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STEVAL-ILL024V1 and STEVAL-ILL025V1 demonstration boards based on the STP16DP05 LED matrix driver and STM32F103VB

Introduction

This user manual describes the operation of the STM32F103VB-based LED matrix display demonstration board. This board demonstrates the capability of the STP16DP05 LED driver to drive the matrix LED panel. The complete system includes one master board, one slave board and LED matrix display panels. The master and slave boards are STM32F103VB microcontroller-based control units which are used for configuring the display settings for the STP16DP05 display driver. This unit has a GPS module interfaced through a USART port. The GPS data can be displayed with information on latitude and longitude and also a real-time clock. The display can be configured for any of the nine different display modes and nine different speeds using a PS2 keyboard. Display panels can also be configured through the HyperTerminal using the serial interface present on the control units. The system also consists of audio-out for playing back the .wav file pre-recorded in the microSD card™.

Figure 1. STEVAL-ILL025V1, LED display panel



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1 Getting started

1.1 Package contents

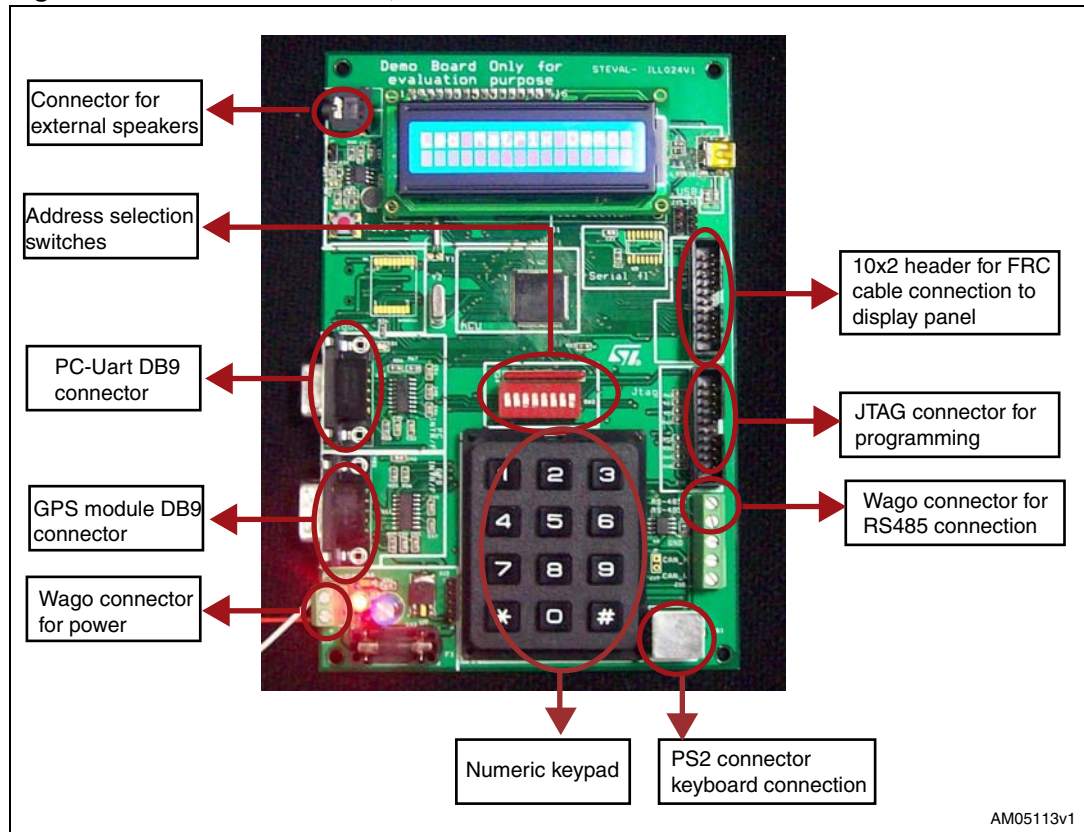
- The STM32-based LED matrix display demo package consists of the hardware and supporting documentation.
 - Hardware: one demonstration motherboard + one LED matrix display panel
 - Documentation: user manual for operating the demonstration board.

1.2 Hardware description

This complete system has one control unit and a display unit. The control unit is a microcontroller-based demonstration board and the display unit is an LED matrix board.

- The major components on the STEVAL-ILL024V1 control unit are:
 - STM32F103VBT6, 32-bit microcontroller
 - ST485ABDR, RS485 transceiver
 - LD1086DT33TR, voltage regulator
 - ST3232BDR, RS232 transceiver
 - TS461CLT, rail-to-rail operational amplifier
 - TDA2822D, post amplifier
 - STM1001RW6XF, reset IC
 - STPS1L30A, Schottky diode
 - 16 x 2 alphanumeric LCD
 - Mini USB connector
 - Screw type connector for external power supply
- Major components on the STEVAL-ILL025V1 display unit are:
 - STP16DP05MTR, display driver
 - TIP105, Darlington pair
 - M74HC245RM13TR, buffer
 - 16 x 32 LED matrix

Figure 2. STEVAL-ILL024V1, LED matrix control unit



1.3 Power supply unit

The power supply for the control unit is 5 V - 0.5 A DC and for each display board it is 3.5 V -5 V / 3 A DC.

The power supply for the display unit is required to be linear supply.

Both the control unit and display unit have one screw-type connector each for power supply connection. [Figure 3](#) shows the power supply connection for the control unit and [Figure 4](#) shows the power supply connection for the display unit. In each display panel there are 2 screw-type connectors for power connection. VCC+5 V0 and GND are mentioned on each of these connectors. Power can be applied to either of these two connectors to power the LED panel. Each panel is to be powered externally and individually.

Figure 3. Power supply connection on control unit

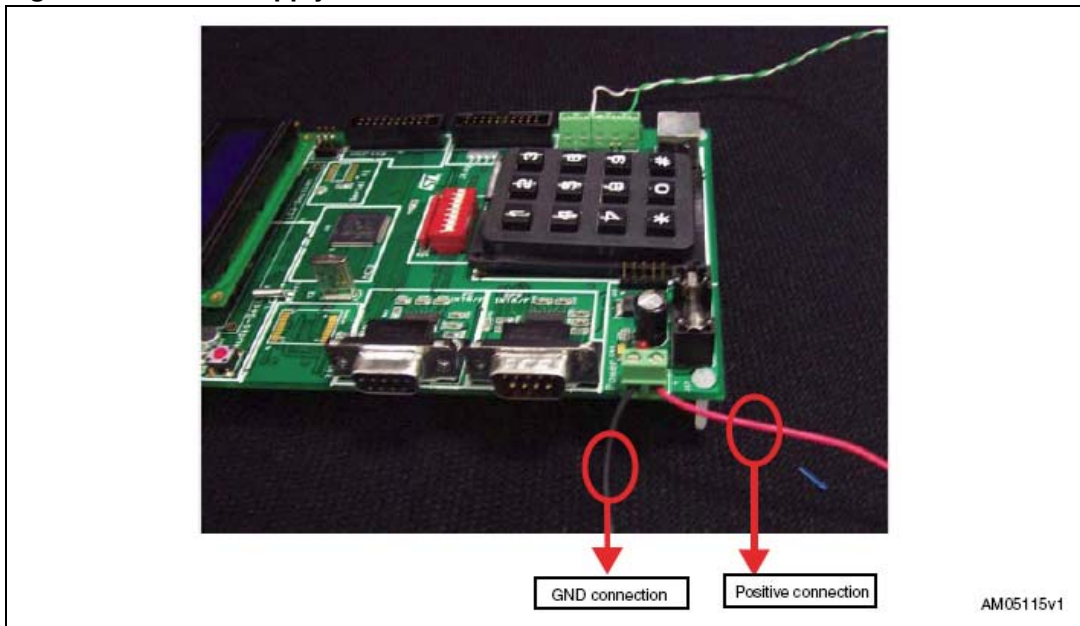
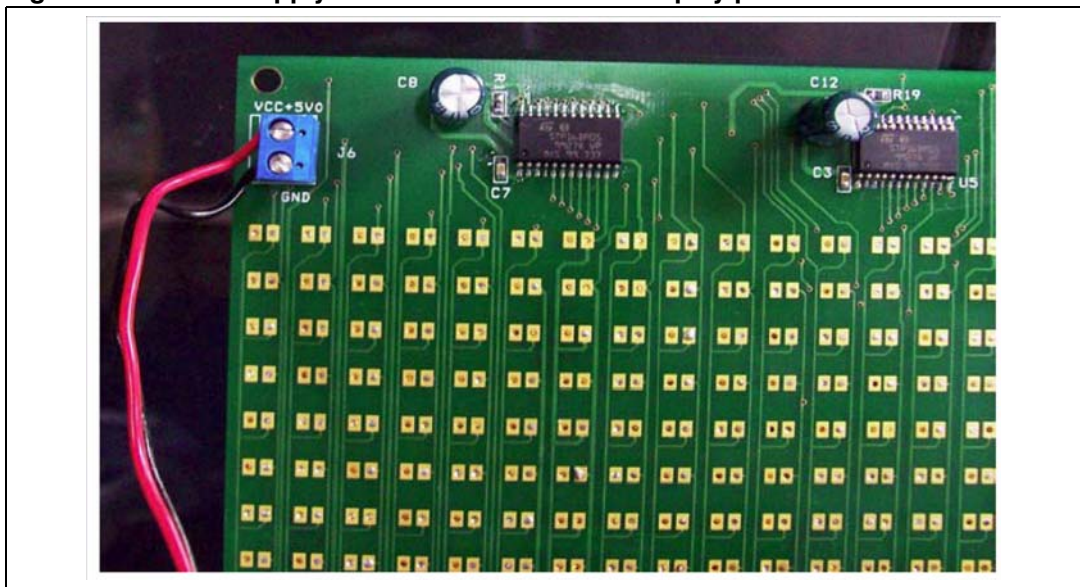


Figure 4. Power supply connection for the LED display panel



2 System description

This STM32-based display demo system has a microcontroller-based control unit and an LED driver-based display unit. The control unit is used for configuring the display driver and the display unit is used for controlling the LED display in accordance with the configuration received from the control unit.

2.1 Description of the STEVAL-ILL024V1 microcontroller-based control unit

The STEVAL-ILL024V1 control unit is an STM32 microcontroller-based board. This board has interfaces for:

- PS2 keyboard
- DB9 (female) connector for PC serial port (UART) connection
- DB9 (male) connector for serial (UART) connection to GPS module
- On-board numeric keypad
- Audio jack and 2-pin connector for the external speaker
- Wago connector for RS485 communication between the master and slave control units
- 10 x 2 header (Ext.Con) for flat-ribbon cable connection to display unit
- Slot for microSD card
- Screw type connector for 5 V DC power connection

This microcontroller-based unit is used to control the display board. This unit can be configured to operate as the master (responsible for sending the commands for display control) or as the slave unit (responsible for receiving the commands and executing them on the display unit). In every system, one control unit acts as a master.

2.1.1 Address configuration of the control unit

Each control unit has 8 switches (SW2). These switches are used to configure the address for the control unit.

Address configuration for the control unit is done by moving the switches to either high or low positions.

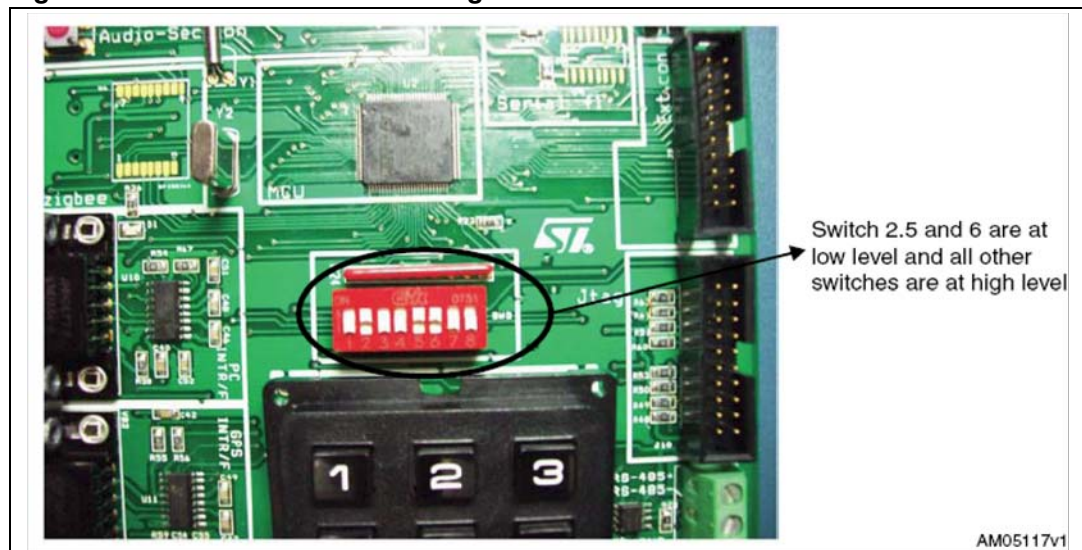
Eight I/O lines are used for address allocation to the control unit. Therefore, up to 255 addresses can be assigned to any control board. The board can have any number of addresses between 0 and 255.

If the switch is slid towards the numbered side, then logic '1' is assigned to the port, if the switch is slid towards the “on” side, then logic '0' is assigned to the board.

Whenever the board is powered-up and is connected as a slave unit then its address is displayed on the LCD mounted on-board. [Figure 5](#) shows the on-board switches.

Note: Address 255 is hardcoded to the master unit and no slave unit is allowed to have this address. Therefore, one should never slide all 8 switches to the numbered side (opposite the side where “on” is written).

Figure 5. Slave unit address configuration switches



2.1.2 Selecting the control unit as master or slave

Any control unit can act as the master or slave. The on-board keypad is used to configure the control unit as master or as slave.

The steps for configuring the control unit are listed below:

- Connect a 5 V power supply to the control unit, as explained in [Section 1.3](#)
- The LCD shows “Press “#” to enter Configuration Mod”, for 4 seconds
- Press “#” on the keypad present on the board. The LCD shows “Master Sel: Entr *1” and “Slave Sel: Entr *2”
- To configure the board as the master, press “*1” or to configure the board as the slave press “*2” on the keypad
- If “*1” is pressed, then the LCD shows “Master Board” for 2 seconds and then starts the master routine on the board
- If “*2” is pressed, then the LCD shows “Slave Board” for 2 seconds and then starts the slave routine on the board.
- On the next power-up of the board the message “Press “#” to enter Configuration Mod” is again shown on the LCD for 4 seconds, but if “#” is not pressed within 4 seconds, the board enters into the last configured mode.

2.2 Description of the STEVAL-ILL025V1 LED driver-based display unit

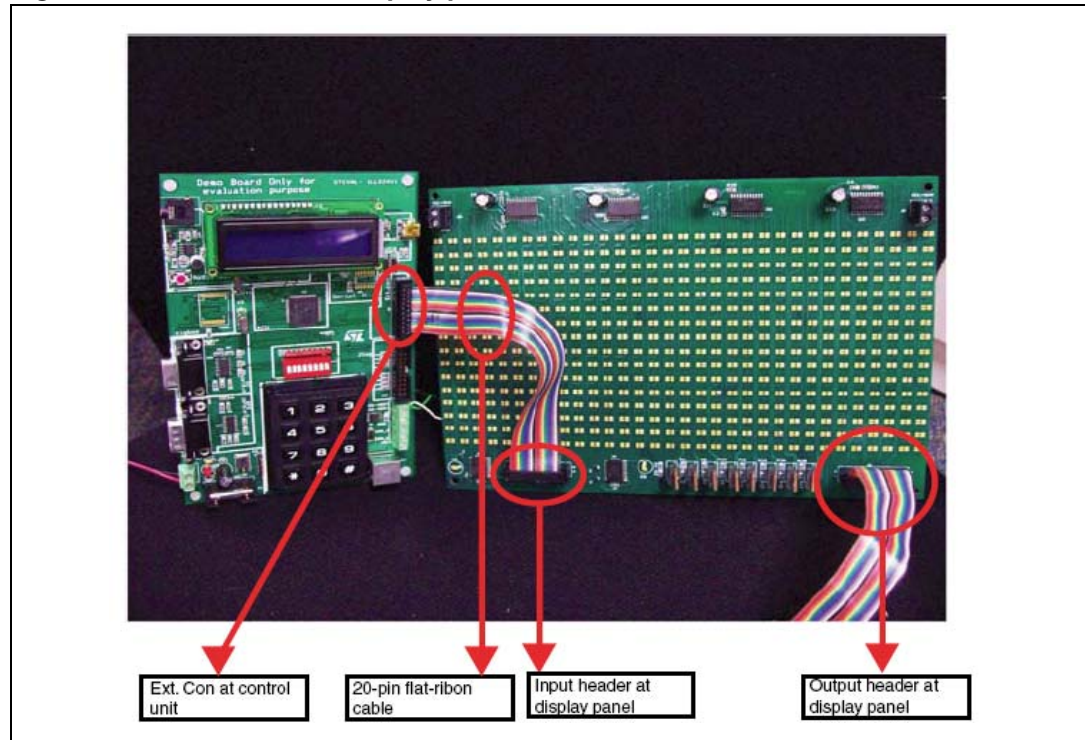
The STEVAL-ILL025V1 display unit is an STP16DP05 LED display driver-based panel.

Each display panel has four STP16DP05 LED display drivers, two buffers, eight Darlington pairs and a matrix of 16 x 32 LEDs. Each panel can be connected in series to create a larger display. Series connection between the display panels is done through a 10 x 2 header. A 20-pin flat-ribbon cable is used to connect the two display panels. Input to the display panel comes from the control unit through the 20-pin flat-ribbon cable. Therefore, the first display

panel is connected to the control unit to receive the data and also to the next display panel to cascade the data further. A total of 8 such panels can be cascaded in series.

Figure 6 shows the connection of the display panel. The first panel is connected at both sides, one to the control unit, using a 20-pin cable between the Ext Con header on the control unit and the input header at the display panel, and the other to the second display panel using the output header at the first panel and the input header at the second panel.

Figure 6. Connection of display panels



3 System configuration

The whole system can be connected in one of the following configurations:

- One control unit and one display unit without a slave unit
- Two control units (one acting as a master and the other as a slave) and one display unit
- Multiple control units (one acting as a master and the others as slaves) and multiple display units (each display unit connected to each slave. One display unit can have up to 8 cascaded panels that may be controlled by a single slave unit.)

3.1 One control unit and one display unit configuration

In this configuration there is a single control unit and a single display unit. The control unit acts as the master.

The steps to operate the system in this configuration are listed below:

- Step 1: connect the PS2 keyboard to the control unit.
- Step 2: connect the control unit with the display panel using a 20-pin flat-ribbon cable. Insert the cable into the 10 x 2 header (Ext.Con) present on the master on one side and in the J1 header (input) on the display panel on the other side.

If needed, the display panels can be cascaded in series to create a longer display. To cascade the display panels connect a 20-pin flat-ribbon cable from the J3 jumper (output) of the first panel to the J1 jumper (input) of the second panel. [Figure 6](#) shows the connections for cascading the display panels. Similarly, connect the FRC cable from the J3 jumper (output) of the second panel to the J1 jumper (input) of the third panel and so on to create a longer display. Up to 8 such display panels can be cascaded in series.

- Step 3: connect the power to the master control unit and to the display panel, as explained in [Section 1.3](#).
- Step 4: the LCD on the master control unit shows “Press “#” to enter Configuration Mod”, for 4 seconds.
- Step 5: press “#” on the keypad present on the board. If 4 seconds elapse and the board is not configured, then it enters into the last configured mode. To configure it again, press the reset button.
- Step 6: if “#” is pressed then the LCD shows “Master Sel: Entr *1” and “Slave Sel: Entr *2”.
- Step 7: press “*1” on the keypad. The LCD shows “Master Board”.
- Step 8: after 2 Seconds the LCD starts the demo showing “Led Matrix Demo”.
- Step 9: the display starts showing 4 options:
 - Press F1 For PC - UART Comm
 - Press F2 For GPS Data Display
 - Press F3 For Typing Data
 - Press F6 For Demo Mode
- Step 10: press F1, F2, F3 or F6 on the keyboard to select one of the above mentioned modes.
- Step 11: based on which of the keys listed above is pressed, the system enters into the chosen mode. Operation in each mode is explained in [Section 4](#).

- Step 12: press Esc on the keyboard to exit the selected mode.
- Step 13: once out of the selected mode, the system resumes from step 9.

3.2 Two control units and one display unit configuration

In this configuration there are two control units and a single display unit. One control unit should be the master and the second should be the slave. By default, the system comes with one master and one display panel.

The steps to operate the system in this configuration are listed below:

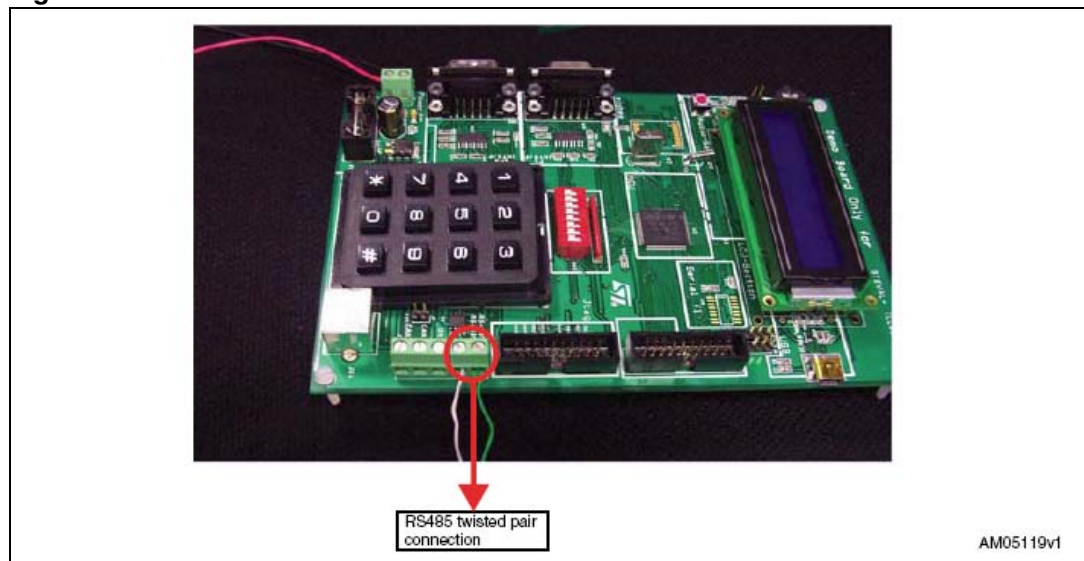
- Step 1: configure one control unit as the master and the second control unit as the slave, as explained in [Section 2.1.2](#).
- Step 2: configure the address of the slave board using the on-board DIP switches, as explained in [Section 2.1.1](#).
- Step 3: connect the PS2 keyboard to the master control unit.
- Step 4: connect the display panel to the slave control unit using a 20-pin flat-ribbon cable. Insert the cable into the 10 x 2 header (Ext.Con) present on the slave at one side and into the J1 header (input) on the display panel at the other side.

If needed, the display panels can be cascaded in series to create a longer display. To cascade the display panels connect a 20-pin flat-ribbon cable from the J3 jumper (output) of the first panel to the J1 jumper (input) of the second panel. [Figure 6](#) shows the connections for cascading the display panels. Similarly, connect the FRC cable from the J3 jumper (output) of the second panel to the J1 jumper (input) of the third panel and so on to create a longer display. Up to 8 such display panels can be cascaded in series.

- Step 5: connect the master and the slave control unit using a twisted pair cable. Ensure that RS485+ at master is connected to RS485+ at slave and RS485- at master is connected to RS485- at slave. Connections are made at the J18 screw type connector. [Figure 7](#) shows the RS485 connection topology.
- Step 6: power-up the master control unit, the slave control unit and the display panel using DC power supplies.
- Step 7: the LCD on the master and slave control unit shows “Press “#” to enter ConfigurationMod”. This is displayed for 4 seconds. If the master and slave boards are

- already configured in Step 1, don't press "#", the board then resumes functioning after 4 seconds.
- Step 8: the master control unit starts the demo showing "LED Matrix Demo" and the slave control unit starts showing its own address. (The address is configured using on-board switches).
 - Step 9: the display at master shows 4 options:
 - Press F1 for PC - UART Comm
 - Press F2 for GPS data display
 - Press F3 for typing data
 - Press F6 for demo mode
 - Step 10: press F1, F2, F3, or F6 on the keyboard, attached to the master board, to select one of the above mentioned modes.
 - Step 11: based on which of the keys listed above is pressed, the system enters into the chosen mode. Operation in each mode is explained in [Section 4](#).
 - Step 12: the master control unit sends commands to the slave control unit. The slave control unit processes these commands and configures the display panel to display the entered data.
 - Step 13: press Esc on the keyboard attached to the master board to exit the present mode. After this, the system resumes from step 9. If the new address entered for the slave selection matches with the slave address then the slave display is interrupted, or else the display continues with the old data.

Figure 7. RS485 communication



3.3 Multiple control and display unit configuration

In this configuration there are multiple control units and multiple display panels. One control unit should be the master and the others slaves. By default, the system comes with one master and one display panel.

The steps to operate the system in this configuration are listed below:

- Step 1: configure one control unit as the master and the other control units as slaves, as explained in [Section 2.1.2](#).
- Step 2: configure the address of the slave boards using the on-board DIP switches, as explained in [Section 2.1.1](#).
- Step 3: connect the PS2 keyboard to the master control unit.
- Step 4: connect the display panels to each slave control unit using a 20-pin flat-ribbon cable. Insert the cable into the 10 x 2 header (Ext.Con) present on the slave at one side and in the J1 header (input) on the display panel at the other side.

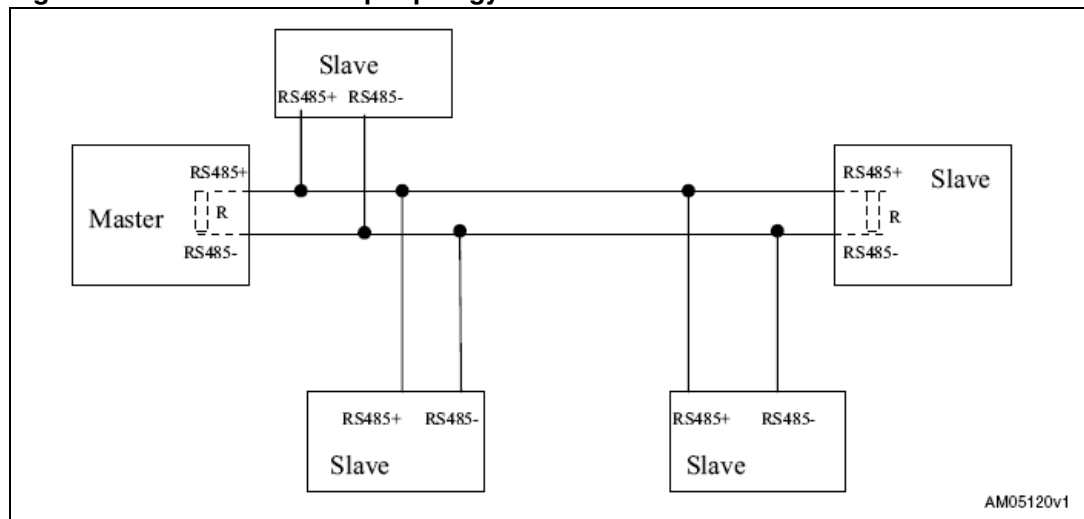
If needed, the display panels can be cascaded in series to create a longer display. To cascade the display panels connect a 20-pin flat-ribbon cable from the J3 jumper (output) of the first panel to the J1 jumper (input) of the second panel. [Figure 6](#) shows the connections for cascading the display panels. Similarly, connect the FRC cable from the J3 jumper (output) of the second panel to the J1 jumper (input) of the third panel and so on to create a longer display. Up to 8 such display panels can be cascaded in series.

- Step 5: connect the master and the slave control units using a twisted pair cable. Ensure that RS485+ at master is connected to RS485+ at slave and RS485- at master is connected to RS485- at slave. Connections are made at the J18 screw type connector. [Figure 8](#) shows the RS485 connection topology.
- Step 6: power-up the master control unit, the slave control units and the display panels using DC power supplies. Please ensure that when cascading the display panels, power should be individually supplied at the J5 screw type connector on each display panel.
- Step 7: the LCD on the master and slave control unit shows “Press “#” to enter ConfigurationMod”. This is displayed for 4 seconds. If the master and slave boards are already configured in Step 1, don't press “#”, the board then resumes functioning after 4 seconds.
- Step 8: the master control unit starts the demo showing “LED Matrix Demo” and the slave control unit starts showing its own address. (The address is configured using on-board switches).
- Step 9: the display at master shows 4 options:
 - Press F1 For PC - UART Comm
 - Press F2 For GPS data display
 - Press F3 for typing data
 - Press F6 for demo mode
- Step 10: press F1, F2, F3, or F6 on the keyboard to select one of the above mentioned modes.
- Step 11: based on which of the keys listed above is pressed, the system enters into the chosen mode. Operation in each mode is explained in [Section 4](#).
- Step 12: the master board LCD asks for the address of the slave control unit in order to configure the display unit.

If the address entered at the master unit matches with the slave unit then the selected slave unit can be configured for display, or else “Address Mismatch” is displayed on the LCD and a new address entry is requested.

- Step 13: when the address is matched, the master control unit sends commands to the selected slave control unit. The slave control unit processes these commands and configures the display panel to display the entered data. The other slave units continue to display the old data.
- Step 14: press Esc to exit the present mode; after this, the system resumes from Step 9. If the new address entered (for slave selection) matches with the slave address then the slave display is interrupted, or else the display continues with the old data.

Figure 8. RS485 multi-drop topology



Note: R is the termination resistance used for impedance matching.

4 System operation modes

The LED display demo board has 4 different modes of operation. These are:

- PC-UART communication mode
- GPS module communication mode
- Keyboard typing mode
- Demo Mode

As soon as the master control unit is powered-up, the LCD on the master board shows "Master Board" for the first 2 seconds, then a menu is started which requests that F1, F2, F3, or F6 is pressed to select one of the above mentioned modes.

4.1 PC-UART communication mode

The master control unit communicates with the computer using UART communication protocol. The female DB9 connector on the control unit is used to connect to a computer using a serial connection cable.

The steps for communicating using the HyperTerminal of the computer are listed below:

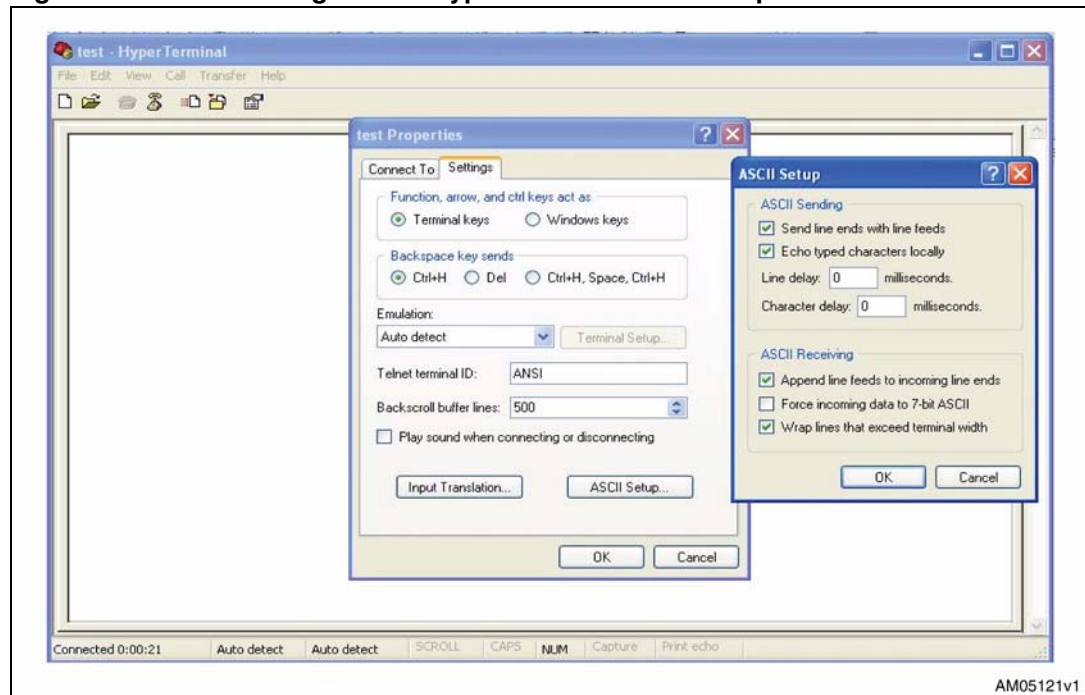
Steps:

- Connect a serial cable between the serial port of the computer and the female DB9 connector of the master control unit (VB1).
- Connect the PS2 keyboard to the master control unit.
- Configure the HyperTerminal on the computer using the following settings:
 - Bits per second: 115200
 - DataBits: 8
 - Parity: none
 - Stop bits: 1
 - Flow control: none
- Configure the ASCII settings as shown in [Figure 9](#).
- Power-up the master control unit, the LED panel and also the slave control unit (if connected).
- The LCD on the master displays the menu program which shows “Press F1 for PC-UARTComm”.
- Press the F1 key on the keyboard attached to the PS2 connector of the master control unit.
- The HyperTerminal shows the message
 - “USART HyperTerminal communication demo maximum allowed string length is 200 Words”
 - “Enter display board address, Enter 1-255”
- Enter the slave control unit address (as seen on the LCD of the slave control unit) or the address of the master (255), and then press the “Enter” key on the PC keyboard. Addresses allowed are between 1 and 255.
- If the entered address is not present there is an error message on the HyperTerminal, “Address Mismatch; enter display board address”. Check the address of the slave board and then re-enter it on the HyperTerminal.
- When the address is matched, the message on the HyperTerminal is “Enter no. of LED boards”. Enter the number of LED display panels connected in cascade to the selected control unit (one LED display panel constitutes 16x32 LED's). A maximum of 8 panels can be connected to any one control unit.
- The next message is “enter mode; Entr between 1-9”. This is for entering one of the 9 display modes. These are the following:
 - Mode 1 => curtain up
 - Mode 2 => curtain down
 - Mode 3 => left to right scroll
 - Mode 4 => right to left scroll
 - Mode 5 => typing data mode
 - Mode 6 => stable display
 - Mode 7 => flashing mode
 - Mode 8 => curtain right
 - Mode 9 => curtain left

If the mode entered is other than 1-9 then the default mode is selected and this message is seen on the terminal: "Default Mode: Right To Left"

- As soon as the mode is entered, the selected mode is seen on the HyperTerminal and the next message is "Enter Speed; Entr between 1-9". This speed is to see the display on the LED matrix. Speed 1 is fastest and 9 is slowest. If the speed entered is other than 1-9 then the default speed of 2 is selected.
- The next message is "Enter String".
- Enter the string (the maximum allowed string length is 200 letters). When the required string is entered, select the Enter key on the keyboard.
- Data is sent to the LED matrix display and can be seen there.
- The next message on the HyperTerminal is "Enter Y to re-enter display mode settings or any other key to exit PC-UART mode:" Therefore if Y is entered, the HyperTerminal again shows a message asking for the slave address. If any other key is entered then the system exits PC-UART mode and the normal menu is seen on the master control unit LCD.

Figure 9. ASCII settings of the HyperTerminal in the computer



4.2 GPS communication mode

Global positioning system (GPS) mode is used for interacting with an externally connected GPS module and display time, latitude, longitude and satellite fixture status.

The steps for communicating with a GPS module are listed below:

Steps:

- Connect a serial cable between the GPS module and the DB9 male connector (VB2) of the master control unit. The GPS system should follow the handshaking protocol for serial communication.
- Connect the PS2 keyboard to the master control unit.
- Power-up the master control unit, the LED panel, and the slave control unit (if connected).
- The master LCD shows the menu program which displays “Press F2 for GPS data display”.
- Press the F2 key on the keyboard attached to the PS2 connector of the master control unit.
- The master LCD shows the GPS mode selected and “Enter Display Board Address”. Enter the slave board address where data is to be displayed on the LED matrix panel. Addresses allowed are between 1 and 255. 255 is fixed for the master unit. If the wrong data is entered the LCD shows “Address Mismatch” and again asks for the address.
- When the address is matched, the LCD asks for the number of display panels connected in cascade at the selected slave device to be entered.
- As soon as the number of display panels is entered, the LED matrix starts showing time, latitude, longitude and satellite fixture status.
- Press Esc on the keyboard to exit GPS mode and return to the main menu.

Note: The GPS module interface is configured for 115200 baud rate.

4.3 Key board typing mode

This mode is for user interaction using the keyboard attached at the PS2 connector on the motherboard.

The steps for operating in typing mode are listed below:

Steps:

- Connect the keyboard to the PS2 connector on the master control unit.
- Power-up the master control unit, the LED panel, and the slave control unit (if present).
- The master LCD shows the menu program which displays “Press F3 for typing data”.
- Press the F3 key on the keyboard attached to the PS2 connector of the master control unit.
- The master LCD shows “Enter Display Board Address”. Enter the slave board address where data is to be displayed on the LED matrix panel. The addresses allowed are between 1 and 255. 255 is fixed for the master unit. If the wrong data is entered then the LCD shows “Address Mismatch”, and again asks for the address.
- When the address is matched, the LCD shows “Enter No. Of LED Boards”. Enter the number of LED panels connected in cascade to the selected control unit (one LED

display panel constitutes 16x32 LED's). A maximum of 8 panels can be connected to any one control unit.

- The next message is “Enter Mode; Entr between 1-9”. This is for entering one of 9 display modes. The modes are explained in step 12 of [Section 4.1](#).
- As soon as the mode is entered, the selected mode is seen on the LCD which then shows “Enter Speed; Entr between 1-9”. This speed is to see the display on the LED matrix. Speed 1 is fastest and 9 is slowest. If the speed entered is other than 1-9, the default speed of 2 is selected.
- The next message is “Enter String; Pres Esc to exit”.
- Enter the data which is to be seen on the LED matrix display. If the user does not want to enter data and wants to exit this mode, the Esc key should be pressed.
- As soon as the data is entered, it is seen on the LED matrix and the LCD shows “Pres Esc to exit; Enter to Proceed”. Therefore to continue with the typing mode select the “Enter” key on the keyboard, the system again asks for the slave board address, or else select the Esc key to exit this mode and return to the main menu.

Note: To check if caps lock is on or off, see the characters on the LCD. If caps lock is on then the letters are seen in capital case on the LCD, alternatively they are in small case.

4.4 Demo mode

Demo mode is executed with the master control unit and the display panel connected to “Master unit”. This mode is supported with audio output.

The steps for demo mode are listed below:

- Steps:
 - Save an audio file in .wav format in the microSD card. Save the audio file with the name “STN2”. Configuration of the audio file should be: 8 Bit, 8 kHz mono. This is the audio heard from the board.
 - Insert the microSD card in the memory card slot connected at the back of the master, as shown in [Figure 10](#).
 - Connect a display panel to the master control unit using a 20-pin flat-ribbon cable.
 - Connect the PS2 keyboard to the master unit.
 - Connect an external speaker to the two-pin audio connector (near the audio jack) or to the audio jack. The audio jack has a mono output only.
 - Power-up the master control unit and the display panel.
 - The LCD menu is started. It shows “Press F6 for Demo Mode”. Press the F6 key to enter demo mode.
 - As soon as F6 is pressed, the LCD shows a message for entry of the display panel number “Enter No. Of LED Boards”. Enter the number of display panels connected to the master unit.
 - After the number of led panels is entered, the audio file saved as STN2 in the microSD card is played on the speaker and the LED panel shows the message: “Wish You A Happy Journey”.
 - Press the Esc key to exit this mode and return to the menu.

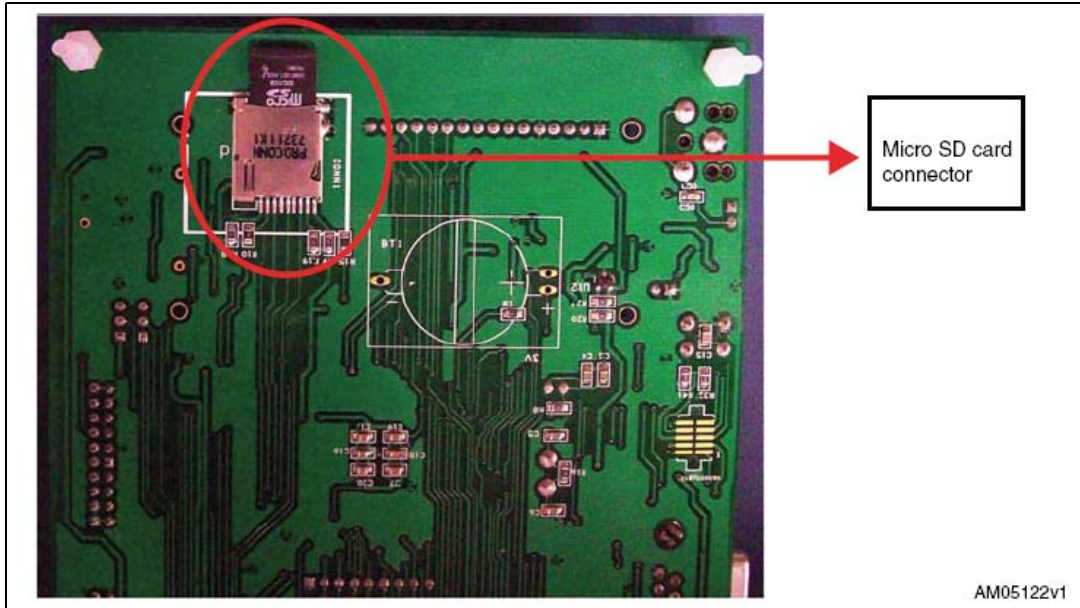
Note: For demo mode, the microSD card should be inserted into the card slot, or no data display occurs. The Esc key is used to exit this mode at any time.

At any point of the system, press Esc twice on the keyboard attached to the master unit to return to the main menu.

Until one of the system modes is entered, by pressing any key other than F1, F2, F3, or F6, the message “Key Not Allowed” is shown.

In PC USART mode the keyboard attached to the mother unit is not active for data entry. Only the Esc key is functional in this mode.

Figure 10. MicroSD card connection



5 Schematics and BOM list

The STM32-based display driver demo schematic is made up of two parts. The first is for a microcontroller-based control unit and the second is for an LED display panel. [Figure 11](#) below shows the schematic for the control unit and [Figure 12](#) shows the schematic for the display panel.

Figure 11. Schematic for the control unit

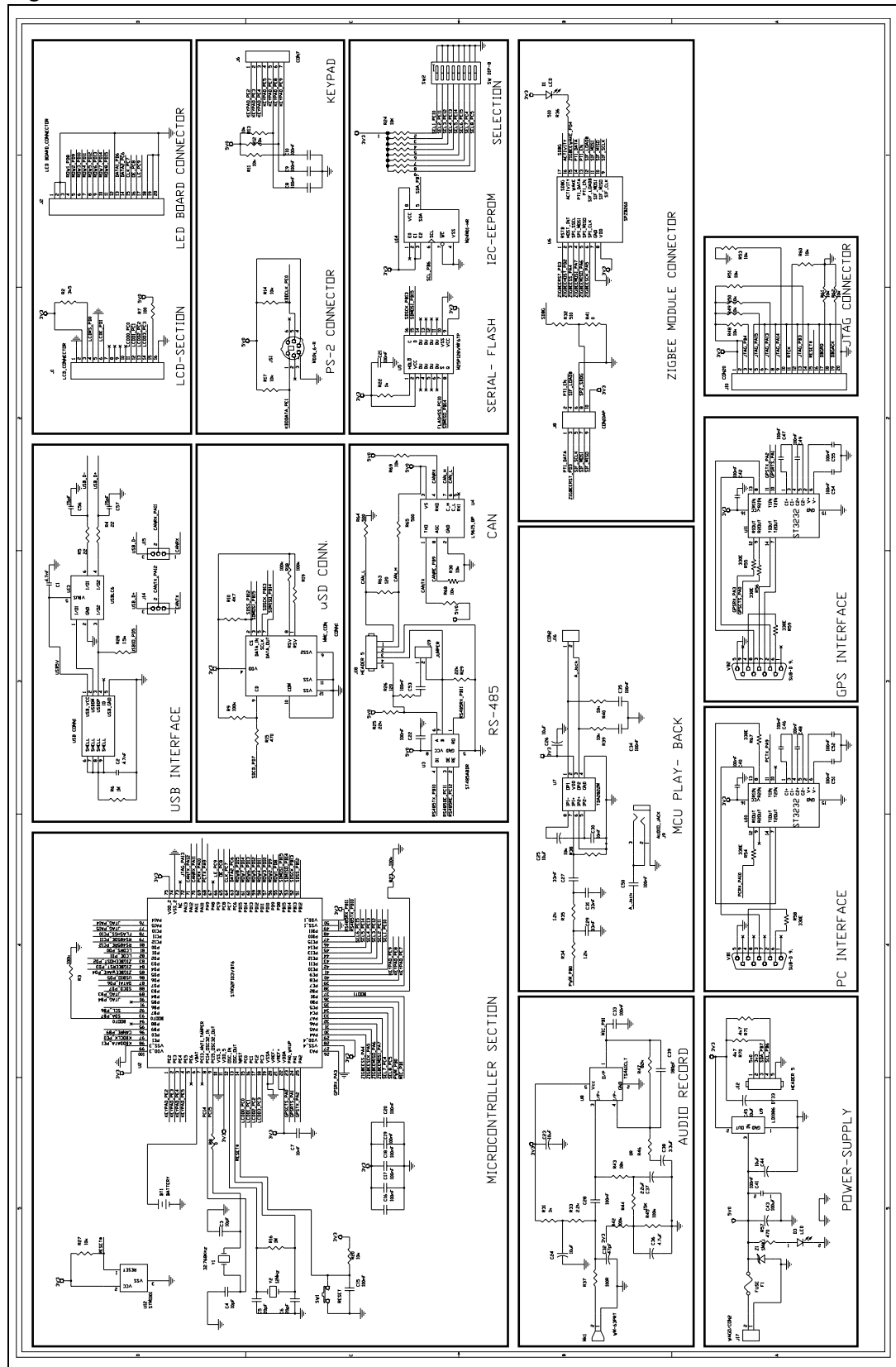
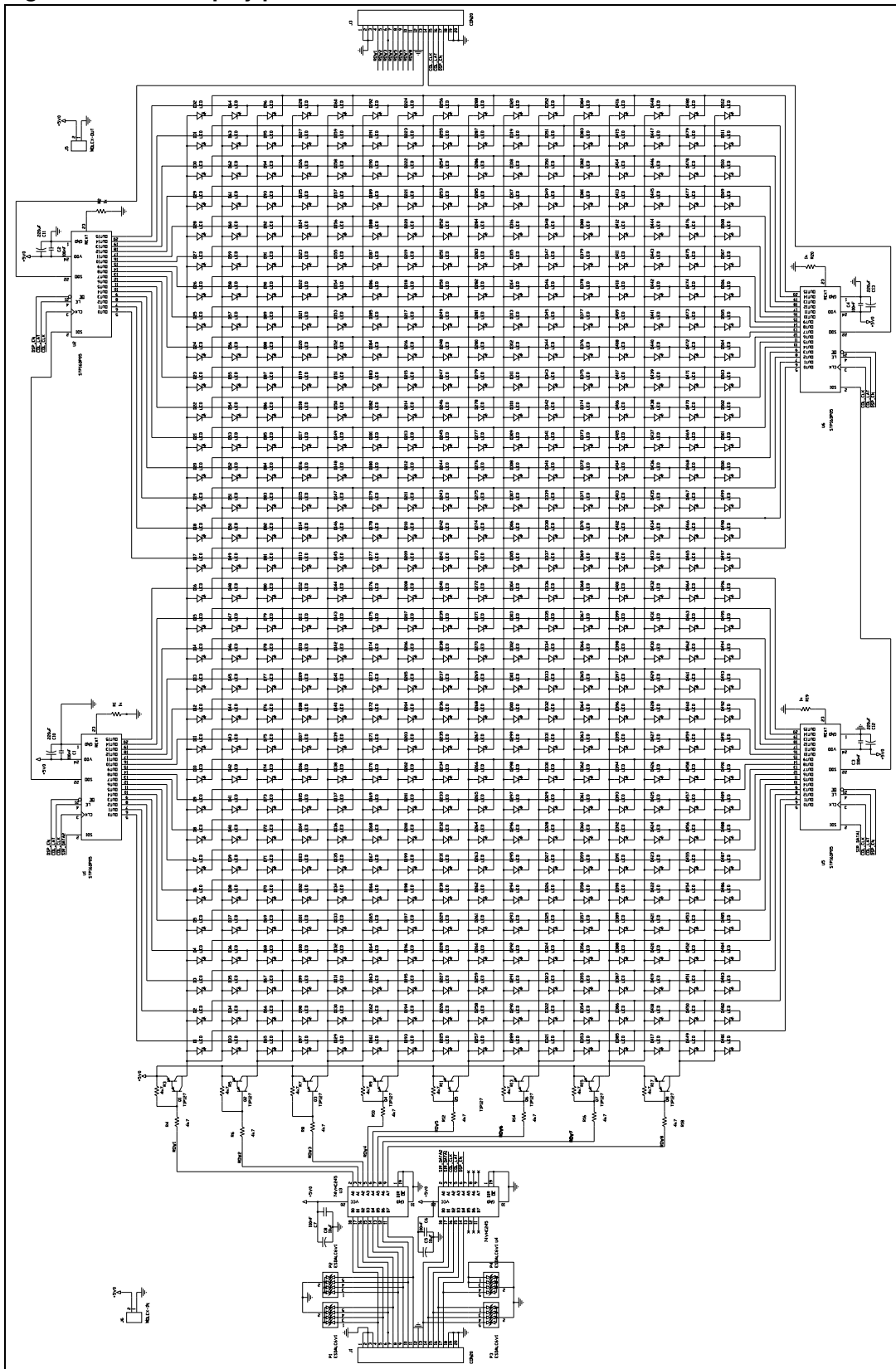


Figure 12. LED display panel schematic



**Table 1. BOM of microcontroller-based control unit**

| Reference designator | Component description | Package | Manuf. | Manufacturer's ordering code / orderable part number | Supplier | Supplier ordering code |
|----------------------|----------------------------------|----------|--------------------|--|----------|------------------------|
| U2 | STM32F103VBT6/microcontroller | LQFP | STMicroelectronics | STM32F103VBT6 | | |
| U3 | ST485ABDR | SO8 | STMicroelectronics | ST485ABDR | | |
| U4 | L9615D/CAN Transceiver | SO8 | STMicroelectronics | L9615D | | |
| U5 | M25P128VMF6TP/ SerialFlash | SO16 | STMicroelectronics | M25P128VMF6TP | | |
| U6 | SPZB260/ Zigbee module | | STMicroelectronics | SPZB260 | | |
| U7 | TDA2822D/Post amplifier | SO8 | STMicroelectronics | TDA2822D | | |
| U8 | TS461CLT/ Rail to rail op amp | SOT23-5L | STMicroelectronics | TS461CLT | | |
| U9 | LD1086DT33TR/voltage regulator | DKPAK | STMicroelectronics | LD1086DT33TR | | |
| U10,U11 | ST3232CDR/RS3232 driver receiver | SO16 | STMicroelectronics | ST3232CDR | | |
| U12 | STM1001RWX6F/Reset Ic | SOT23-3 | STMicroelectronics | STM1001RWX6F | | |
| U13 | USBLC6-2P6 | SOT-666 | STMicroelectronics | USBLC6-2P6 | | |
| U14 | M24M01- HWMN6TP/EEPROM | SO8 | STMicroelectronics | M24M01-HWMN6TP | | |
| Z1 | STPS1L30A/ Schottky rectifier | SMA | STMicroelectronics | STPS1L30A | | |
| Y1 | 32.768 kHz | XTAL-3 | ECS | ECS-327-18-9X | Mouser | 520-ECS-3276-18-9X |
| Y2 | 8 Mhz | XTAL-3 | Fox | FOXSLF/080-20 | Mouser | 559-FOXS080-20-LF |
| USB CONN1 | USB-B type mini connector | SMD | Molex | 67503-1020 | Mouser | 538-67503-1020 |

**Table 1. BOM of microcontroller-based control unit (continued)**

| Reference designator | Component description | Package | Manuf. | Manufacturer's ordering code / orderable part number | Supplier | Supplier ordering code |
|----------------------|---|----------------------|----------------------------------|--|----------|------------------------|
| VB1 | DB9 connector/ female | Through hole | Tyco Electronics | 5747844-4 | Mouser | 571-5747844-4 |
| VB2 | DB9 connector/ male | Through hole | Tyco Electronics | 5747840-4 | Mouser | 571-5747840-4 |
| J1 | LCD connector and 16 x 2 alphanumeric LCD | 16 x 1 berg strip | Oriole | ODM16216-9SL3/AX | Oriole | |
| J2 | LED board connector | 10 x 2 header | 3M electronic solutions division | 30320-6002HB | Mouser | 517-30320-6002 |
| J5,J14,J15 | 3-pin berg strip | 3 x 1 pin berg strip | Any | | Samtec | TSW-150-32-G-S |
| J6 | 7-pin berg strip and keypad | 7 x 1 pin berg strip | Any | | Futurlec | KEYPAD3X4B |
| J8 | 8-pin header/zigbee header | 8-pin header | Any | | | |
| J9 | Audio Jack | 3-pin through hole | CUI | SJ1-3523NG | Digi-Key | CP1-3523NG-ND |
| J10 | Jtag connector | 10 x 2 header | 3M electronic solutions division | 30320-6002HB | Mouser | 517-30320-6002 |
| J12,J16 | Berg strip/jumpers | 5 x 1 bergstrip | Any | | Samtec | TSW-150-32-G-S |
| J18 | Wago connector | Through hole | Phoneix Contact | 1729131 | Mouser | 651-1729131 |
| CONN1 | MMC card connector | SMD | Proconn Technology | MSPN09-X0-1000 | | |
| J17 | Wago connector | Through hole | Phoneix Contact | 1729128 | Mouser | 651-1729128 |
| D1,D3 | LED-Red | LED-3 mm | Everlight | EL-204HT | Mouser | 638-204HT |
| C1,C2 | 4.7 nF | SMD0805 | Panasonic - ECG | ECJ-2VB1H472K | Digi-Key | PCC472BNTR-ND |
| C3,C4, | 10 pF | SMD0805 | Panasonic - ECG | ECJ-2VC1H100D | Digi-Key | PCC100CNTR-ND |
| C5,C6 | 20 pF | SMD0805 | Murata Electronics North America | GQM2195C1H200JB01D | Digi-Key | 490-3607-2-ND |
| C7,C30 | 10 nF | SMD0805 | Panasonic - ECG | ECJ-2VB1H103K | Digi-Key | PCC103BNTR-ND |