Index Labs K7DYY Super Senior Troubleshooting and Maintenance

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Rev 0.3, version 5abc, 2026-June-24

DRAFT

Photo of 80/40M Super Senior AM Transmitter (from http://www.k7dyy.com)

> "*As a member of the amateur radio community I think I am obligated to publish all the technical details of my designs and especially to provide support and encouragement for experimenters who want to use that data*."
> --Bruce Franklin, K7DYY

Introduction

The Index Labs K7DYY Super Senior transmitter series is a popular transmitter among amateur AM'ers due to its small size, light weight, power output and efficiency. Since Index Labs owner and transmitter designer Bruce Franklin K7DYY passed away in February of 2026, support has ended. It is now up to us with technical experience with this transmitter to share knowledge to help folks those using one, and to honor Bruce's good work. There are no repair depots, so it is up to you to repair your faulty transmitter, with the help of this document.

There are two models of the Super Senior that have slight differences: The earlier 160/80 model and the newer 80/40 model introduced a year later; both with small improvements over time, such as more reliable capacitors and increased VFO resolution. The 80/40 model has 1KHz tuning while the earliest 80/160 models have 5KHz tuning. The transmitter accepts line level unbalanced audio at 0dBm with an internal 560-ohm termination resistor. Heed Bruce’s instructions here: http://www.k7dyy.com/p/supersenior-both-models.html

Note: This PDF will be updated once we have further tests and viable substitute RF FETs proven. This document will assist you as an experienced amateur radio operator with electronics knowledge in repairing and maintaining your Index Labs K7DYY Super Senior AM transmitter. This work is a collaboration with Greg Wasik K1YW, Ed Timmons N2FRY, Paul Courson WA3VJB, Janis Carson AB2RA, Rick Maxwell W8KHK, Peter McNulty WA1SOV and myself. These folks provided valuable insight and information. There is no warranty of any kind, and we take no responsibility for further equipment failures, personal injury or death.

Your Role

To repair your transmitter you must have good electronics troubleshooting skills, some switching power supply, audio and RF experience. Also, as this transmitter is a complex assembly that is not built for easy repair, you will need some mechanical dexterity. Finally, personal electrical safety is paramount as you will be dealing with dangerous high voltage. If you are not comfortable in repairing your transmitter, please send it to an experienced repair person.

Transmitter limitations

The Super Senior is a 350-Watt carrier, 1,500w PEP AM transmitter. This means that you can run 350 Watts with 100% modulation; however, I run my transmitters at 240-watts or less as I have experienced positive peak clipping at 350W. If you power on the unit while in transmit mode, the unit will fail (failure mode?).

While there is good SWR protection, it is not perfect and a failure still can occur.

Erratic tuning: The rotary encoder VFO control can become erratic if not used frequently. This can result in large frequency jumps and difficulty in achieving your desired final frequency (remedy??).

Proper Operation

Follow Bruce’s and Janis’s guides. Ensure a low SWR load. Do not overmodulate in the negative direction.

Be SURE the Tune and Transmit buttons are OFF before powering or on or off the transmitter. If they are on when power is applied, failure can occur. Make sure you have a proper RF load before powering on the transmitter.

Protective faults: The transmitter can fault on HI-SWR (at what level reflected power?), negative overmodulation resulting in carrier pinch-off or direct shorts (where?). If a trip has occurred, you will see “HI-SWR” on the LCD display. To recover, power off the transmitter using the front panel breaker/switch. Correct any external issues, then power on the transmitter and transmit in Tune to verify a low SWR, and that your issue was remedied.

If feeding audio from an external active balanced audio processor, Use the + audio and ground to feed the “MIC” input pins 2 and 1 respectively, and terminate the processor’s – audio source in a 600-ohm resistor. If you have audio drive headroom in your external processor, it is good idea to add a resistive pad between the processor and transmitter to limit the audio voltage fed to the transmitter. While there is a filter capacitor at the input connector, wrapping a toroid core around the input cable could help in RFI if you have this issue. I add grounding braid to a screw underneath the RF PA unit, as this helped to cure RFI in one instance.

Operating Recommendations

1. Ensure a low SWR load!
2. Install an SWR meter very close to the transmitter to view reflected power.
3. Test transmit at 50w or less with no audio to verify low SWR.
4. Do not over-modulate.
5. Operate the transmitter at about 240w carrier or less.
6. Do not power up in transmit mode.
7. After your last transmission, wait a minute or more to let the RF heatsink cool off before powering the unit off.

Theory of operation (based on the 8040 Super Senior)

For a comprehensive theory of operation, please refer to Rick Maxwell W8KHK’s *INDEX LABS K7DYY Super Senior Circuit Walkthrough and Analysis* PDF document, available on the Wireless Girl website:
https://wirelessgirl.com/Projects/K7DYY_repair_theory.html.

Here is a simplified walk-through. Refer to Bruce’s schematics available on his website or on the Wireless-Girl website. For each model transmitter there are four JPEG images of the schematics for the: PWM board, Panel board, LPF board, and RF board.

The Super Senior uses a Class D RF amplifier driven by a PLL VFO and modulated by PWM off a direct AC line power supply. The RF power amplifier is floating from ground via input and output transformers (i.e. HOT!), as is the PWM circuitry. These locations have high voltages and are exposed to your AC power line!!

There is a ground referenced 19V DC switching supply that runs the front panel PIC micro-controller, LCD display, Si570 PLL IC, 74HC74-series TTL flip-flop and gate driver ICs.

The AC line power supply provides a floating and filtered unregulated 160VDC that feeds the PWM modulator. The negative output (black) wire that foes to the RF board contains the modulated HV. The red HV wire is common but floating above ground. Both these wires run from the power supply/modulator output to the RF deck.

PWM board

This board is fed from the line switch/circuit breaker, and has the AC line rectifier, HV filter caps, PWM modulator, switching transistors and flywheel diode. Below this board are the PWM filter coils and an AC line feed to the 19V switching supply that is taped to the case.

The power supply is line rectified by D2 and sourced NTC thermistor R1. Filter capacitors C10 and C11 smooth the AC ripple, while R17 is a safety bleeder that takes over a minute to discharge.

The audio with carrier-level DC enters the board at J2 via a mini-coax from the Panel Board. This passes through linear opto-isolator U1, a Renesas/NEC PS8802-1 that also sets the peak limit, then to U2, a TI UCC35702 a PWM regulator IC, which operates at around 75KHz. Unregulated (25v unloaded) power for the PWM IC is supplied from the AC line via D1 and filter caps C8 and C9, and the chip's internal Zener sets the IC's internal operating voltage.

Audio and carrier DC level for modulation, developed across R8 by Optical Coupler output transistor cathode follower, enters at pin 9. HV DC from the unregulated line power supply is attenuated by R4, and a sample enters at pin 6 to cancel AC hum and improve dynamic regulation. A sample of the regulated reference voltage from output pin 12 re-enters at pin 6.

Over-current protection is provided by resistor R15 (0.01-ohm) feeding the PWM IC's current limit input pin 2. If too much carrier or audio is applied and this pin reaches about 200mv, the IC will limit the current. If about 600mv reaches the pin, the IC's output will be muted, turning off the switching transistors.

A quick soft-start is created by capacitor C5 on pin 14. Note the bottom line on the schematic is NOT ground, rather it is common, but at a floating potential.

The output of the PWM IC is a variable duty square wave at around 75KHz that feeds two FET transistors in parallel, Q1 and Q2. The variable duty square wave is filtered to recover the audio component with DC by the PWM filter consisting of L1, L2, C12 and C14. Filter negative overshoots are clamped by D3.

The power supply/modulator output is floating from chassis ground, with the positive rail being solid DC and the negative rail being modulated DC. These outputs feed the RF deck. And the highest available output voltage is about 160VDC, but if the carrier trim-pot is set to 19v, a 100w carrier is created drawing 5A.

Panel Board

The front Panel Board contains all front panel controls (except the AC power breaker), including the audio input circuitry, carrier set trim-pot, PLL VFO, and the PIC micro-controller. Audio and PTT closure enters via the 4-pin CB-style connector J2. R3 sets the carrier level by adjusting a regulated 8V source where this DC passes through Q2 and is added to the mic audio. The audio input is terminated via a 560-ohm resistor R1 and low-pass filtered via R30 and C23. This audio is coupled to Q2 via C4.
The Spot switch reduces the DC level appearing at Q2 and mutes the audio, thus reducing the carrier level.

The SWR latch line from the filter board turns on Q2, shunting the Q, quenching the Q2 collector load resistor, preventing DC and audio from reaching the PWM IC in the PWM board. The PWM IC then sends no pulses to the switching FETs, inhibiting any DC voltage from feeding the RF board.

The PTT line from the front panel jack or an external switch grounds the 3.3v for transmit. This feeds the PIC micro-controller, as well as the T/R relay driver in the filter board.

The RF is generated at four times the transmitter’s operating frequency in U4, a Skyworks Si570 PLL IC, and buffered and divided down to the desired frequency by U5, a 74HC74-series TTL flip-flop. For instance, if you set the VFO to operate on 3.880 MHz, the PLL IC will generate 15.52MHz.

LPF board

This board receives the T/R and band-LPF relay control lines from the Panel Board and contains the harmonic low-pass filters that are selected via the PIC micro-controller on the Panel Board, as well as the Transmit/Receive relay. It also has the SWR detector.

RF output from the RF Board is switched through the 80m or 40m low-pass filters via relays RY1 and RY2. These filters reduce the RF harmonics of the class D amplifier.

For SWR protection, a sample of the reflected RF is taken from T1, diode D2, and capacitor C10. The resulting DC potential is applied to Q2-Q3 transistor pair, connected as a monostable flip-flop. When the danger threshold is reached, both transistors latch into saturation, sending an active-low “High SWR” Latch signal to the PIC controller, and pulling down the audio and carrier DC level feeding the PWM board.

RF board

This board contains the IXDD614 gate driver IC’s, RF power FETs and input and output transformers.

The RF board receives the on-frequency TTL square wave from the Panel Board via a coax cable at J1. This signal feeds Ixys gate driver IC’s U1 and U2 that are designed to drive the high capacitance of the RF FET gate inputs via series tuned circuits and input transformers. These series tuned circuits and transformers feed four sets of FETs in push-pull. The AC level across any Gate to Source is about 35v.

The balanced output from the alternate FETs feed tuned circuits consisting of C7 (40m) or C8-C10 (80m) in parallel with T1 underneath. The unbalanced output feeds twisted line that goes to the filter board.

VERY IMPORTANT SAFETY NOTE:

Parts of this transmitter are directly connected to the AC power line, are floating from ground and contain high voltage. These voltages can KILL YOU, and we take no responsibility for your actions. Please be VERY careful in troubleshooting. If you are not sure of what you are doing, please send your unit to a professional technician for repair.

Since the DYY rig is AC-line operated, use an isolation transformer capable of not less than 6 amps to prevent connection directly to the AC line. A Variac is also helpful. Unplug the power cable and wait for the filter capacitors to drain before making changes to your test setup or attempting repairs.

When using an oscilloscope, as the unit is floating and connected to your power line, use the ‘scope in “differential mode”. Use matched probes feeding the ‘scope inputs channel 1 and 2 (In later Tektronix oscilloscopes, such as the 2445, you can select Add and Invert, and clip both probes to the front panel calibration signal to verify proper subtraction). You now have a good floating differential measuring system and the display will show the voltage between Channels 1 and 2. Do not connect the scope or probe ground leads to any part of the floating power supply, but you can connect to the chassis, which should be grounded for your safety. Consider using 100:1 probes to look at the FET Drains and RF output transformer as there is high DC and RF voltage there. Be sure the probes are rated for the DC and RF voltages encountered.

Warning: Probes are rated for less RF voltage than the DC rating, often decreasing as the frequency goes higher. For example, the popular Tektronix P6105 probe can handle 500v peak at DC but is derated to about 120V at 4MHz and about 105V at 7MHz.

Failures and Remedies

The most common failure is a short in one or more of the output MOSFET RF power transistors on the RF board due to high SWR from an antenna or exceeding the thermal limit of the transistor. The symptom can be the transmitter just stopped transmitting to a catastrophic “pop!” where one or more of the RF transistors explode. Class D RF amplifiers do not handle reflected power well, and Bruce’s SWR protect circuit is not perfect. The main reason for failure is reflected voltage from a high SWR event adding to the 200v operating voltage that exceeds the FET’s breakdown voltage of 400V, or the flyback energy stored in the PWM low-pass filter which could dump voltage into a FET as the filter drains.

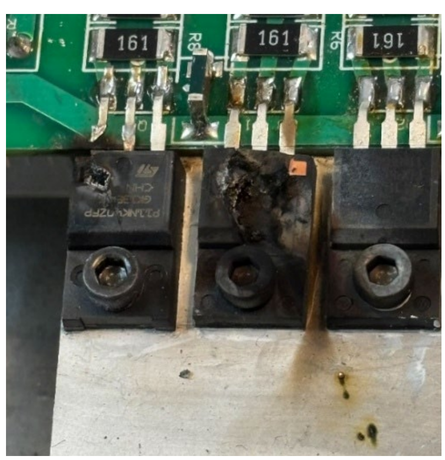

Fig. 1. RF FET’s that had a catastrophic failure

The second common failure is in the modulator, where a failure in the analog audio path, PWM IC or switching transistors can put full power supply rectified DC voltage to the RF deck, destroying one or more RF transistors.

<u>Troubleshooting</u>
Noting your failure symptom, we use the “divide and conquer” method of troubleshooting:

<u>RF Deck Failures</u>

1. When going into transmit, there is no indication of being in transmit in the LCD display, but the T/R relay closes but there is no RF output: Open unit and check visually for damaged transistors at the RF board. With AC power unplugged and the power supply capacitors drained, unsolder the red and black modulated DC wires from the RF board’s HV+ and HV- terminals. Ohm the RF board’s power input terminals; if shorted, one or more of the RF FET’s are shorted. Remove FETS until the short is gone. Replace with the same make and model or replace all the RF FETs with recommended improved models.
2. Check the modulator as well. If one or both of modulator switching transistors are shorted, replace them, also check R15 on the PWM board (0.01-ohms, 1 watt), as it will usually be open. It is a good idea to replace the UCC35702D PWM IC as well as it probably has failed due to over-voltage of the current limit input pin 2.
3. With AC power disconnected and HV DC drained, turn the Carrier trim-pot fully counter-clockwise-you will hear a slight click coming from the trim-pot when you reach the end. Carefully connect a DVM to the free power supply/modulator HV wires and Variac up the unit. Check to see if there is any DC voltage when not in transmit. If full DC voltage exists, there is a fault in the modulator circuit (i.e. shorted switching transistors or bad PWM IC) that passes the full rectified DC to the RF deck. Power off, un-plug the AC power and let the filter capacitors drain. Do not power up the RF deck until this is corrected, as doing so can destroy the RF FETs.
4. If no HV DC voltage exists in receive mode, go into tune mode and check for voltage. If you see some, then go into transmit. Turn the Carrier trim-pot clockwise until you see an increasing DC voltage (the knee will be between 8 and 10 turns in). You should be able to reach about 60V, but in normal operation, you will set between 6V(10W out) and 30V (0ver 200W out). If good, stop transmitting, turn the trim-pot CCW, unplug the AC power, let the supply drain and re-solder the HV wires to the RF deck.

5. When all is repaired, connect a power and SWR meter between the transmitter RF output and a 50-ohm resistive load. Verify the Carrier trim-pot is fully CCW. Power on the transmitter. Hopefully there will be no new component failure. If good, go into Tune and advance the trim-pot some (up to 8-10 turns) to make a few watts of RF. If OK, go into Transmit. If it is still OK, turn the Carrier trim-pot clockwise to your desired power level. Hopefully you will see a carrier and RF power to your load. Test with an audio generator to verify modulation.
6. To check for a shorted RF FET, ohm the center terminal (Drain) of the FET to the HV- terminal of the RF board, or ohm across the HV+ and HV- board inputs. Remove the lead on each FET until the short is removed.

<u>Modulator failures</u>

If you have a nasty RF deck FET short, it can also take out the modulator switching transistors Q1 and/or Q2. If the Drain or Source short to the Gate, it can take out the PWM IC as well, as the output pin would be raised to above the chip's limit of 14V to 160V. Replace Q1, Q2 and U2. Check R15, a 0.01-ohm resistor. If this is open, too much voltage can enter U2's current limit pin 2, destroying the PWM IC. Test with a Variac and the HV to the RF deck HV disconnected. AC primary supply voltage of about 60V from a Variac should power the transmitter.

<u>Possible Retrofits and Ideas</u>

These ideas are hoped to reduce failures and increase transmitter reliability. Some are untested:

1. Add an 8A fuse to the AC input after the inrush limiter (This has been tested to 300w carrier on 80m).
2. Add a 10A fuse at the modulated negative HV that feeds the RF deck. This may save the modulator transistors (This has been tested to 300W carrier, but did not save the modulator during one failure. Good to have though).
3. Add an SWR detect circuit sample jack at the rear of the LPF module. Connect at junction of L6 and C9, which is the top of trim-pot R5 to feed a hi-impedance 'scope. This allows for one to set an external antenna tuner for the lowest SWR (K1YW recommendation, W1DAN tested with a 10k series resistor, which is too high. Suggest 1K).
4. Move the modulated HV wires to outside the LPF module, put in shield braid. This will keep modulated audio from getting into the SWR detect circuit (W1DAN tested, recommended by N2FRY).
5. Add a TVS Transorb to the RF FET drain-source circuits (or primary of T1) to clamp excessive SW voltage to say 400v? Maybe an ST 1.5KE350A/CA? (High capacitance, may need to adjust tank capacities. Not tested yet).

6. Add a 1N914 or similar clamping diode across C13. The current limit is 700mV for chip shutdown. Current limit starts at 200mV and current fault is at 600mV.
7. Possibly clamp the PWM IC's output pin 4 to VDD to protect from shorted switching FETs?? Note R3 and R13 are both connected to pin 4 as the switching transistors are in parallel.
8. If an RF FET has failed, replace all the FETs with upgraded ones that have higher VDS (being researched).
9. Augment the PTT and SWR latch lines to also control the Ixys gate driver IC's enable pins. Add a series FET switch between the modulated HV- and the RF board, also controlled by this logic.

Note: T/R timing measurements are being performed.

Some sample HV voltages and currents

Some stock Super Senior 8040 HV voltage, current and power measurements at 3900KHz. Note my DVM has too much resistance for correct current measurement at high power. Taken with an unmodulated carrier.

POWER	VOLTAGE	CURRENT
10W	6V	1.5A
50W	14V	3.5A
75W	17V	4.4A
100W	19V	5A
150W	23V	6.3

Some stock 8040 Super Senior HV Voltage, Current and Power Measurements at 7290KHz. Note my DVM has too much resistance for correct current measurement. Taken with a carrier.

POWER	VOLTAGE	CURRENT
10W	6V	1.575A
50W	14V	3.5A
75W	17V	4.26A
100W	19.5V	5A
150W	23V	6.4A?
200W	27.6V	?

RF power FET Substitutions:

The Fairchild/Onsemi FQPF11N40C RF FETs are obsolete. You can substitute ST P11NK40ZFP's (we call them "Pink 40's"), which have slightly less power dissipation capability of 30w than the original transistors that could dissipate 44w. Bruce used these in later production runs successfully, and no modifications are needed.

Note that when substituting transistors with a different model that has less output capacity (Coss), Pete WA1SOV notes "*The smaller output capacitance will affect the resonant frequency of the tank circuit. However the Q of the tank is so low that it's effect may be minor but it will influence efficiency*". This means you should adjust the resonant tank circuit inductance to compensate and retain top efficiency.

Make sure that any RF FET you use has the insulated TO220-FP package, as the tab cannot be connected to the heatsink. Alternatively a standard TO-220 part can be used if sil-pads and nylon screws are used for electrical isolation.

<u>Metal tab FQP11N40C FET tests by K1YW</u>
Greg K1YW installed FQP11N40C metal-tab TO220 FETs in his 8040 and used sil-pads and insulating sleeves with success. He believes the heat transfer is more efficient and the power drift has been eliminated.

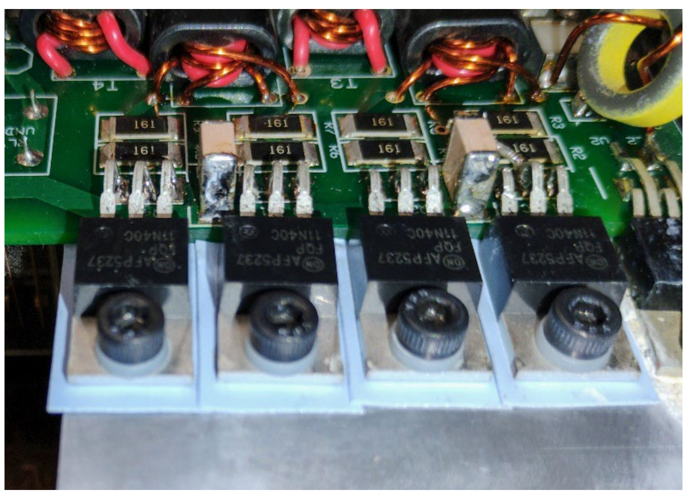

Fig. 2. K1YW's Super Senior 8040 with FQP11N40C transistors

<u>Parts</u>
It is best to purchase spare semiconductors now, before they all become obsolete. Purchase from a reputable vendor such as Mouser or Digi-Key. At minimum, you should have spares for the RF power FETs, PWM driver FETs, PWM IC and resistor R15. I have listed Digi-Key part numbers and costs below.

FQPF11N40C RF MOSFET (obsolete)
Digikey FQPF11N40CFS-ND

FQP11N40C (metal tab TO220, needs sil-pads, tested by K1YW)
DigiKey
FQP11N40CFS-ND
$2.96ea

ST P11NK40ZFP RF MOSFET (tested substitute by K7DYY)
497-12603-5-ND
$3.15ea

UCC35702D Pulse Width Modulator IC
296-11428-5-ND
$9.53ea

FQPF27N25 (Modulator Q1 and Q2)
FQPF27N25FS-ND
$4.35ea

Ixys IXDD614CI FET gate driver IC
212-IXDD614CI-ND
$5.40ea
$41.27 for 10

Ixys IXDD414 FET driver IC (for 80/160 model, obsolete. May be able to substitute the IXDD614?)

Diode D3
FFPF20UP40S (obsolete)
400v 20A
Or STTH12R06 (600V 12A)
497-5407-5-ND
$0.90ea

Possible sub: FFPF20U40STU-FS
2156-FFPF20U40STU-FS-ND
$1.70ea

Opto-isolator U1
Renesas PS8802-1
PS8802-1-F3-AXCT-ND
$4.90ea

R15 (0.01-ohm, 1 watt on PWM board)
Panasonic ERJ-M1WSJ10MU obsolete,
recommend Bourns CRF2512-FZ-R010ELF:
Digikey CRF2512-FZ-R010ELFCT-ND
$0.49ea

LCD Display
Newhaven NHD-0108CZ-FSW-GBW-33V3
Digikey part NHD-0108CZ-FSW-GBW-33V3-ND
$.6.18ea

Front panel breaker
TE Connectivity/Potter and Brumfield W51-A122B1-7
7A 250V
PB654-ND
$7.84 ea.

Cooling Fans
Everflow R126010DM A
12vdc 0.16A, 60x60x10mm
Possible Sub: Orion OD6010-12HB01A.
RS Components, Amazon or eBay. Cut off yellow sense wire.

References
http://www.k7dyy.com/index.html
http://www.k7dyy.com/p/supersenior-both-models.html
https://wireless-girl.com/Projects/AMTransmitters/K7DYYtransmitter.html
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MOSFET Design Notes
https://www.rohm.com/products/mosfets/high-voltage/nch-800v-super-junction/r8019knx-product#technicalAricleSubMenu
https://www.onsemi.com/pub/Collateral/AN-9010.pdf

https://community.onsemi.com/s/article/Brief-Guide-to-Power-MOSFET-Failure-Mechanisms
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http://www3.nautel.com/pub/Post%20NAB%202023/Design%20Considerations%20%20for%20AM%20Transmitters.pdf
https://www.electronicdesign.com/technologies/power/article/21795492/the-spirito-effect-improved-my-designand-i-didnt-even-know-it
https://www.st.com/resource/en/application_note/an2344-power-mosfet-avalanche-characteristics-and-ratings-stmicroelectronics.pdf

Data Sheets
ST P11NK40ZFP: https://www.st.com/en/power-transistors/stp11nk40zfp.html
ST FQP11N40 (metal tab): https://rocelec.widen.net/view/pdf/skfcwnbrpe/FAIRS18961-1.pdf?t.download=true&u=5oefqw
Onsemi FQPF27N25FS: https://www.onsemi.com/pdf/datasheet/fqpf27n25-d.pdf
Ixys IXDD614CI: https://www.littelfuse.com/products/power-semiconductors-control-ics/gate-drivers/gate-driver-ics/igbt-mosfet-driver-ics/low-side-drivers/ixd-614
TI UCC35702D: https://www.ti.com/product/UCC35702
74HC74: https://www.ti.com/product/SN74HC74
PIC16F872: https://ww1.microchip.com/downloads/en/DeviceDoc/30221c.pdf
Si570: https://www.skyworksinc.com/-/media/SkyWorks/SL/documents/public/data-sheets/Si570-71.pdf
LCD display: https://newhavendisplay.com/content/specs/NHD-0108CZ-FSW-GBW-33V3.pdf

Troubleshooting guidance available via email:
Greg Wasik K1YW
Ed Timmons N2FRY
Janis Carson AB2RA
Rick Maxwell W8KHK
Dan Brown W1DAN

Folks who may be able to repair your Super Senior:
Kevin Pease WB0JZG
Ed Timmons N2FRY

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