 remote fan speed controller

Introduction

The remote fan speed controller is a single channel TRIAC based solution meant to replace the existing fan speed controllers and provide the IR remote control feature. It is designed to fit easily inside an enclosure with the dimensions of a single-switch module.

A non-isolated capacitive power supply is used to power the microcontroller and the IR sensor. The TSOP38438 IR sensor is used to demodulate the 38 kHz IR signal from the IR transmitter and decoded by the STM8S003 value line microcontroller to perform the various control functions. IR communication is based on the RC5 protocol standard. A TRIAC is used as the control element to regulate the power going into the fan by varying its firing angle for different speed settings. The speed settings can be changed by using the onboard tactile switches or by using the IR remote controller.

The STM8S003F3 value line 8-bit microcontroller, with its internal data EEPROM, hardware timers and external interrupts on GPIOs, makes an efficient implementation of the application possible while keeping the size, cost and external component count to a minimum.

Figure 1. Remote fan speed controller board STEVAL-IHM037V1

AM12340v1

This document explains the different parts of the application.

The key features of the application are:

- Fan speed control using SW1, SW2 keys or IR remote
- Compact and cost effective capacitive power supply
- Example firmware based on RC5 protocol. Can also work with NEC and other IR protocols
- Low cost solution. Can be used for light dimmer applications with software modifications.

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1 Getting started

1.1 Package

The remote fan speed controller includes the following items:

- Hardware content:
  - Demonstration board: STEVAL-IHM037V1
- Documentation:
  - User manual (this document)
  - Schematics, Gerber files, BOM
- Firmware:
  - Pre-programmed STM8S device soldered on the demonstration board
  - Object files are also available for the firmware.

1.2 Safety rules

This board can be connected to mains voltage (240 V). In the case of improper use, wrong installation or malfunction, there is a danger of serious personal injury and damage to property. All operations such as transport, installation and commissioning, as well as maintenance, should be carried out only by skilled technical personnel (regional accident prevention rules must be observed).

Danger: **Due to the risk of electrical shock or death when using this prototype on mains voltage (240 V), only skilled technical personnel who are familiar with the installation, mounting, commissioning and operation of power electronic systems and have the qualifications needed to perform these functions, may use this prototype.**

Warning: **The debugger tool must not be connected to 4-pin header(J3) for SWIM interface when circuit is running on mains supply.**

1.3 System setup

The remote fan speed controller board can be setup as follows:

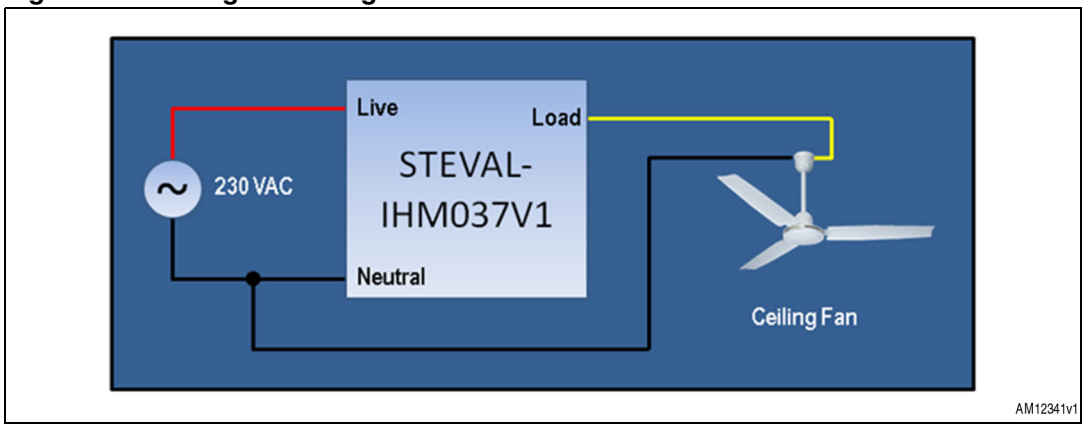
1. Before proceeding, ensure that the mains power supply switch used during testing is capable of disconnecting both the live and neutral terminals and it is in the off position. Always wear safety gloves when working with mains operated circuit.
2. Connect fan/lamp live terminal to J5 of the FSC board.
3. Connect the fan neutral terminal to J7 of the FSC board.

4. Connect the two combined neutral black wires to the mains supply neutral and, lastly, connect J6 from the FSC board to live of the mains supply.
5. Ensure that all parts of the FSC PCB and connection wires are well isolated from any conducting surfaces such as metal parts, etc. to avoid accidental shock hazard or damage to the circuit.
6. Once the switch is turned on, ensure that no part of the PCB is touched using bare hands or metallic objects.
7. The fan speed can now be changed using the IR remote transmitter unit or using the tactile switches provided onboard. When using the onboard tactile switches, kindly ensure that no direct body contact is made with the circuit (use safety gloves).
8. The microcontroller can be programmed over the SWIM interface using an ST-Link or R-Link programming tool. When doing so, the circuit should be completely disconnected from the mains supply and powered using the +5 V supply from an R-Link or an external +5 V power supply.

2 System overview

2.1 Hardware design description

Figure 2. Wiring block diagram



2.1.1 STEVAL-IHM037V1

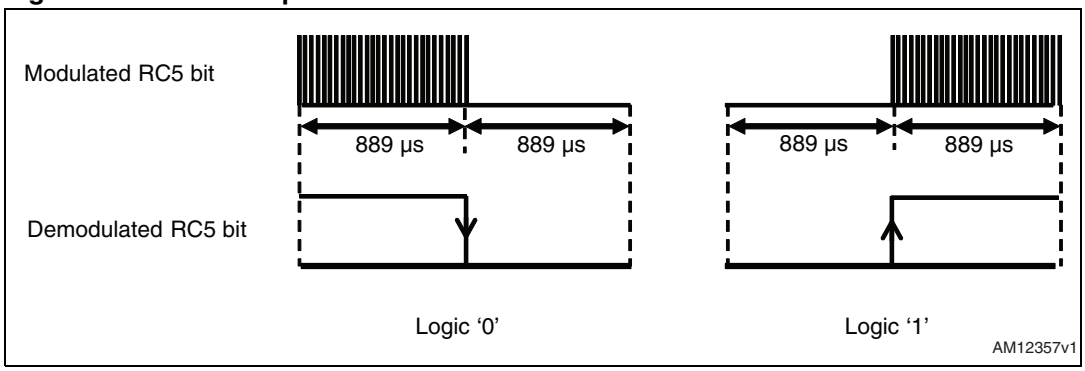
This application uses two timers and two external interrupts, one each for decoding the IR remote signal and the other pair for detecting the zero crossing and timing the firing angle of the TRIAC for fan speed control. This application can be easily adapted for remote control of light dimmers, room heaters, water heaters, window pane/curtain control, home automation and other similar applications. The TRIAC used in this design is rated at 4 A current. This may be changed to suit the application requirements while keeping everything else the same. The same MCU can even control multiple TRIACs depending on the application.

2.1.2 RC5 protocol

RC protocol basics:

The RC5 code is a 14-bit word, it uses bi-phase modulation (also called Manchester coding) of a 36 kHz IR carrier frequency. All bits have an equal length of 1.778 ms, with half of the bit time filled with a burst of the 36 kHz carrier and the other half being idle. A logical zero is represented by a burst in the first half of the bit time. A logical one is represented by a burst in the second half of the bit time (refer to *Figure 1*). The duty cycle of the 36 kHz carrier frequency is 33% or 25%. This reduces power consumption for the IR LED on the transmitter side and also allows the LED to operate at a higher peak current for a longer communication range.

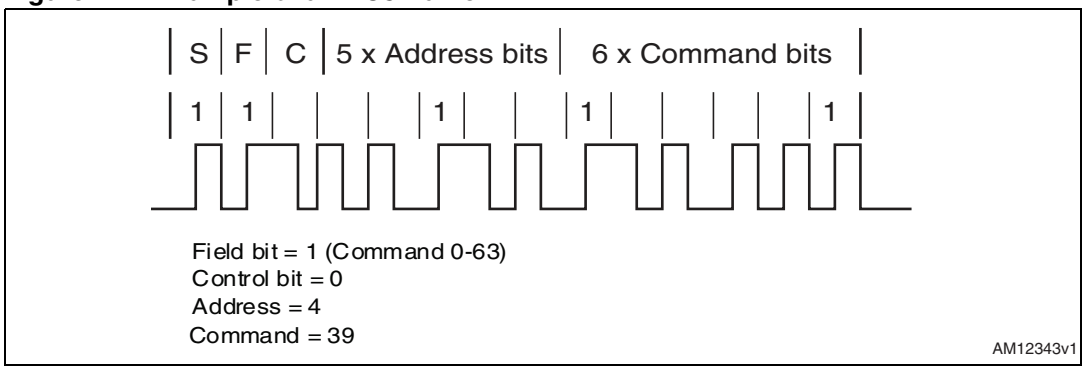
Figure 3. RC5 bit representation



The RC5 frame can generate 2048 (32x64) different commands organized in 32 groups, each group has 64 different commands. An RC5 frame contains the following fields (an example of an RC5 frame is shown in *Figure 2*):

- Start bit (S): 1 bit length, always logic 1.
- Field bit (F): 1 bit length, which denotes whether the command sent is in the lower field (logic 1 = 0 to 63 decimal) or the upper field (logic 0 = 64 to 127 decimal).
- Control bit or Toggle bit (C): 1 bit length, which toggles each time a button is pressed. This allows the receiving device to distinguish between two successive button presses (such as “1”, “1” for “11”).
- Address: 5-bit length that selects one of 32 possible systems.
- Command: 6-bit length, that (in conjunction with the field bit) represents one of the 128 possible RC-5 commands.

Figure 4. Example of an RC5 frame



To avoid frame collisions, an idle time is inserted between two frames with a specific width (see *Figure 3*).

The idle time is defined as 50 bits wide. So the periodicity of a frame is 64 x 1 bit width: 64 x 1.778 = 113.792 ms (exactly 113.788 ms).

Figure 5. RC5 idle time

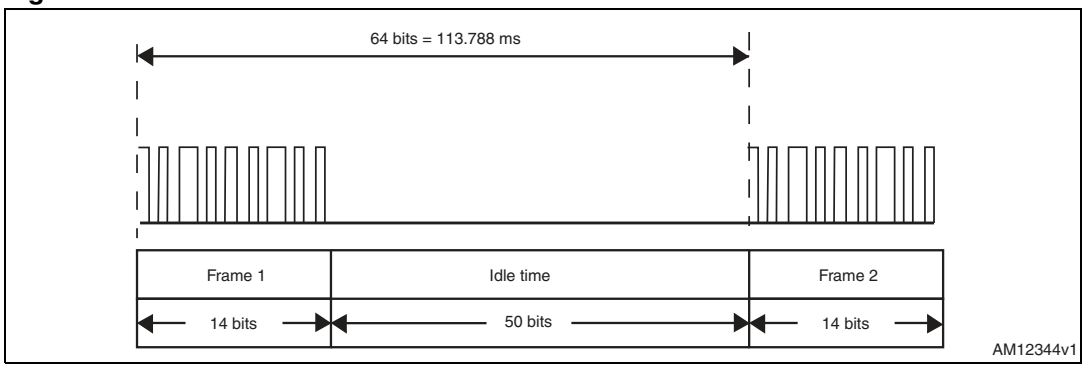


Table 1. RC5 timings

Description	Min.	Typical	Max.	Units
RC5 half bit period	640	899	1140	µs
RC5 full bit period	1340	1778	2220	µs
RC5 message time	23.644	24.889	26.133	ms
RC5 message repetition time	108.089	113.778	119.467	ms
Carrier pulse bit time	27.233	27.778	28.345	µs

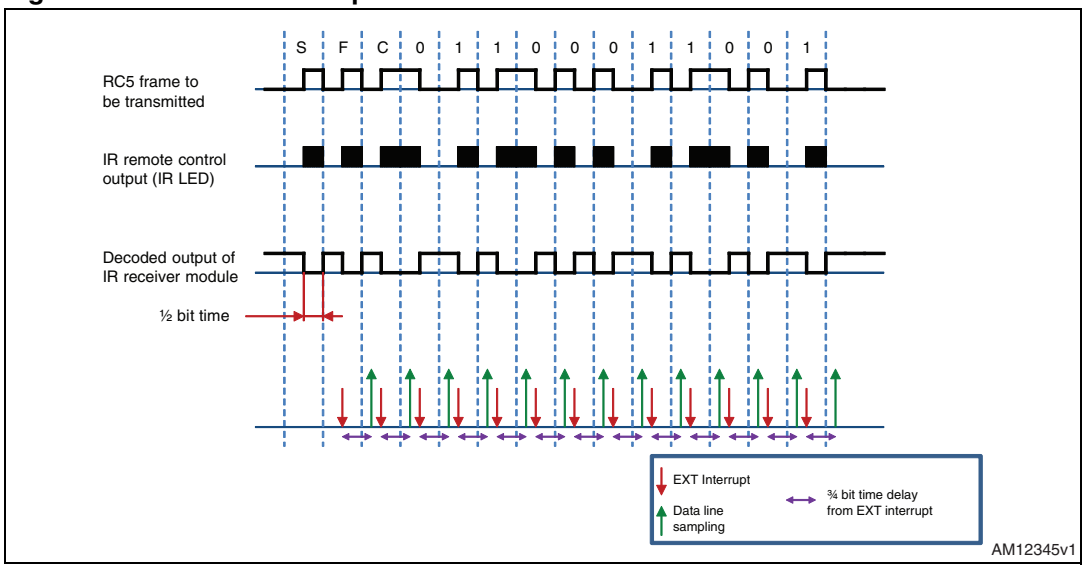
2.1.3 RC5 frame reading mechanism

RC5 decoding algorithm features:

- Adaptive timing takes care of variations in transmitter bit period within the standard range specified in *Table 1*.
- Algorithm synchronizes sampling time after every bit to ensure robust decoding performance.
- Uses one external interrupt and one hardware timer to efficiently decode received data on the fly.

The RC5 decoded data has the inherent property of changing its logic state at the middle of every bit transmitted, as it is Manchester format. This state change can be used to synchronize the sampling of the RC5 data output line connected to the microcontroller for robust decoding performance irrespective of timing variations at the receiver, as well as the transmitter side. *Figure 4* highlights the decoding algorithm used in this application.

Figure 6. RC5 frame reception mechanism



The decoding algorithm uses a small finite state machine as follows:

- State 1: Enable EXT interrupt and start timer with ARR value for 3.5 ms overflow time. Go to State 2 when timer overflow occurs.
- State 2: Wait for first EXT interrupt, when it occurs, initialize and start timer and go to State 3.
- State 3: Wait for second EXT interrupt. When it occurs, stop timer and validate ½ bit time period. If valid, use it to calculate ¾ bit time and go to State 4, or else reset state to State 1.
- State 4: Wait for EXT interrupt. When it occurs (red downward arrow), disable EXT interrupt and start timer with ARR set to ¾ bit time. Go to State 5.
- State 5: When timer overflow interrupt occurs, sample the data line (green upward arrow) and push its value into the RC5 data sampling variable. If all 13 bits are sampled (including the last idle state), give the valid decoded output and go back to State 1 for the next detection cycle, or else re-enable EXT interrupt and go to State 4.

The algorithm synchronizes the first half midpoint sampling location (green upward arrow) of each bit with the logic transition point of the previous bit (red downward arrow). The field bit is not decoded in the existing algorithm but this can be easily incorporated with minor modifications in the firmware.

2.2 Hardware layout

The STEVAL-IHM037V1 component layout for top and bottom layers is shown below in *Figure 6* and *7* respectively. It helps the user to locate different components / sections on the board.

Figure 7. Hardware layout: main board - top side

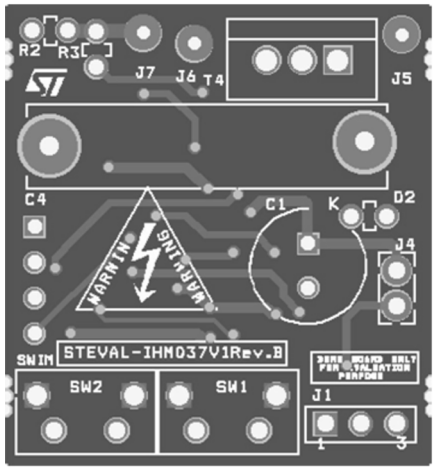
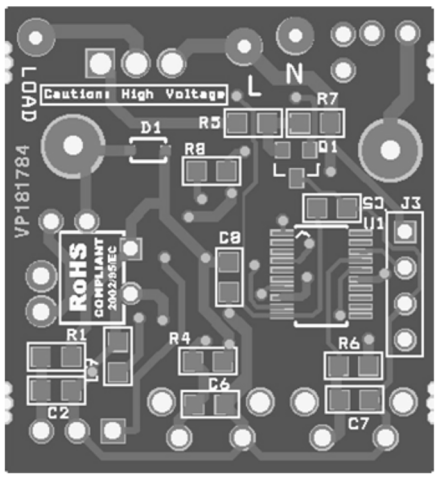


Figure 8. Hardware layout: main board - bottom side



3 Hardware schematics

Figure 9. IR remote transmitter STEVAL-IHM037V1

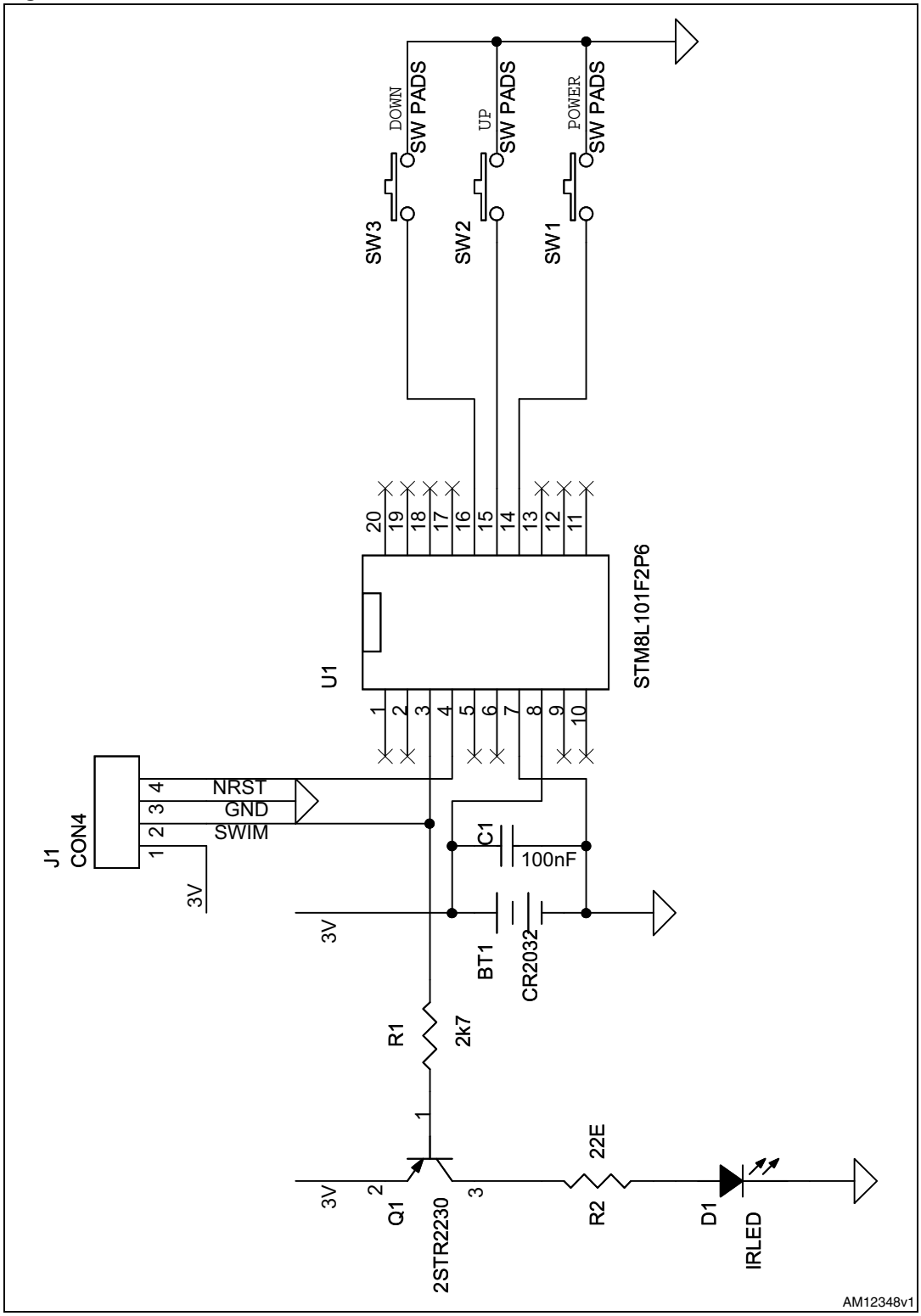
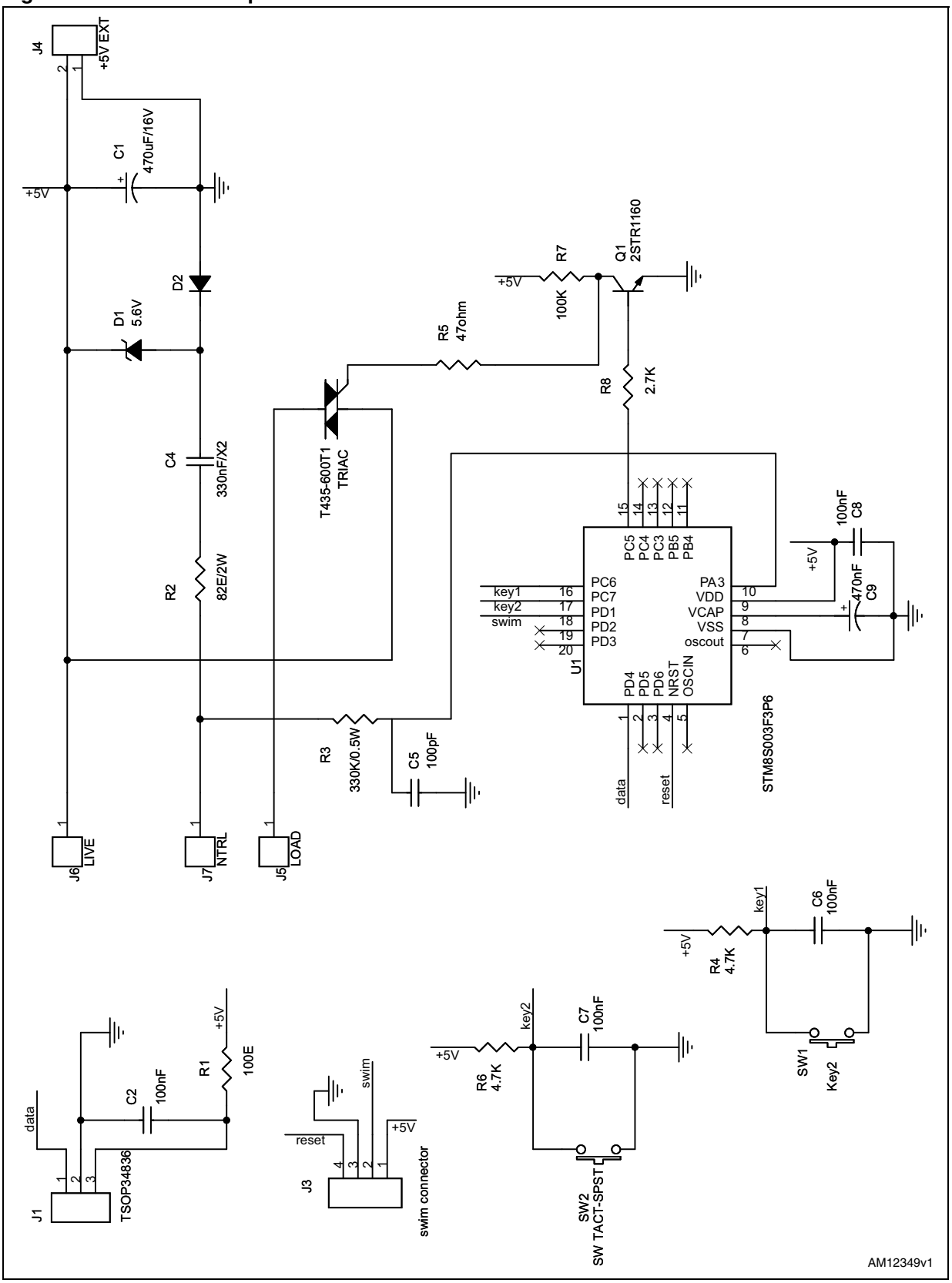


Figure 10. Remote fan speed controller



3.1 Bill of material

Table 2. BOM

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier ordering code
Document / project reference: BOM for the AC Fan speed controller/dimmer							
ST devices	U1	STM8S003F3 value line series MCU	TSSOP-20	STMicroelectronics	STM8S003F3P6		
	Q1	Logic level TRIAC	TO-220AB	STMicroelectronics	T435-600T		
	Q2	NPN Transistor	SOT-23	STMicroelectronics	2STR1160		
Other devices	TSOP	IR receiver 38 kHZ, DOME AXIAL	TSOP 2.54 mm	Vishay	TSOP34838	Digi-Key	751-1386-5-ND
	D1	Zener diode 5.6 V/ 0.5 W	SOD123	Any	DDZ5V6B-7	Digi-Key	DDZ5V6BDICT-ND
	D2	LL4148	SOD80	Any	LLN4148	Digi-Key	LL4148FSCT-ND
Capacitors	C1	470 µF/16 V Electrolytic	Radial 8 mm diameter / 3.5 mm Pitch	Any		Digi-Key	P5141-ND
	C2, C6,C7,C8	100 nF ceramic	SMD0805	Any			
	C4(1)	330 nF or 680 nF/X2 rated film capacitor	22.5 mm Pitch	Vishay	BFC238312334 or BFC233920684	Digi-Key	2222 383 12334-ND or BC2591-ND
	C5	100 pF ceramic	SMD0805	Any			
	C9	470 nF ceramic	SMD0805	Any			
Resistors	R1,R5	100 Ω	SMD0805	Any			
	R2	82, 2 W	Leaded	Yageo	RSF200JB-82R	Digi-Key	82W-2-ND

Table 2. BOM (continued)

Category	Reference designator	Component description	Package	Manufacturer	Manufacturer's ordering code / orderable part number	Supplier	Supplier ordering code
Resistors	R3	330 kΩ/0.5 W	Leaded	Any		Digi-Key	PPC330KW-1CT-ND
	R4,R6	4.7 kΩ	SMD0805	Any			
	R7	100 kΩ	SMD0805	Any			
	R8	2.7 kΩ	SMD0805	Any			
Switches	SW1, SW2	Push button switch right angle	Switch tactile SPST-NO 0.05 A 12 V	TT Electronics	SWT6-R6K	Digi-Key	987-1385-ND
Document / project reference: BOM for the IR remote transmitter							
ST devices	U1	STM8L101 8-bit low power MCU	TSSOP-20	STMicroelectronics	STM8L101F2P6		
	Q1	PNP transistor	SOT-23	STMicroelectronics	2STR2260		
Other devices	IRLED	940 nm IR LED	3 mm through hole	Vishay	TSAL4400	Digi-Key	751-1201-ND
	BT1	3 V CR2032 battery retainer		Memory protection devices	BK-833	Digi-Key	BHSD-2032-SMCT-ND
Capacitors	C1	100 nF ceramic	SMD0805	Any			
Resistors	R1	22 Ω	SMD0805	Any			
Switches	SW1, SW2, SW3(2)	Carbon contact push button switch on PCB	ENIG gold plated carbon contact switch (PCB)			3	
Enclosure	N/A	BOSS 3 button key FOB enclosure	Enclosure	Boss Enclosures	2955-20R-3	Farnell	1264656

1. C4 X2 rating is important for reliable operation. A DC rated capacitor (even rated at 1000V DC) will fail over time as it is not designed to withstand the stress conditions present on AC supply lines. Use 330 nF for 230 V AC nominal supply voltage and increase to 680 nF for 110V AC supply.
2. SW1, SW2, SW3 are carbon contact footprints on PCB while the actual carbon contact is integrated into the enclosure. Alternately 2 pin tactile SMD switch from MULTICOMP part no. DTSM-32S-B can be used on the same footprint.

Appendix A Definitions

Table 3. Acronym definitions

Acronym	Definition
FSC	Fan speed controller
ARR	Auto reload register
MCU	Microcontroller unit

Revision history

Table 4. Document revision history

Date	Revision	Changes
12-Sep-2012	1	Initial release.

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