INTRODUCTION

This is the first of a class of products the amateur community has never seen. This product increases the feature set of an existing product such as the CS800D as well as unify multiple radios to allow the generation of a multi-band multiprotocol device. This is what the CS8000 project was going to eventually be.

The CS7000 and CS8000 was a R&D project started many years ago that was never finished because of technical problems. It never got beyond the research stage. The purpose of that product was to have in a single radio a device that would be able to do the following protocols:

(1) Analog
(2) DMR
(3) DSTAR
(4) NXDN
(5) Fusion
(6) DPMR
(7) P25 Phase 1
(8) P25 Phase 2

The CS-BFD and CS-BMFD is a device that allows us to achieve that result and in addition have the following additional functions:

(1) CWID
(2) SSB
(3) AM
(4) Various Digital Modes used in the HF bands

The CS7000 was designed to be a single band device because of space while the CS8000 was going to be a dual band radio because we had additional space. The CS-BFD and CS-BMFD will be able to work from all frequencies from DC to Light because of its architecture.

The CS-BFD is a controller that allows the operator from a single device to control many different radios in a unifying structure. The CS-BMFD continues that philosophy but has some additional features that allows the user to operate all the different radios using a single microphone and a single speaker, do cross band repeat, and many other functions. The CS-BFD requires a separate microphone and speaker for each radio. The Microphone that plugs into the CS-BFD and the speaker that is already in the CS-BFD is all that is required for the CS800D, CS800, or CS801.

When using the CS-BFD with multiple radios, you need to have a separate interface board for each radio other than the CS800D, CS800, or CS801. The reason for the interface board was because it was impossible to design the features needed in the basic product. The following are some of the issues of why a separate board is required:

(1) Level of the audio and digital signals going between from the various radios varies. The CS-BFD and the CS-BMFD uses 3.3 volts in the product. One of the radios we are using has a five volts interface. We are not sure what the requirements of the radios we have not yet seen. The interface board unifies the structure by having level shifters convert what is in the radio to something compatible with the CS-BFD and the CS-BMFD.

(2) Timing of the signals going to and from the radio is sometimes tight. The CS-BFD and CS-BMFD has some functions that takes a significant amount of processing power and if you tried to operate multiple radios from that single processor the timing requirements of the radio might not be met.

(3) Computational speed necessary to achieve the needed functions is very high. Because of the tremendous computational speed needed to achieve the required functions of all the radios, we would need a processor much more powerful than what we already are using. If we put all the functions needed within the CS-BFD and CS-BMFD, the price of that product would be too high if all you wanted to do was operate a CS800D.

(4) Connection to the radios are different. Different radios have different connections. The CS800D only requires a single 8 pin connector. The FT-857 requires a single 6 pin connector and a single 8 pin connector. We do not know what the other radios require at this time. Because of the uncertainty of what is required for all the different radios we will eventually support, it would be impossible to put it on the C-BFD and ever finish the product.

To achieve a working product in light of the problems shown above, it was decided the CS-BFD and the CS-BMFD would have the CS800D, CS800, and CS801 interface native to the product and the other radios supported by an interface board. This interface board connects to the radio on one side and the other side connects to either a USB port or a Serial Port. The Yaesu FT-857 will use the serial port while the other radios will use the USB ports. The CS-BFD and CS-BMFD has a total of three ports used for hooking up additional radios. One port is a serial port and the other two ports are USB ports.

The Interface board does the following:

(1) Provides the physical connections to the radio.

(2) Provides a physical connection to the CS-BFD or CS-BMFD.

(3) Provides audio levels to and from the CS-BMFD consistent between different radios.

(4) Provides the ability to maintain tight timing requirement as required by the radio.

(5) Provides enough processing power to preprocess the data before being presented to the CS-BFD or CS-BMFD.

(6) Multiplexes the digital audio data and the information required for the display and switches in a single data stream.

What we are doing with the CS-BFD, CS-BMFD, and the interface boards is monitoring the lines on the interface between the radio and its removable display as well as the microphone interface. We then interpret what the signals mean, and we use that information to put information on the large display. Unfortunately, the manufactures are not giving us the information to decode their signals, so we must reverse engineer their products. That requires us to look at the signals for weeks at a time until we find the pattern and then write the firmware to exploit what we have found.

We wanted the firmware in the product to be open source so an individual can customize the product to meet their own needs as well as the HAM community and we also wanted to make it so the Chinese or other groups cannot rip us off and make clones of what we spend a lot of time and money developing. We think we came up with a fair compromise.

Most of the firmware will be available in source form. All the object code will be available, so the programmer can modify what we have started. The most difficult part of this project was to reverse engineer the interface to the radio. This and a few other pieces will not be available in source code form. However, we will provide the results of what is needed to use those firmware modules in clear easy to understand form.

MECHANICAL PARAMETERS

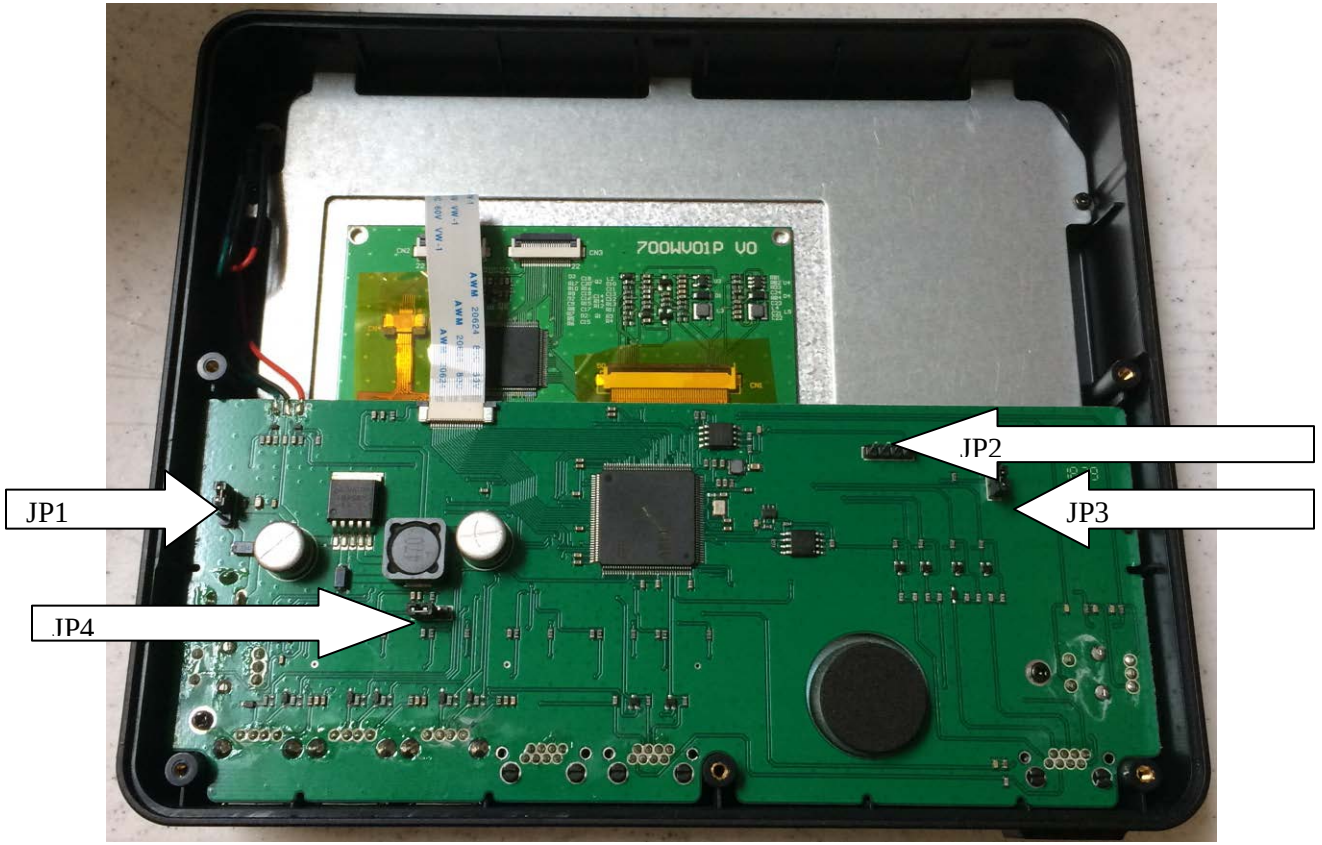
Weight: 25 Ounces

Dimensions: 7 ¾ x 6 ¾ x 1 ¼

Screen Diagonal Size: 7”

Active Screen Size 6 x 3 ½

JUMPERS



JP1 is used to determine the source of its power. If the jumper is between the center pin and the pin closest to the top of the display, then the power is derived from the radio. If the jumper is between the center pin and the bottom of the display, then the power is derived from an external power supply.

JP2 is a four pin jumper block and is used as the connector for attaching a debug pod to allow the programmer to debug the display.

JP3 is used for setting the microprocessor to boot mode to allow the user to load the firmware in case the display gets bricked. If the jumper is between the center pin and the pin closest to the four pin jumper, then the microprocessor is in boot mode. If the jumper is between the center pin and the bottom of the display, then the microprocessor is in normal mode.

JP4 is used for enabling the backlight for P1 - P4 and the power key. If the jumper is between the middle pin and the pin closest to JP1 then the backlight for those keys are always on. If the jumper is absent or the jumper is between the center pin and the pin closest to JP2, then the backlight for those keys are always off. The backlight for those keys take a significant amount of power.

UPDATING THE FIRMWARE

We are going to continue updating this product for a long time to add new features, fix problems, and add the ability to add new radios. Updating the firmware takes just a few seconds after the Dfuse program is installed.

Updating can normally be done by pressing the P1 and P4 keys at the same time while power is applied. However, if the unit is bricked, it is necessary to open the back of the case, insert a jumper in a jumper block, and then turn on the power.

Then you load the new file in the Dfuse program, and press the button to start the update.

We provided a separate application note that goes in exquisite details on how to perform this simple task.

USING THE CS-BFD WITH YOUR CS800D, CS800, OR CS801

(1) Plug a CAT 5 or CAT 6 cable between the CS-BFD and your display connector on your radio.

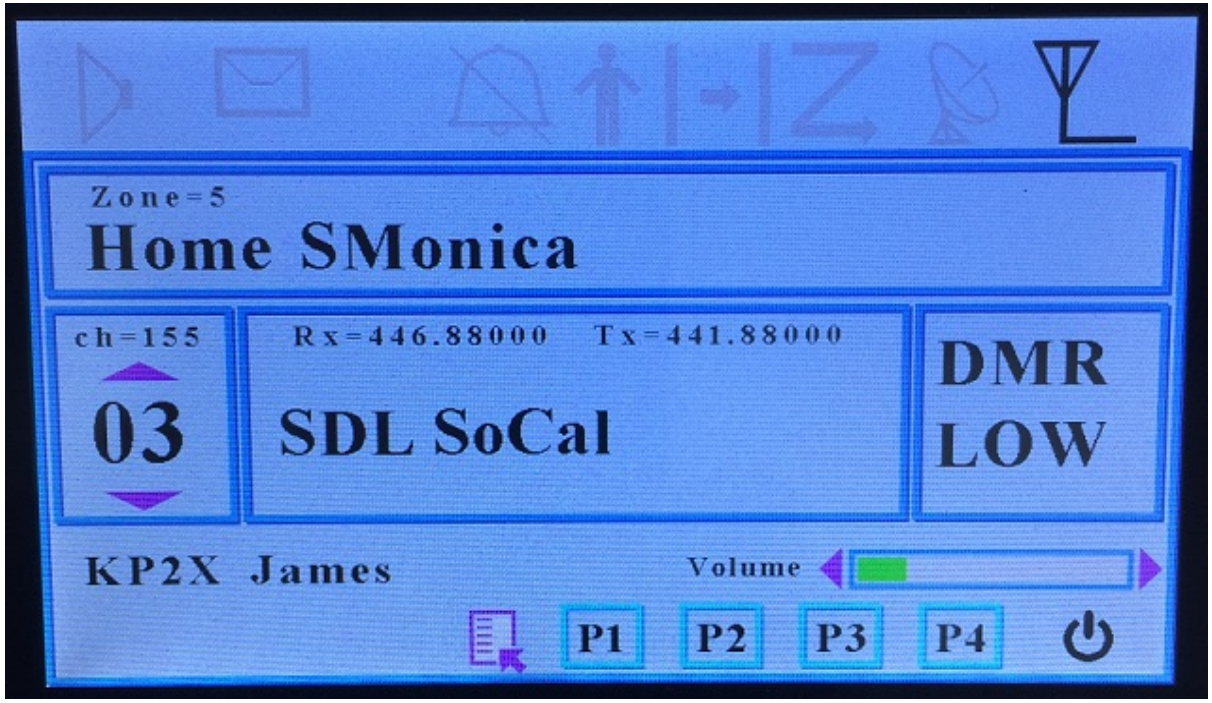
(2) Plug the microphone that came with the radio into the microphone port of the CS-BFD. If you do not want to use the one that came with the radio, you can use a Kenwood MC-59 microphone or buy another microphone from Connect Systems.

(3) Provide power to your radio.

(4) Press the power switch on the CS-BFD for about six seconds. In a few seconds the display will light up and you are now ready to use the CS-BFD. If the radio turns off after you released the power switch, you did not press the power switch long enough. You should press it long enough to hear the turn on tone sequence. If you press the power button and then release it before you hear the tone, then the panel might look like its working but seems to be locked up. The display is not locked up. it is the radio. The radio is supply power to the display but is actually off. If you continue to press the power button under those circumstances, then the radio will generate the tones and you are ready to go.

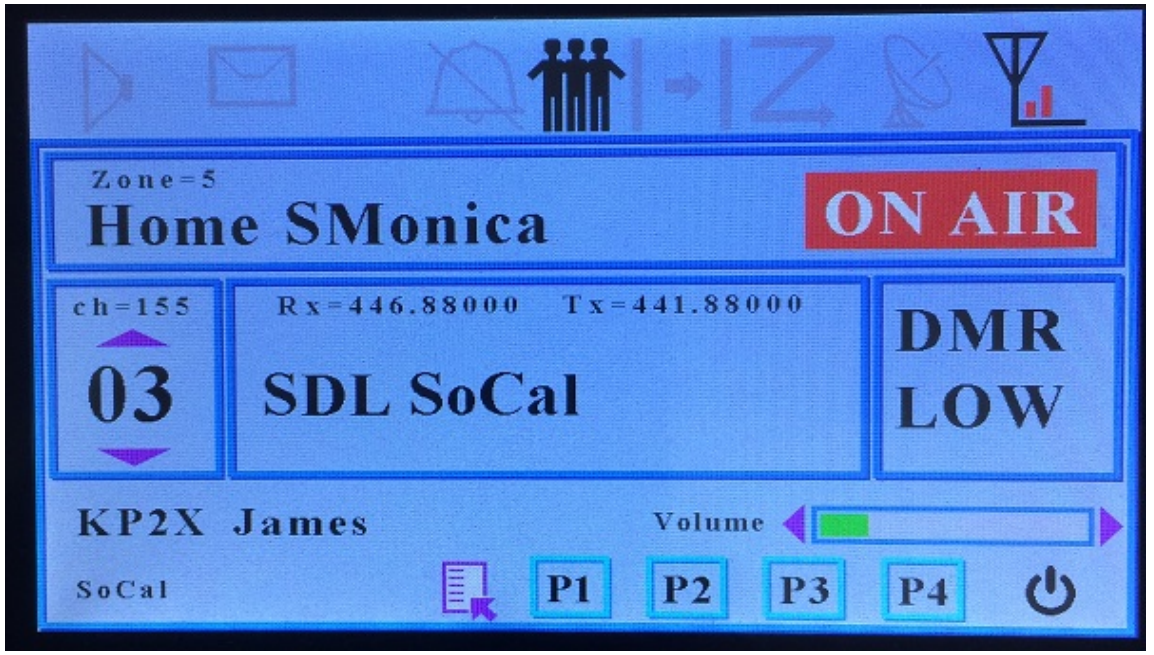
OPERATION OF THE CS-BFD

When you first turn on the CS-BFD, you will get the following screen:



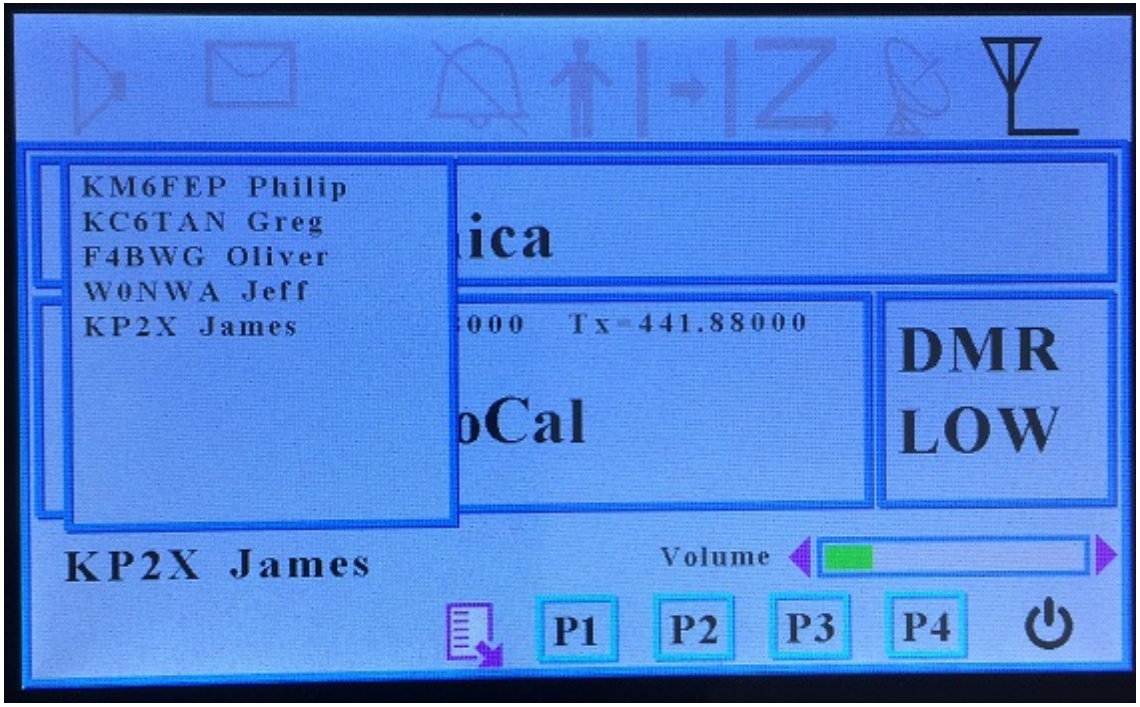
By comparison, if you have the standard CS-800D with the small screen, you will get the following when you first turn on power:

If you press the PTT, then you will get the following screen:



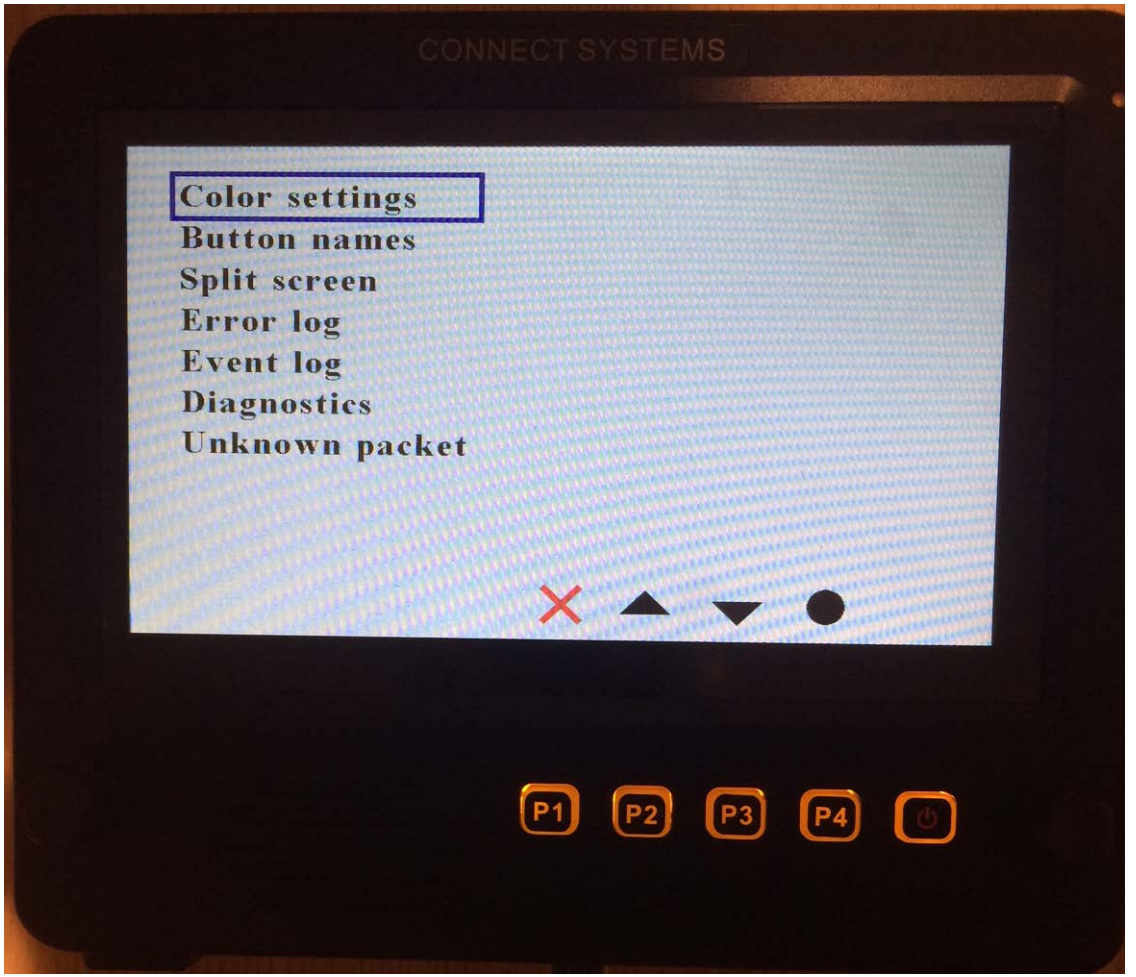
By comparison, if you have the standard CS-800D with the small screen, you will get the following with the red led turned on when you go in transmit mode:

If you want to see the last called, you press the ICON to the left of the P1 soft key and you get:



ADVANCED FEATURES

Pressing the rotary switch on the right will bring up the following screen:



The up and down arrow on the touch screen or P2 or P3 will select which feature you want to select. The solid circle on the touch screen or P4 will select that feature that is highlighted. To exit from this menu select press the Red X on the touch screen or P1.

Color settings
The Color setting will allow you to change the default colors on the different screens. The program assumes a fixed palette of colors. If you do not like the selection it is possible to completely redefine the color selection in the palette. In case you made a mistake, it is possible to set the display back to the default colors.

Button names
The default settings on the screen for the four buttons is P1 through P4. This screen will allow you to change the default settings to something that is more meaningful. This feature is not supported in the first release.

Split Screen
This is to set up the screen for multiple radios attached to the single display. It can be set up for two or four radios. This feature is not supported in the first release.

Error Log
There are a significant number of traps in the firmware to look for problems that should never happen. The error log records the information and allows the user to see those. The customer should take a photo of those errors and send it to the factory to allow us to make the firmware better.

Event Log
This records the major events in the system such as pressing a key and receiving packets from the radio.

Diagnostics
The hardware can be tested with this diagnostic. It checks for various things such as the proper operation of the touch screen, switches, and various components inside the unit.

Unknown Packet
The design of this product is based on reverse engineering the operation of the radio attached to the CS-BFD. Different packets are sent from the radio dependent on the keys the user presses and what is happening with the radio. It is possible we never seen a particular event happen and that event gives us a packet we have never seen before. If that happens we capture and store the packet and that packet will be displayed in this screen. If that happens we will ask you to take a photo of the unknown packet as well as the event log so we could hopefully reproduce it and fix the problem, so it never happens again.

COLOR SETTING

If the color setting is selected, you will get a screen as shown below. You can now select what feature of the screen you want to change. As an example, I will show how to change the text to white and the text background to black. Start by pressing the circle with your finger or the P4 key.

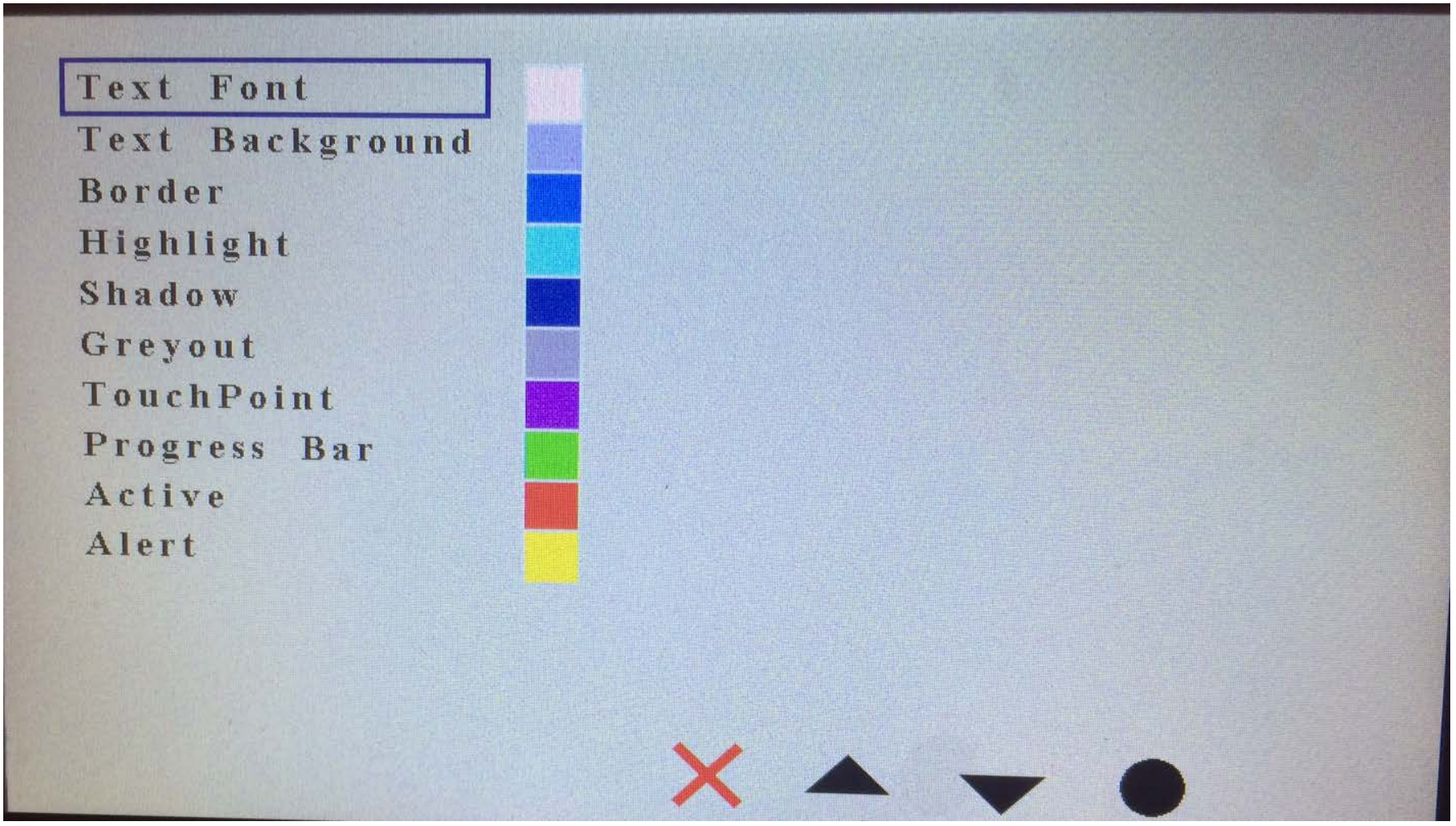
Use the left arrow of P2 or the right arrow or P3 to select the color of the text font. In this case we want to select white.

Use the left or right arrow key or P3 or P4 to select the color you want and then press the Select key or P4 to lock it in. Notice that when the arrow key is moved to the left or right, the active color is show with a blue outline around the key and the color of the selected item has changed to that color as shown below.

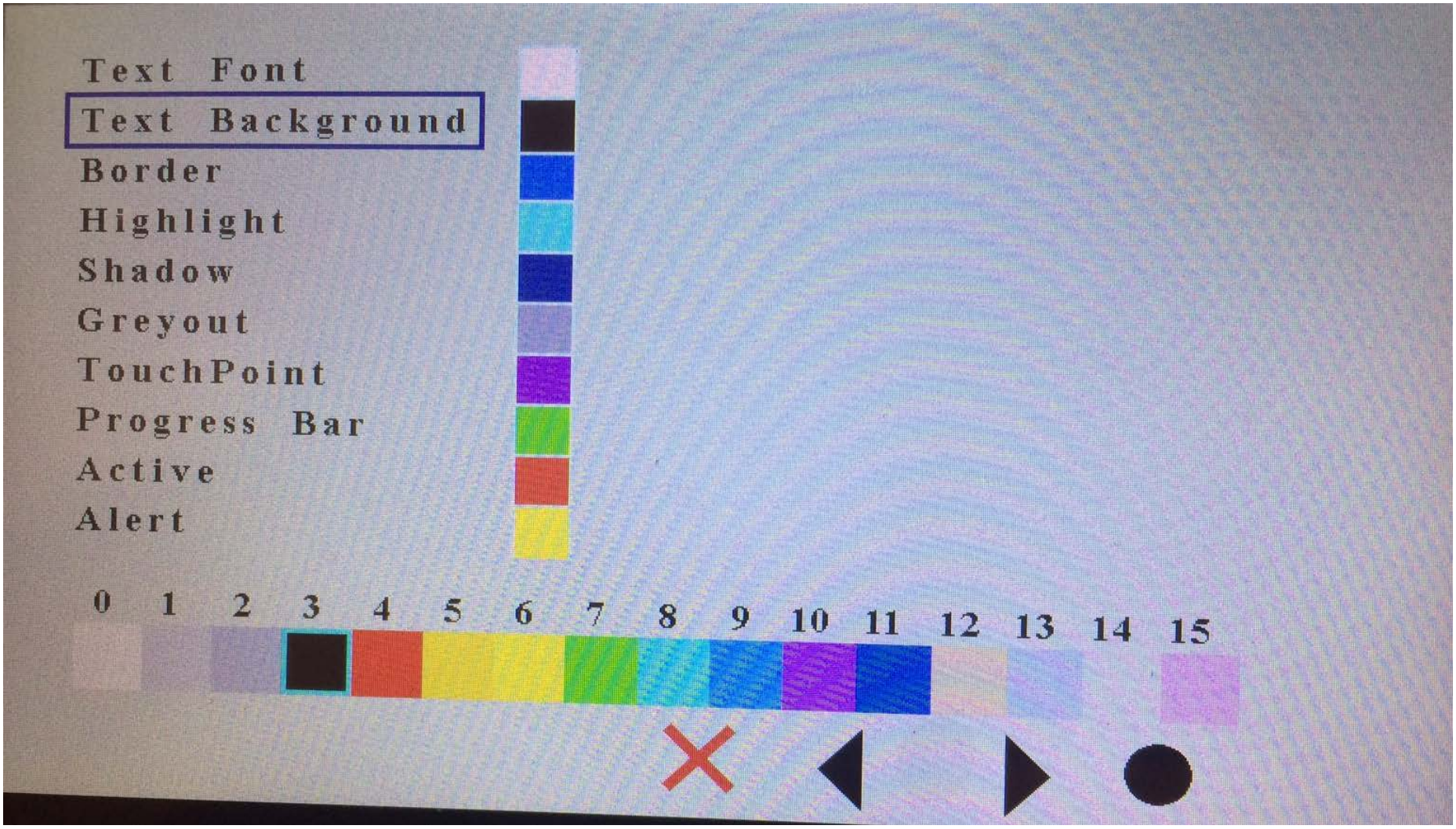
Now that white is selected, press the circle or the P4 key.

Now press the circle or the P4 key and notice that the Text Font went from black to white.

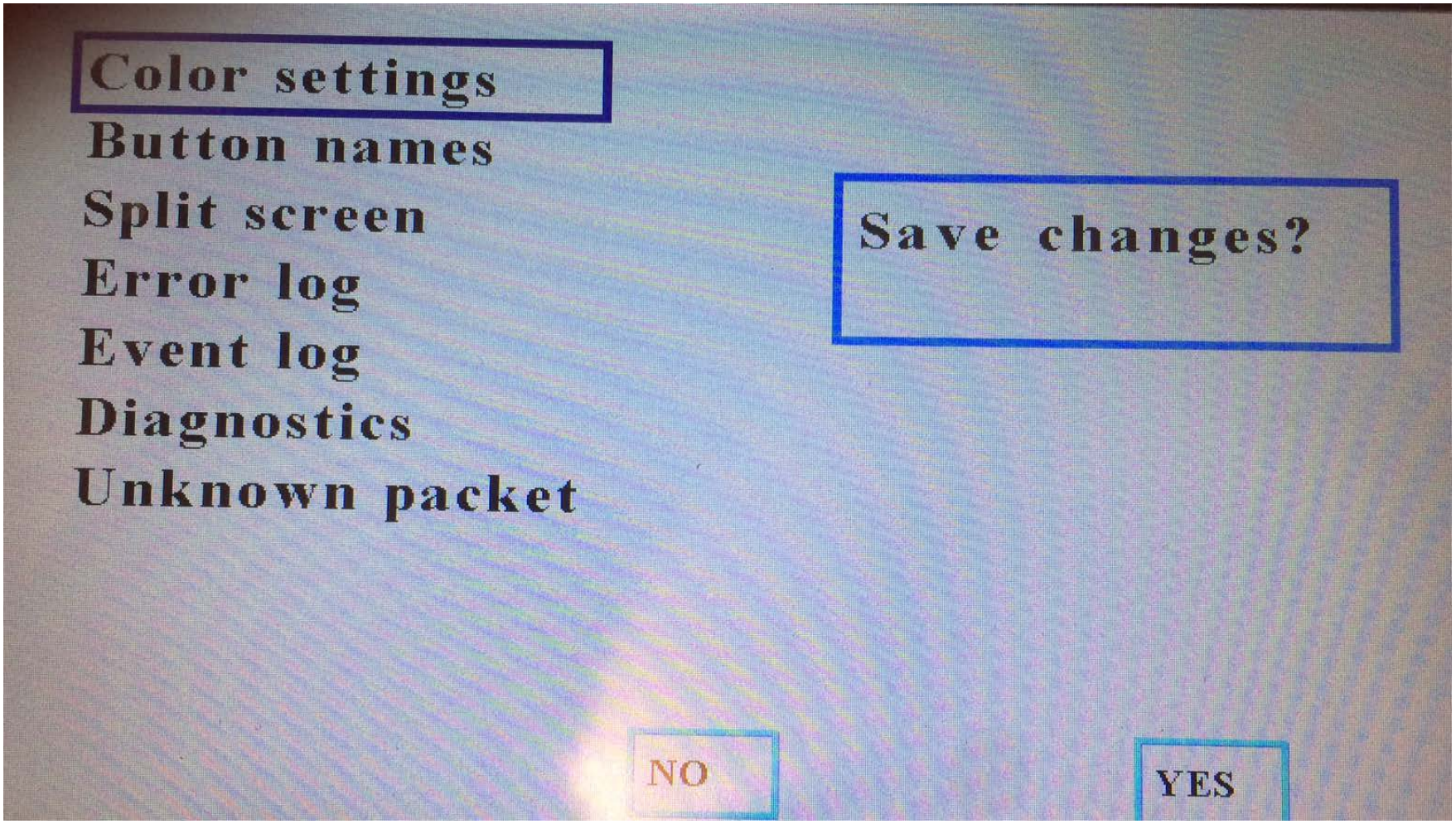
Press the red X or the P1 key and the screen will return to the previous screen as shown on the next page.



Go through the same sequence until you get the text background color black as shown on the next page.



Press the Red X or P1 key twice and you will get the screen as shown on the next page.

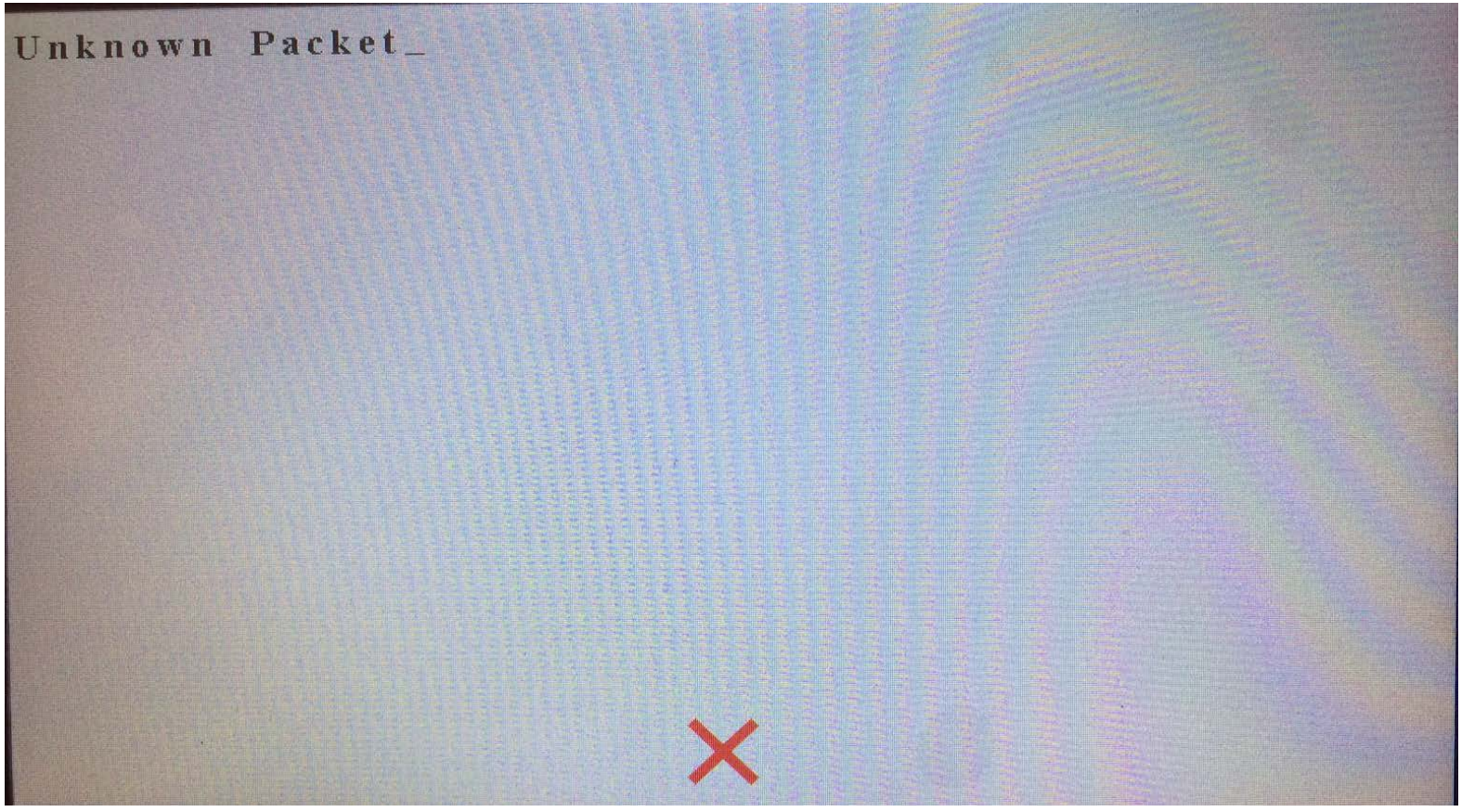


Press the Yes or P4 key and you are finished. Pressing the rotary switch on the right will return you to the main screen as shown on the next page.


CONNECT SYSTEMS
Zone=39
Pacificon
ch=964
01
Rx=147.66000 Tx=147.66000
W6CX V
ANALOG
HIGH
Volume
P1
P2
P3
P4
P1
P2
P3
P4

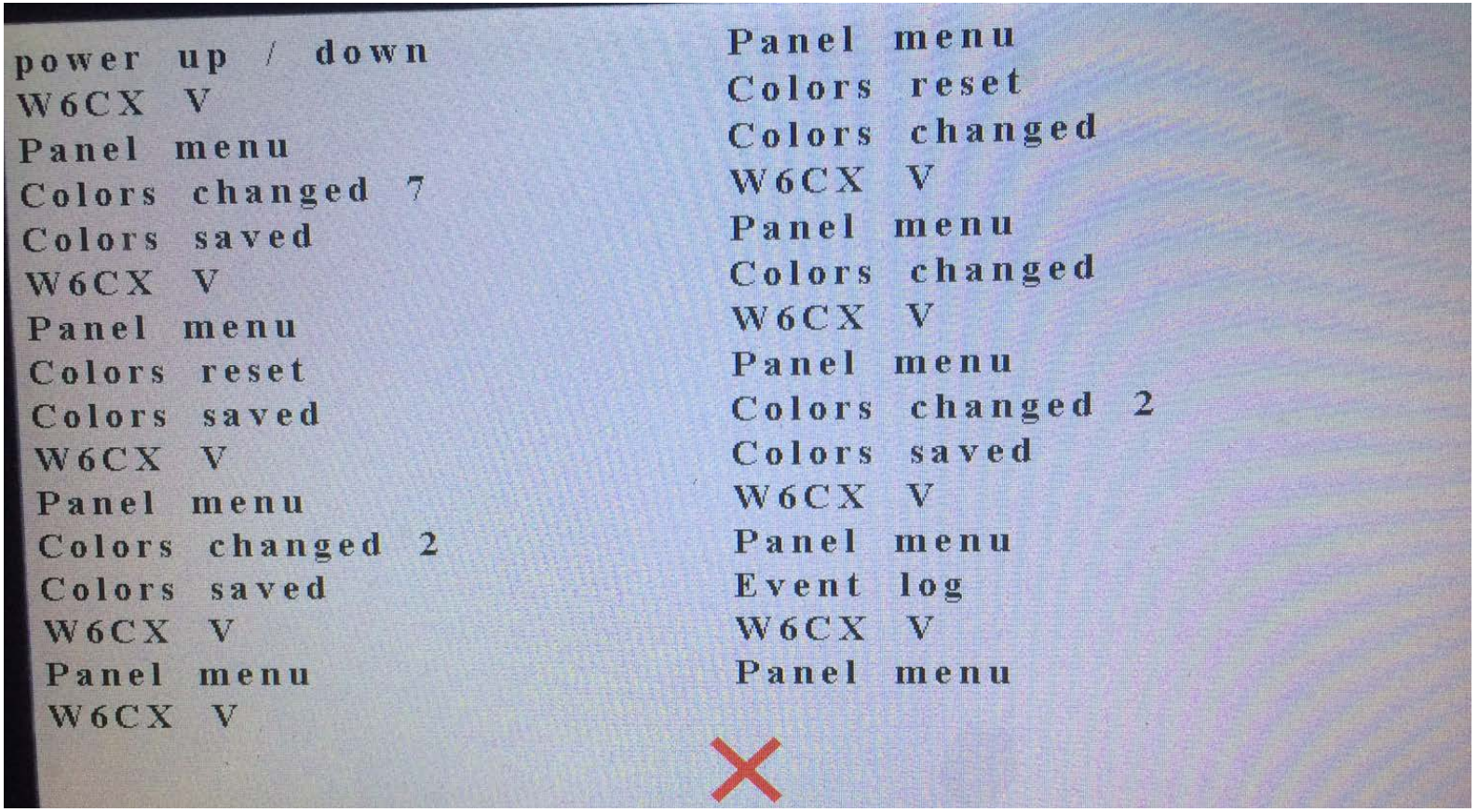
ERROR LOG

This error indicates there is an unknown packet and the user should take a photo of this screen as well as the event log screen and the unknown packet screen and e-mail it to connect systems so we can fix the problem.



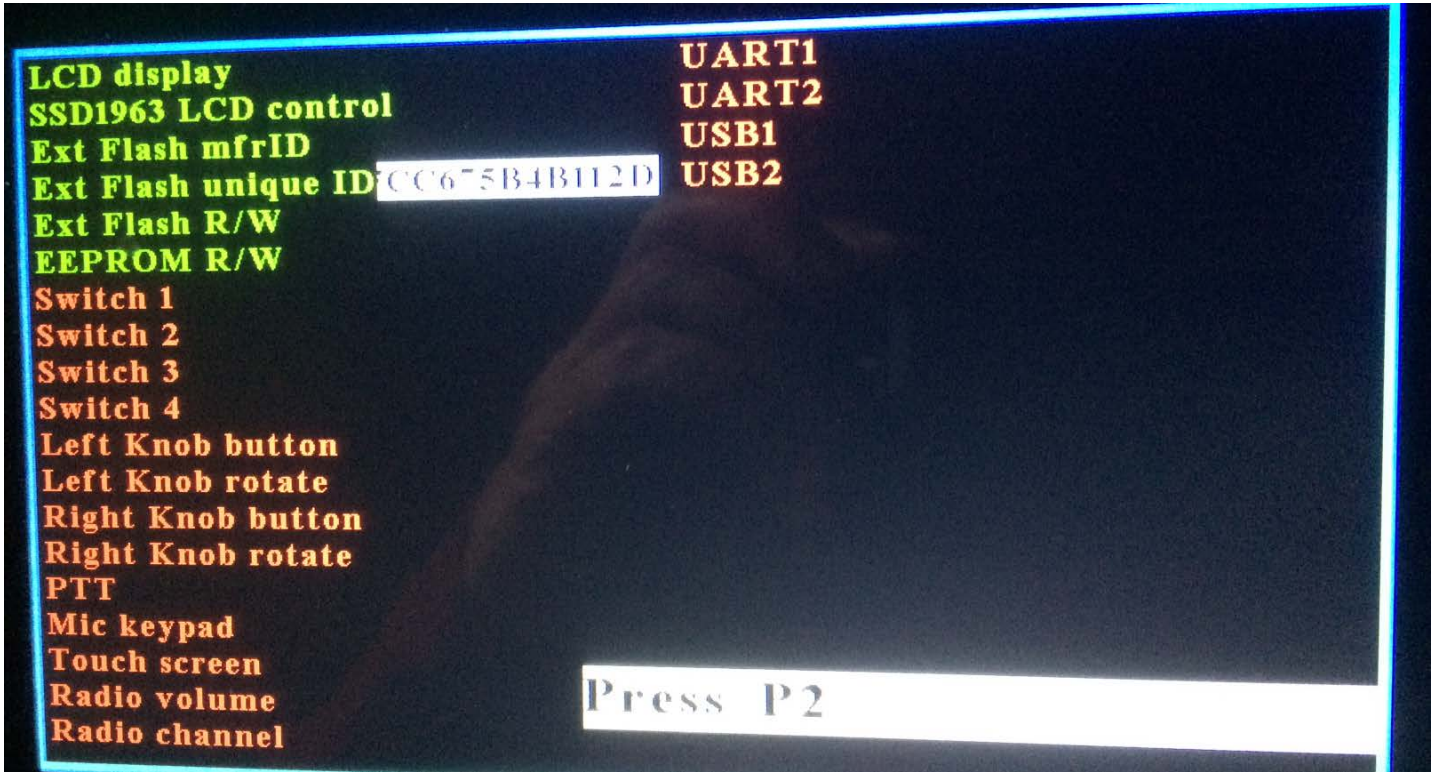
EVENT LOG

To help with diagnostics, especially when there is a problem, we provide a screen that shows the major transaction the CS-BFD processed. We might ask you to take a photo of this screen to help resolve unknown issues.

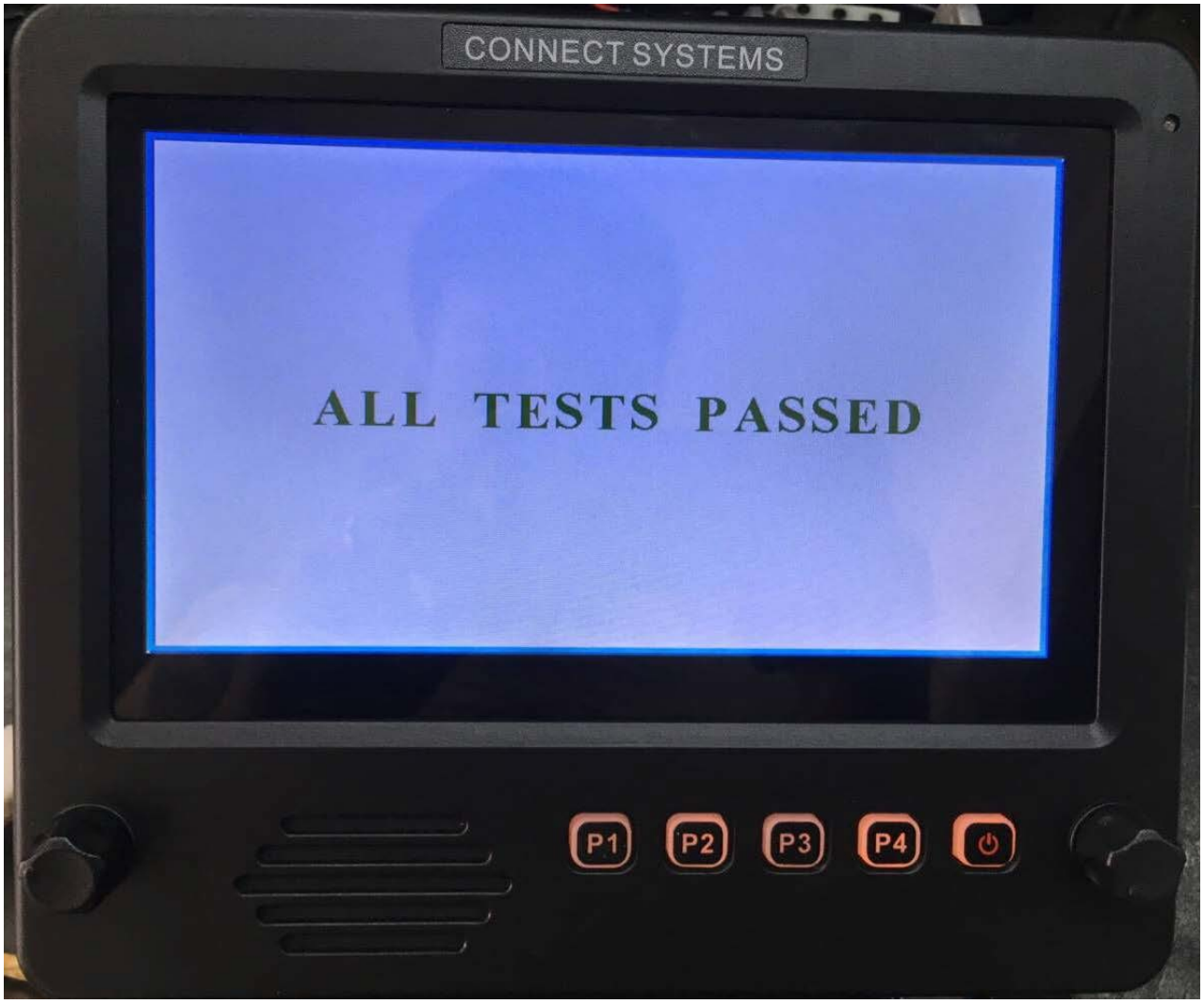


DIAGNOSTICS

To help with hardware problems, the CS-BFD has a complete set of hardware diagnostic test that should isolate any problems.



If all the hardware diagnostics test passed, you get the following screen.



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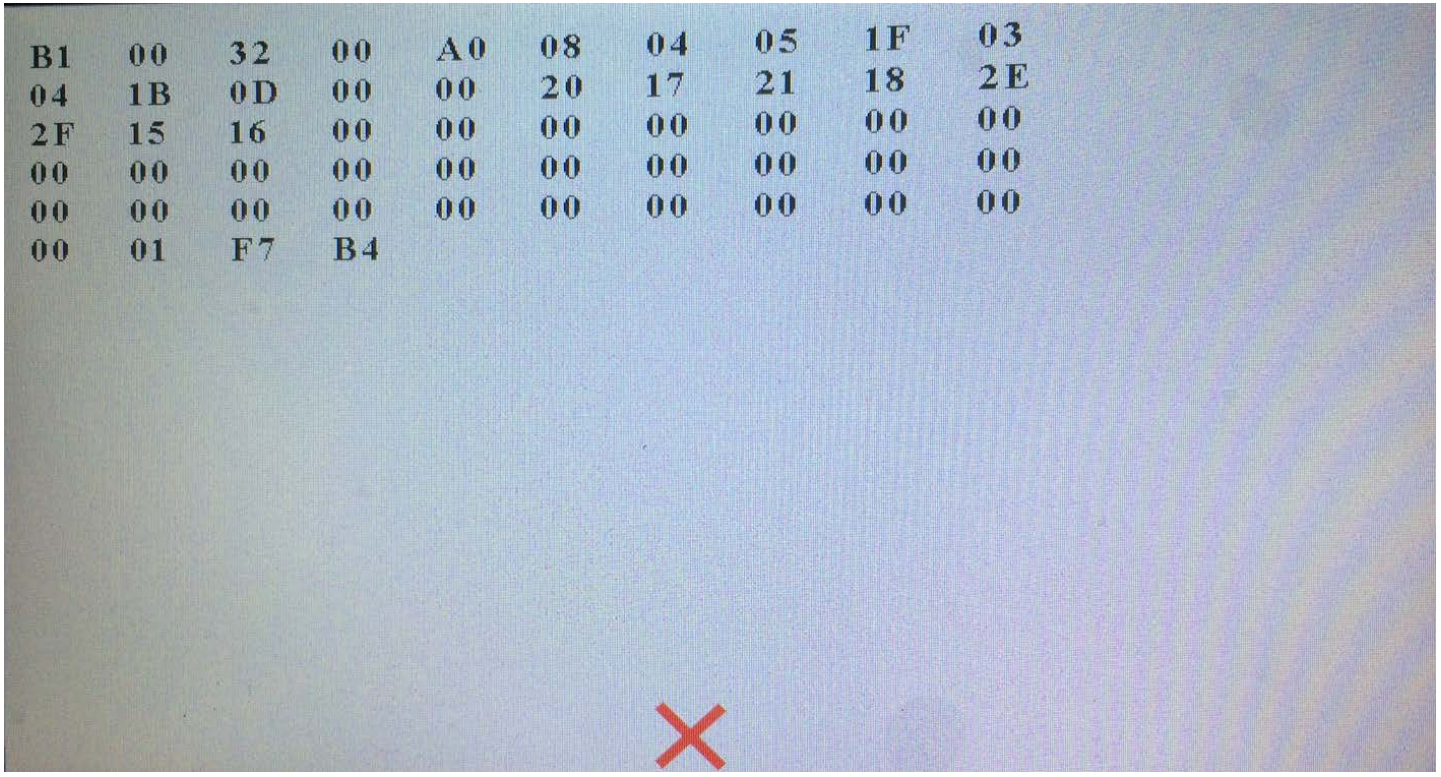


FRONT OF THE CS-BFD

The P1, P2, P3, and P4 corresponds to the P1, P2, P3, P4 on the CS800D. When used with other radios, they might have different meanings. The two knobs on the edges correspond to the rotary knob on the CS800D and the Up and Down button on the CS800D. Both of those rotary knobs can be pushed for additional functions like on the CS800D. Please look in the operations manual of this document on how those keys are used.

REAR OF THE CS-BFD

Notice the four holes on the back are made to fit any AMPS compatible device.

CS-BFD Operation

Board Jumpers

JP1 selects if the power to the unit is coming from an external power supply plugged into the jack or from a radio.
JP2 is the Debug Connector for those advanced users who want to modify the firmware.
JP3 is used for putting the unit in boot mode if the unit is bricked
JP4 selects if the backlit keys are on or off.

POWER

Power for the unit is supplied by the CS800D, CS800, or CS801 radio under normal conditions. Under certain conditions, the user might want to power the radio either from a power supply or directly from a car battery. This selection is done by a jumper. This power goes directly to the microphone jack as well as a switching regulator IC2 that converts the voltage to 3.3V which is used for powering the rest of the circuits.

Interface to the CS800D, CS800, or CS801

The interface to the radios have the following connections:
Pin 1 (SPGND) This is the speaker ground connection from the radio. It goes directly to the internal speaker of the CS-BFD.
Pin 2 (SPOUT) This is the speaker audio connection from the radio. It goes directly to the internal speaker of the CS-BFD.
Pin 3 (8M) This is the power from the radio and is about 8 volts.
Pin 4 (RxD) This is the connection between the UART of the CS-BFD and the UART of the radio.
Pin 5 (TxD) This is the connection between the UART of the CS-BFD and the UART of the radio.
Pin 6 (POWER) This connection when grounded, turns the radio on if it is off or turns the radio off if it is on.

Pin 7 (MIC) This is the direct audio connection from the microphone
Pin 8 (GND) This is the common ground for the power and audio

Interface to the DTMF Microphone
Pin 1 (MBL) Not used
Pin 2 (8V) Power required by the microphone.
Pin 3 (GND) Ground
Pin 4 (PTT) Push to talk from the microphone
Pin 5 (ME) Microphone Ground
Pin 6 (MIC) Microphone Audio
Pin 7 (Hook) Off Hook switch connection
Pin 8 (DM) Reads the DTMF keys

Interface to USB 1 Connector
Pin 1 (VCC) 3.3 Volts
Pin 2 (D-) TxD from the UART
Pin 3 (D+) RxD From the UART
Pin 4 (GND) Ground

Interface to USB 2 Connector
Pin 1 (VCC) 3.3V
Pin 2 (D-) USB DM Connection
Pin 3 (D+) USB DP Connection
Pin 4 (GND) Ground

Interface to USB 3 Connector
Pin 1 (VCC) 3.3V
Pin 2 (D-) USB DM Connection

Pin 3 (D+) USB DP Connection
Pin 4 (GND) Ground

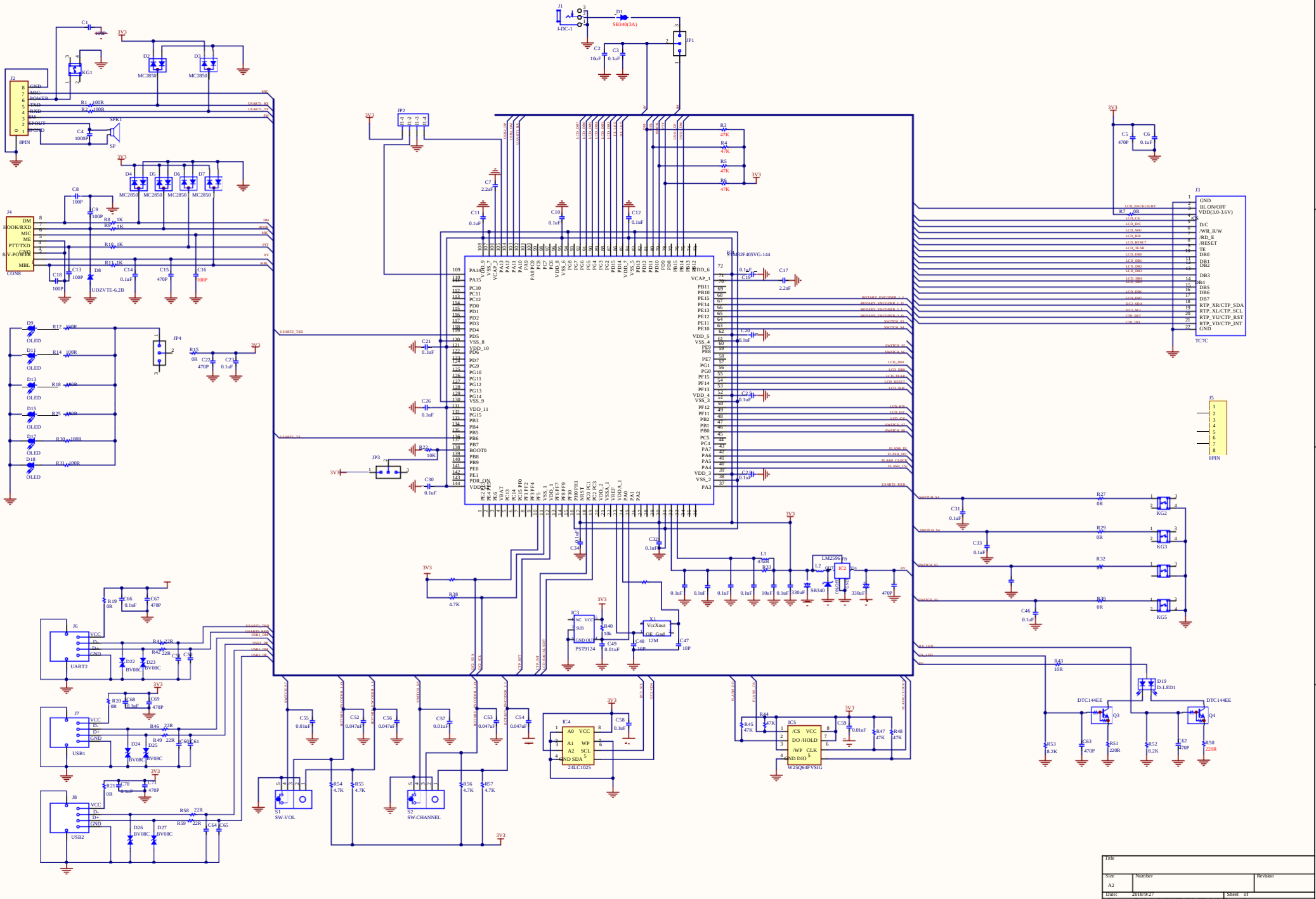
Rotary Encoders and Switches
The rotary encoders and the switches are hooked directly to the microprocessor. Debouncing is handled by the firmware of the microprocessor.

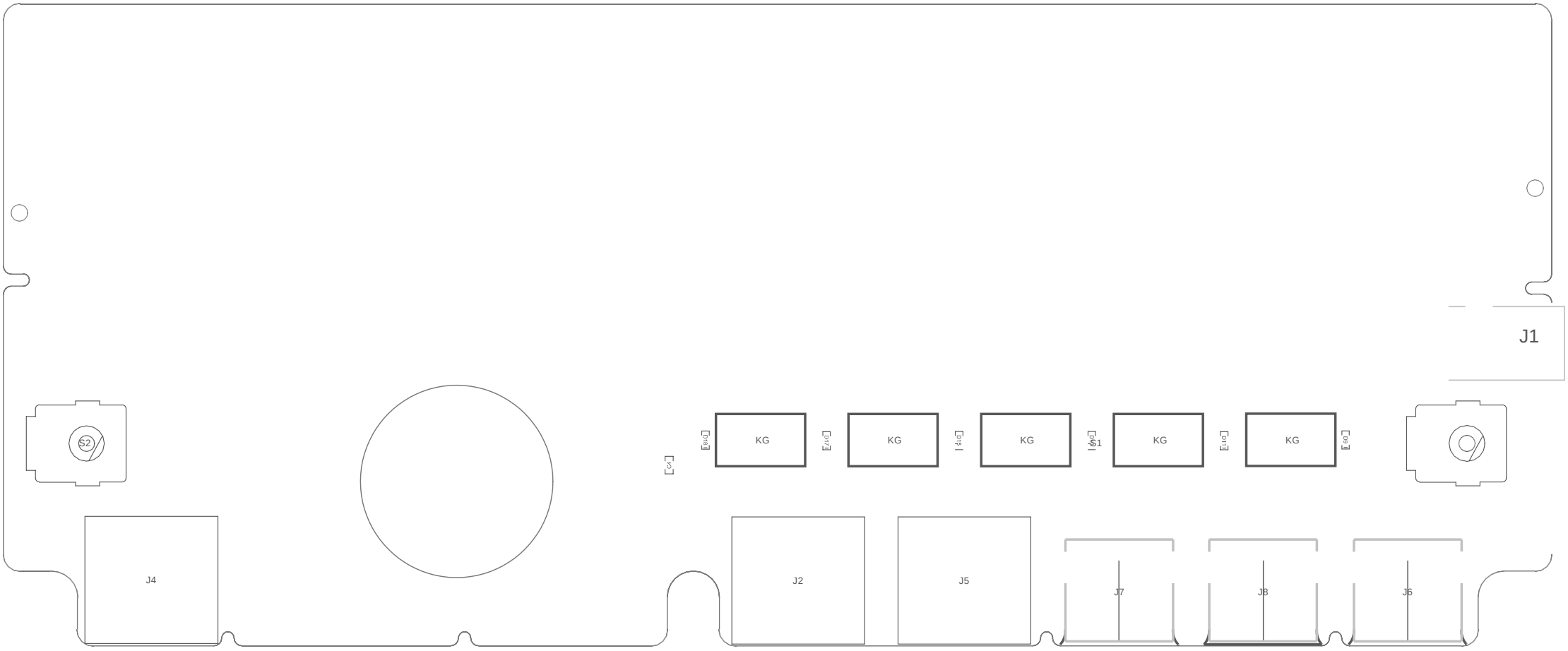
Front Panel LED
There is a green and red LED that is used to indicate various functions. These two LEDS are independently controlled by the microprocessor.

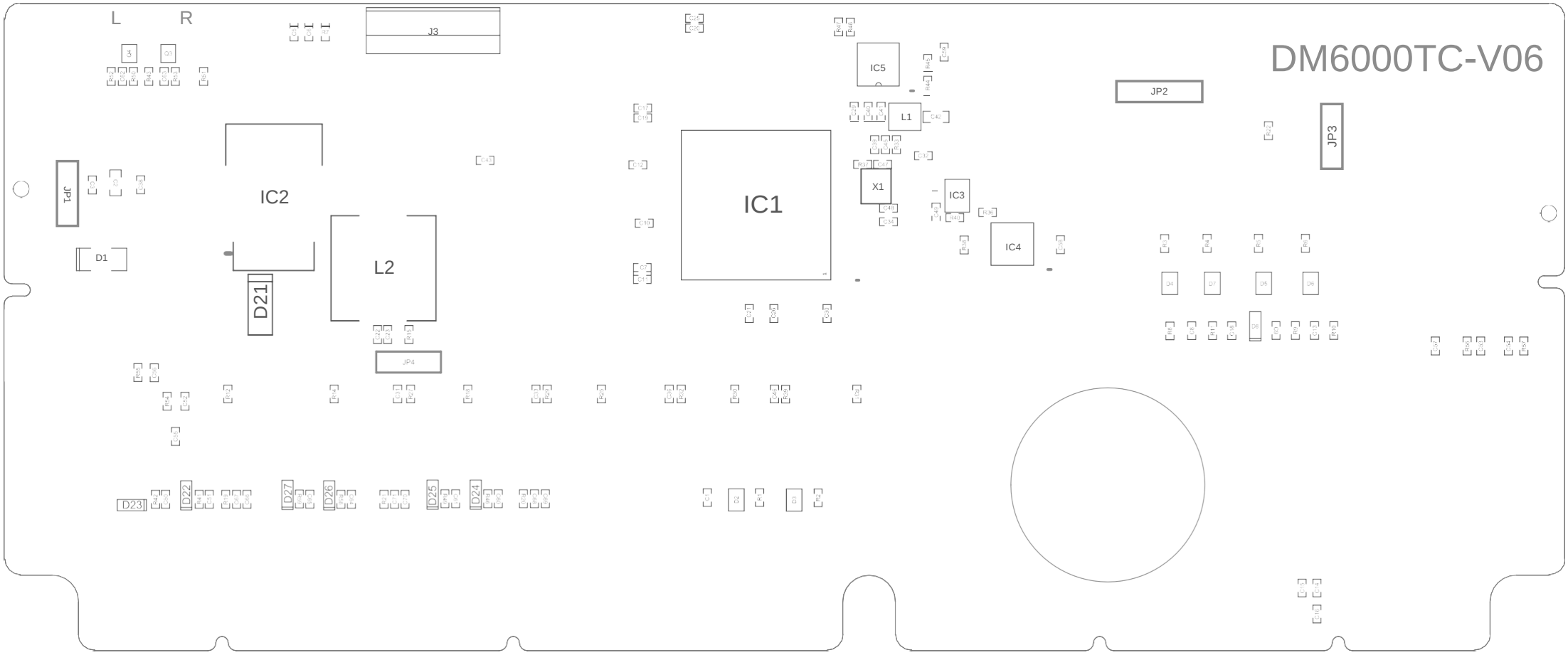
LCD Interface
The LCD uses an eight-bit parallel interface. The backlight is controlled by a logic level pin.

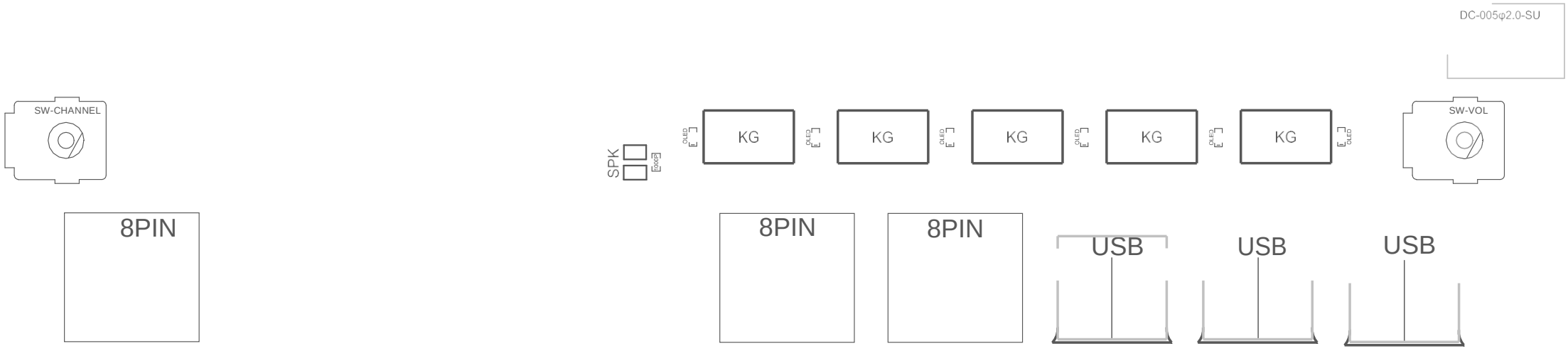
Touch Screen
The touch screen uses an I2C interface along with a line that indicates there is data ready to be read.

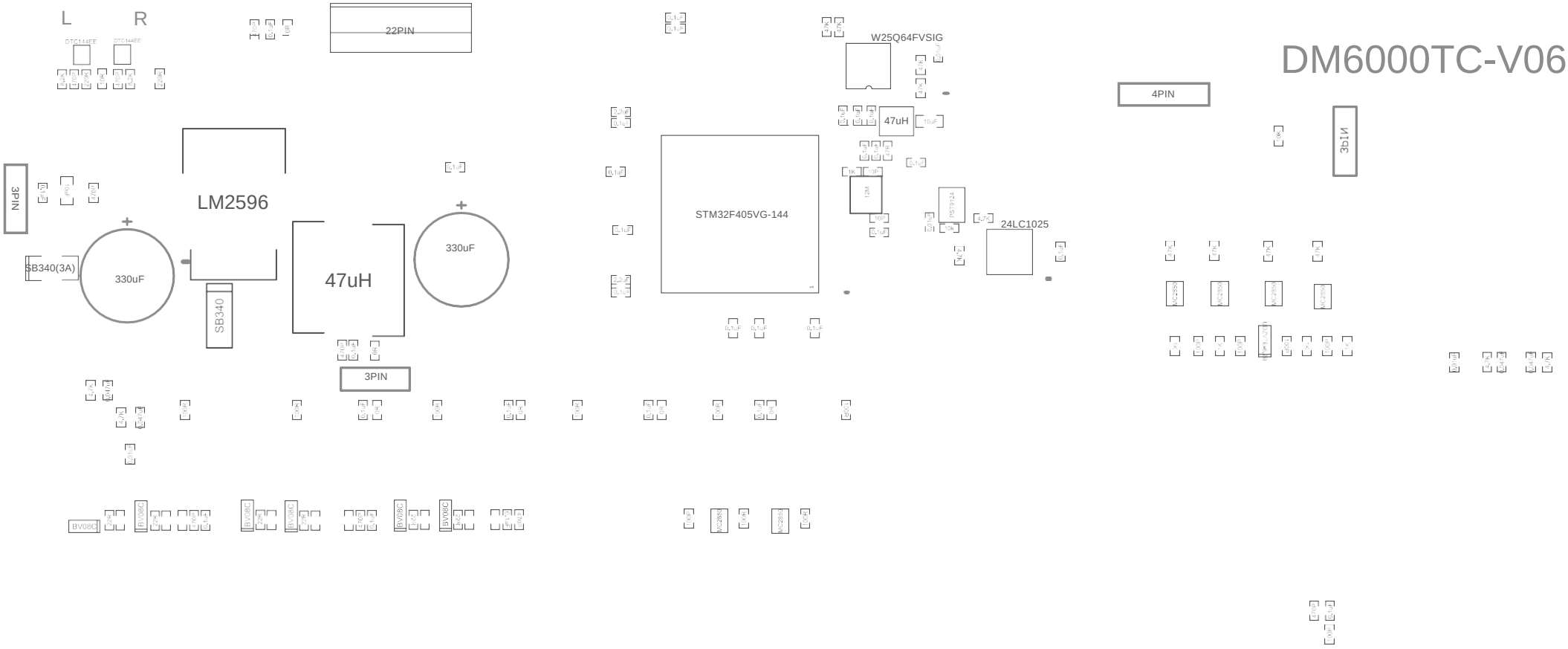
Microprocessor Logic
The microprocessor is reset by the PST9124 when power is first turned on. The clock is generated by a 12 MHz crystal which then gets converted to a 168 MHz signal to power its internal logic. The microprocessor is a STM32F405VG144. It has 1 megabyte of internal flash memory for program storage and 196 Kilobytes of internal ram. Attached to the microprocessor is a 24LC1025 which is a 128 Kilobyte E2PROM memory and a W25Q64FVSIG which is an eight-megabyte flash memory.


J1
J-DC-1
D1
SB340(3A)
JP1
C1
100P
3V3
KG1
D2
MC2850
D3
MC2850
J2
8PIN
R1 100R
R2 100R
C4 1000P
SPK1
SP
D4
MC2850
D5
MC2850
D6
MC2850
D7
MC2850
C8 100P
C9 100P
J4
CON8
R8 1K
R9 1K
R10 1K
R11 1K
C13 100P
C18 100P
D8
UDZVTE-6.2B
C14 0.1uF
C15 470P
C16 100P
D9 OLED
D11 OLED
D13 OLED
D15 OLED
D17 OLED
D18 OLED
R12 100R
R14 100R
R18 100R
R25 100R
R30 100R
R31 100R
JP4
R15 0R
C22 470P
C23 0.1uF
JP2
C7 2.2uF
C11 0.1uF
C10 0.1uF
C12 0.1uF
R3 47K
R4 47K
R5 47K
R6 47K
STM32F405VG-144
C19 0.1uF
C17 2.2uF
C20 0.1uF
C21 0.1uF
C26 0.1uF
C24 0.1uF
C25 0.1uF
R22 10K
JP3
C30 0.1uF
C31 0.1uF
C32 0.1uF
C33 0.1uF
C34 0.1uF
L1 47uH
R33 4.7K
LM2596
IC2
SB340
330uF
470P
R38 4.7K
IC3
PST9124
R40 10k
C49 0.01uF
X1
12M
C48 10P
C47 10P
J3
TC7C
R7 0R
C5 470P
C6 0.1uF
J5
8PIN
R27 0R
R29 0R
R32 0R
R39 0R
KG2
KG3
KG5
C46 0.1uF
R43 10R
D19
D-LED1
DTC144EE
Q3
Q4
R53 8.2K
C63 470P
R51 220R
R52 8.2K
C62 470P
R50 220R
J6
UART2
R19 0R
C66 0.1uF
C67 470P
R41 22R
R42 22R
C58 C59
D22 BV08C
D23 BV08C
J7
USB1
R20 0R
C68 0.1uF
C69 470P
R46 22R
R49 22R
C60 C61
D24 BV08C
D25 BV08C
J8
USB2
R21 0R
C70 0.1uF
C71 470P
R58 22R
R59 22R
C64 C65
D26 BV08C
D27 BV08C
C55 0.01uF
C52 0.047uF
C56 0.047uF
C57 0.01uF
C53 0.047uF
C54 0.047uF
S1
SW-VOL
S2
SW-CHANNEL
R54 4.7K
R55 4.7K
R56 4.7K
R57 4.7K
IC4
24LC1025
C58 0.1uF
IC5
W25Q64F-VSIG
C59 0.01uF
R44 47K
R45 47K
R47 47K
R48 47K
Title
Size A2
Number
Revision
Date: 2018/9/27
Sheet of
File: E:\AD10...\DM6000TC_V0K~(372).SchDoc
Drawn By:


J1
S2
KG
KG
KG
KG
KG
J4
J2
J5
J7
J8
J6


DM6000TC-V06
L
R
J3
IC1
IC2
IC3
IC4
IC5
L1
L2
X1
JP1
JP2
JP3
JP4
D1
D21
D22
D23
D24
D25
D26
D27


DC-005φ2.0-SU
SW-CHANNEL
SPK
OLED
KG
KG
KG
KG
KG
SW-VOL
8PIN
8PIN
8PIN
USB
USB
USB


DM6000TC-V06
L
R
22PIN
3PIN
LM2596
SB340(3A)
330uF
SB340
47uH
330uF
3PIN
W25Q64FVSIG
47uH
STM32F405VG-144
24LC1025
4PIN
3PIN

Overall Theory of Interface Board

This board takes the information from the radio and transfers it to the CS-BFD or CS-BMFD and takes the data from the CS-BFD or CS-BMFD and transfers it to the radio. The radio has an 8 pin mike jack and a 6 pin display jack. The CS-BFD or CS-BMFD has a four pin USB jack to supply power and serial communication.

CS-BFD and CS-BMFD USB Jack

This jack has four pins as follows:
Pin 1: 3.3V
Pin 2: TxD
Pin 3: RxD
Pin 4: Ground
The 3.3V is used to power this interface board. The TxD is serial data from the display board. The RxD is serial data to the display board

Mike Jack

This jack has eight pins as follows:
Pin 1: Power on Switch
Pin 2: Ground
Pin 3: PTT
Pin 4: Mike Audio
Pin 5: Mike Ground
Pin 6: 5 Volts
Pin 7: TxD (Radio to DTMF Mike)
Pin 8: RxD (DTMF Mike to Radio)

The Mike Jack on the Yaesu FT-857 is expecting mike audio from a microphone, PTT information, as well as digital data going back and forth between the microphone and the radio. This digital data is used to tell the radio which keys are pressed and to tell the microphone which LEDS are to be turned on and off.

Display Jack

This jack has six pins as follows:
Pin 1: Speaker Audio
Pin 2: Power on Switch
Pin 3: Ground
Pin 4: 8 Volts
Pin 5: TxD (Radio to Panel)
Pin 6: RxD (Panel to Radio

CPU

The CPU has to perform the following task:
(1) Read data from the display jack and convert it into a format compatible with the CS-BFD and CS-BMFD.
(2) Send digital data to the radio to indicate certain buttons were pressed on the display.
(2) Convert the speaker audio into a digital format and send it to the CS-BMFD. The CS-BFD does not use the speaker audio.
(3) Take the audio in digital format from the CS-BMFD and convert it into analog format and send it to the microphone port of the radio. The CS-BFD does not generate digital audio.
(4) Generate a PTT at the microphone port of the radio. The CS-BFD does not generate a PTT
(5) Turn on the radio by pressing the Power on Switch in the display port of the radio.

UART 0
This is used for sending control information and audio to and from the CS-BFD or CS-BMFD. The CS-BFD does not use the audio. Because there is a single port to the CS-BMFD, the audio and control information are time division multiplexed.

UART 1
This is mostly used for processing display information from the radio and sending button commands to the radio. The level shifter is used to convert the 3 volts from the interface board to the five volts on the radio.

UART 2
This is used for sending keyboard presses to the radio and receiving various commands from the radio. The level shifter is used to convert the 3 volts from the interface board to the five volts on the radio.

D/A
This is used to convert the digital data from the CS-BMFD to voice audio to be sent to microphone jack of the radio. The amplifier has a two pole low pass filter to act as an anti-aliasing filter for the D/A converter. The amplifier converts the audio to a level compatible with the radio. Data is sampled at about 8 KHz.

A/D Audio
This is used to convert the audio from the speaker connection in the display jack to digital data to be sent to the CS-BMFD. The amplifier has a two pole low pass filter to act as an anti-aliasing filter for the A/D converter. The amplifier converts the audio to a level compatible with the A/D converter.

A/D 8V
This is used to monitor the voltage coming from the radio to determine if the radio is turned on or turned off. The 8 volts is converted to five volts through a voltage regulator to act as a reference for the level shifter.

I/O Power on/off
Grounding this points turns the radio on if the radio is off and off if the radio is on.

I/O PTT
Grounding this point is the same as pressing the PTT on the microphone.

CS-BFD AND CS-BMFD TO YAESU FT-857 INTERFACE