MOTOROLA

Professional Radio

GM Series

Controlhead

Service Information

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OVERVIEW

1.0 GM140/GM340/GM640 Models (GCN6112_)

The Controlhead contains the internal speaker, the on/off/volume knob, the microphone connector, several buttons to operate the radio and several indicator Light Emitting Diodes (LED) to inform the user about the radio status. To control the LED's and to communicate with the host radio the control head uses the Motorola 68HC11E9 microprocessor.

2.0 GM160/GM360/GM660 Models (GCN6114-GM160 / GCN6120-GM360/660)

The Controlhead contains the internal speaker, the on/off/volume knob, the microphone connector, several buttons to operate the radio, several indicator Light Emitting Diodes (LED) to inform the user about the radio status, and a 14 character Liquid Crystal Display (LCD) for alpha - numerical information e.g. channel number or call address name. To control the LED's and the LCD, and to communicate with the host radio the control head uses the Motorola 68HC11E9 microprocessor

3.0 GM380/GM1280 Models (GCN6121_)

The Controlhead contains the on/off/volume knob, the microphone connector, several buttons to operate the radio, several indicator Light Emitting Diodes (LED) to inform the user about the radio status, and a Liquid Crystal Display (LCD) with 21 pre - defined symbols and a 32*96 dot matrix for graphical or alpha - numerical information e.g. channel number, select code, call address name. To control the LED's and the LCD, and to communicate with the host radio the control head uses the Motorola 68HC11K4 microprocessor.

Chapter 2

THEORY OF OPERATION

1.0 Introduction

This Chapter provides a detailed theory of operation for the Controlhead circuits. For details of the trouble shooting refer to the related Section of this manual.

2.0 Controlhead Model for GM140, GM340 and GM640

The controlhead contains the internal speaker, the on/off/volume knob, the microphone connector, several buttons to operate the radio and several indicator Light Emitting Diodes (LED) to inform the user about the radio status. To control the LED's and to communicate with the host radio the controlhead uses the Motorola 68HC11E9 microprocessor.

2.1 Power Supplies

The power supply to the controlhead is taken from the host radio's FLT A+ voltage via connector J0801 pin 3 and the regulated +5V via connector J0801 pin 7. The voltage FLT A+ is at supply voltage level and is used for the LED's, the back light and to power up the radio via on / off / volume knob. The stabilized +5 volt is used for the microprocessor and the keypad buttons. The voltage USW 5V derived from the FLT A+ voltage and stabilized by the series combination of R0822, VR0822 is used to buffer the internal RAM of the microprocessor (U0831). C0822 allows the supply voltage level to be disconnected for a couple of seconds without losing RAM parameters. Dual diode D0822 prevents radio circuitry from discharging this capacitor. When the supply voltage is applied to the radio, C0822 is charged via R0822 and D0822. To avoid, that the µP enters the wrong mode when the radio is switched on while the voltage across C0822 is still too low, the regulated 5V charge C0822 via diode D0822.

2.2 Power On / Off

The On/Off/Volume knob when pressed switches the radio's voltage regulators on by connecting line ON OFF CONTROL to line UNSW 5V via D0821. Additionally, 5 volts at the base of digital transistor Q0822 informs the controlhead's microprocessor about the pressed knob. The microprocessor asserts pin 62 and line CH REQUEST low to hold line ON OFF CONTROL at 5 volts via Q0823 and D0821. The high line ON OFF CONTROL also informs the host radio, that the controlhead's microprocessor wants to send data via SBEP bus. When the radio returns a data request message, the microprocessor will inform the radio about the pressed knob. If the radio was switched off, the radio's µP will switch it on and vice versa. If the On/Off/Volume knob is pressed while the radio is on, the software detects a low state on line ON OFF SENSE, the radio is alerted via line ON OFF CONTROL and sends a data request message. The controlhead µP will inform the radio about the pressed knob and the radio's µP will switch the radio off.

2.3 Microprocessor Circuit

The controlhead uses the Motorola 68HC11E9 microprocessor (µP) (U0831) to control the LED's and to communicate with the host radio. RAM and ROM are contained within the microprocessor itself.

The microprocessor generates it's clock using the oscillator inside the microprocessor along with a 8 MHz ceramic resonator (U0833) and R0920.

The microprocessor's RAM is always powered to maintain parameters such as the last operating mode. This is achieved by maintaining 5V at µP pin 25. Under normal conditions, when the radio is off, USW 5V is formed by FLT A+ running to D0822. C0822 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Diode D0822 prevents radio circuitry from discharging this capacitor.

There are 8 analogue to digital converter ports (A/D) on the µP . They are labeled within the device block as PE0-PE7. These lines sense the voltage level ranging from 0 to 5V of the input line and convert that level to a number ranging from 0 to 255 which can be read by the software to take appropriate action.

Pin VRH is the high reference voltage for the A/D ports on the µP . If this voltage is lower than +5V the A/D readings will be incorrect. Likewise pin VRL is the low reference for the A/D ports. This line is normally tied to ground. If this line is not connected to ground, the A/D readings will be incorrect.

The microprocessor can determine the used keypad type and the controlhead ID by reading the levels at ports PC0 – PC7. Connections JU0852/3/4 are provided by the individual keypads.

The MODB / MODA input of the µP must be at a logic „1" for it to start executing correctly. The XIRQ and the IRQ pins should also be at a logic „1".

Voltage sense device U0832 provides a reset output that goes to 0 volts if the regulated 5 volts goes below 4.5 volts. This is used to reset the controller to prevent improper operation.

2.4 SBEP Serial Interface

The host radio (master) communicates to the controlhead µP (slave) through its SBEP bus. This bus uses only line BUS+ for data transfer. The line is bi-directional meaning that either the radio or the controlhead µP can drive the line. The microprocessor sends serial data via pin 50 and D0831 and it reads serial data via pin 47. Whenever the microprocessor detects activity on the BUS+ line, it starts communication.

When the host radio needs to communicate to the controlhead µP , it sends data via line BUS+. Any transition on this line generates an interrupt and the µP starts communication. The host radio may send data like LED and back light status or it may request the controlhead ID or the keypad ID.

When the controlhead µP wants to communicate to the host radio, the µP brings request line CH REQUEST to a logic „0" via µP pin 62. This switches on Q0823, which pulls line ON OFF CONTROL high through diode D0821. A low to high transition on this line informs the radio, that the controlhead requires service. The host radio then sends a data request message via BUS+ and the controlhead µP replies with the data it wanted to send. This data can be information like which key has been pressed or that the volume knob has been rotated.

The controlhead µP monitors all messages sent via BUS+, but ignores any data communication between host radio and CPS or Universal Tuner.

2.5 Keypad Keys

The controlhead keypad is a 6 - key keypad. All keys are configured as 2 analogue lines read by µP pins 13 and 15 . The voltage on the analogue lines varies between 0 volts and +5 volts depending on which key has been pressed. If no key is pressed, the voltage at both lines will be 5 volts. The key configuration can be thought of as a matrix, where the two lines represent one row and one column. Each line is connected to a resistive divider powered by +5 volts. If a button is pressed, it will connect one specific resistor of each divider line to ground level and thereby reduce the voltages on the analogue lines The voltages of the lines are A/D converted inside the µP (ports PE 0 - 1) and specify the pressed button. To determine which key is pressed, the voltage of both lines must be considered.

An additional pair of analogue lines and A/D µP ports (PE 3 – 2) is available to support a keypad microphone, connected to the microphone connector J0811. Any microphone key press is processed the same way as a key press on the controlhead.

2.6 Status LED and Back Light Circuit

All indicator LED's (red, yellow, green) are driven by current sources. To change the LED status the host radio sends a data message via SBEP bus to the controlhead µP . The controlhead µP determines the LED status from the received message and switches the LED's on or off via port PB 7 – 0 and port PA4. The LED status is stored in the µP 's memory. The LED current is determined by the resistor at the emitter of the respective current source transistor.

The back light for the keypad is controlled by the host radio the same way as the indicator LED's using µP port PA 5. The µP can switch the back light on and off under software control. The keypad back light current is drawn from the FLT A+ source and controlled by 2 current sources. The LED current is determined by the resistor at the emitter of the respective current source transistor.

2.7 Microphone Connector Signals

Signals BUS+, PTT IRDEC, HOOK, MIC, HANDSET AUDIO, FLT A+, +5V and 2 A/D converter inputs are available at the microphone connector J0811. Signal BUS+ (J0811-7) connects to the SBEP bus for communication with the CPS or the Universal Tuner. Line MIC (J0811-5) feeds the audio from the microphone to the radio's controller via connector J0801-4. Line HANDSET AUDIO (J0811-8) feeds the receiver audio from the controller (J0801-6) to a connected handset. FLT A+, which is at supply voltage level, and +5V are used to supply any connected accessory like a microphone or a handset.

The 2 A/D converter inputs (J0811-9/10) are used for a microphone with keypad. A pressed key will change the dc voltage on both lines. The voltages depend on which key is pressed. The µP determines from the voltage on these lines which key is pressed and sends the information to the host radio.

Line PTT IRDEC (J0811-6) is used to key up the radio's transmitter. While the PTT button on a connected microphone is released, line PTT IRDEC is pulled to +5 volts level by R0843. Transistor Q0843 is switched on and causes a low at µP port PA2. When the PTT button is pressed, signal PTT IRDEC is pulled to ground level. This switches off Q0843 and the resulting high level at µP port PA2 informs the µP about the pressed PTT button. The µP will inform the host radio about any status change on the PTT IRDEC line via SBEP bus.

When line PTT IRDEC is connected to FLT A+ level, transistor Q0821 is switched on through diode VR0821 and thereby pulls the level on line ON OFF CONTROL to FLT A+ level. This switches on the radio and puts the radio's µP in bootstrap mode. Bootstrap mode is used to load the firmware into the radio's flash memory (See controller subsection for more details).

The HOOK input (J0811-3) is used to inform the µP when the microphone´s hang-up switch is engaged. Dependent on the CPS programming the µP may take actions like turning the audio PA on or off. While the hang up switch is open, line HOOK is pulled to +5 volts level by R0841. Transistor Q0841 is switched on and causes a low at µP port PA1. When the HOOK switch is closed, signal HOOK is pulled to ground level. This switches off R0841and the resulting high level at µP port PA1 informs the µP about the closed hang up switch. The µP will inform the host radio about any status change on the HOOK line via SBEP bus.

2.8 Speaker

The controlhead contains a speaker for the receiver audio. The receiver audio signal from the differential audio output of the audio amplifier located on the radio's controller is fed via connector J0801-10, 11 to the speaker connector P0801 pin 1 and pin 2. The speaker is connected to the speaker connector P0801. The controlhead speaker can be disconnected if an external speaker, connected on the accessory connector, is used.

2.9 Electrostatic Transient Protection

Electrostatic transient protection is provided for the sensitive components in the controlhead by diodes VR0811 VR00812 VR0816 - VR0817. The diodes limit any transient voltages to tolerable levels. The associated capacitors provide Radio Frequency Interference (RFI) protection.

3.0 Controlhead Model for GM160, GM360 and GM660

The controlhead contains the internal speaker, the on/off/volume knob, the microphone connector, several buttons to operate the radio, several indicator Light Emitting Diodes (LED) to inform the user about the radio status, and a 14 character Liquid Crystal Display (LCD) for alpha - numerical information e.g. channel number or call address name. To control the LED's and the LCD, and to communicate with the host radio the controlhead uses the Motorola 68HC11E9 microprocessor.

3.1 Power Supplies

The power supply to the controlhead is taken from the host radio's FLT A+ voltage via connector J0801 pin 3 and the regulated +5V via connector J0801 pin 7. The voltage FLT A+ is at battery level and is used for the LED's, the back light and to power up the radio via on / off / volume knob. The stabilized +5 volt is used for the microprocessor, the display, the display driver and the keypad buttons. The voltage USW 5V derived from the FLT A+ voltage and stabilized by the series combination of R0822, VR0822 is used to buffer the internal RAM of the microprocessor (U0831). C0822 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Dual diode D0822 prevents radio circuitry from discharging this capacitor. When the supply voltage is applied to the radio, C0822 is charged via R0822 and D0822. To avoid that the µP enters the wrong mode when the radio is switched on while the voltage across C0822 is still too low, the regulated 5V charge C0822 via diode D0822.

3.2 Power On / Off

The On/Off/Volume knob when pressed switches the radio's voltage regulators on by connecting line ON OFF CONTROL to line UNSW 5V via D0821. Additionally, 5 volts at the base of digital transistor Q0822 informs the controlhead's microprocessor about the pressed knob. The microprocessor asserts pin 62 and line CH REQUEST low to hold line ON OFF CONTROL at 5 volts via Q0823 and D0821. The high line ON OFF CONTROL also informs the host radio, that the controlhead's microprocessor wants to send data via SBEP bus. When the radio returns a data request message, the microprocessor will inform the radio about the pressed knob. If the radio was switched off, the radio's µP will switch it on and vice versa. If the On/Off/Volume knob is pressed while the radio is on, the software detects a low state on line ON OFF SENSE, the radio is alerted via line ON OFF CONTROL and sends a data request message. The controlhead µP will inform the radio about the pressed knob and the radio's µP will switch the radio off.

3.3 Microprocessor Circuit

The controlhead uses the Motorola 68HC11E9 microprocessor (µP) (U0831) to control the LED's and the LCD and to communicate with the host radio. RAM and ROM are contained within the microprocessor itself.

The microprocessor generates it's clock using the oscillator inside the microprocessor along with a 8 MHz ceramic resonator (U0833) and R0920 .

The microprocessor's RAM is always powered to maintain parameters such as the last operating mode. This is achieved by maintaining 5V at µP pin 25 . Under normal conditions, when the radio is off, USW 5V is formed by FLT A+ running to D0822. C0822 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Diode D0822 prevents radio circuitry from discharging this capacitor.

There are 8 analogue to digital converter ports (A/D) on the µP . They are labeled within the device block as PE0-PE7. These lines sense the voltage level ranging from 0 to 5V of the input line and convert that level to a number ranging from 0 to 255 which can be read by the software to take appropriate action.

Pin VRH is the high reference voltage for the A/D ports on the µP . If this voltage is lower than +5V the A/D readings will be incorrect. Likewise pin VRL is the low reference for the A/D ports. This line is normally tied to ground. If this line is not connected to ground, the A/D readings will be incorrect.

The microprocessor can determine the used keypad type and the controlhead ID by reading the levels at ports PC0 – PC7. Connections JU0852/3/4 are provided by the individual keypads.

The MODB / MODA input of the µP must be at a logic „1" for it to start executing correctly. The XIRQ and the IRQ pins should also be at a logic „1".

Voltage sense device U0832 provides a reset output that goes to 0 volts if the regulated 5 volts goes below 4.5 volts. This is used to reset the controller to prevent improper operation.

3.4 SBEP Serial Interface

The host radio (master) communicates to the controlhead µP (slave) through its SBEP bus. This bus uses only line BUS+ for data transfer. The line is bi-directional, meaning that either the radio or the controlhead µP can drive the line. The microprocessor sends serial data via pin 50 and D0831 and it reads serial data via pin 47. Whenever the microprocessor detects activity on the BUS+ line, it starts communication.

When the host radio needs to communicate to the controlhead µP , it sends data via line BUS+. Any transition on this line generates an interrupt and the µP starts communication. The host radio may send data like display information, LED and back light status or it may request the controlhead ID or the keypad ID.

When the controlhead µP wants to communicate to the host radio, the µP brings request line CH REQUEST to a logic „0" via µP pin 62. This switches on Q0823, which pulls line ON OFF CONTROL high through diode D0821. A low to high transition on this line informs the radio, that the controlhead requires service. The host radio then sends a data request message via BUS+ and the controlhead µP replies with the data it wanted to send. This data can be information like which key has been pressed or that the volume knob has been rotated.

The controlhead µP monitors all messages sent via BUS+, but ignores any data communication between host radio and CPS or Universal Tuner.

3.5 Keypad Keys

The controlhead keypad is a 6-key kepad (Model B) or a 10- key keypad (model C). All keys are configured as 2 analogue lines read by µP pins 13 and 15. The voltage on the analogue lines varies between 0 volts and +5 volts depending on which key has been pressed. If no key is pressed, the voltage at both lines will be 5 volts. The key configuration can be thought of as a matrix, where the two lines represent one row and one column. Each line is connected to a resistive divider powered by +5 volts. If a button is pressed, it will connect one specific resistor of each divider line to ground level and thereby reduce the voltages on the analogue lines The voltages of the lines are A/D converted inside the µP (ports PE 0 - 1) and specify the pressed button. To determine which key is pressed, the voltage of both lines must be considered.

An additional pair of analogue lines and A/D µP ports (PE 3 – 2) is available to support a keypad microphone, connected to the microphone connector J0811. Any microphone key press is processed the same way as a key press on the controlhead.

3.6 Status LED and Back Light Circuit

All the indicator LED's (red, yellow, green) are driven by current sources. To change the LED status the host radio sends a data message via SBEP bus to the controlhead µP . The controlhead µP determines the LED status from the received message and switches the LED's on or off via port PB 7 – 0 and port PA4. The LED status is stored in the µP 's memory. The LED current is determined by the resistor at the emitter of the respective current source transistor.

The back light for the LCD and the keypad is controlled by the host radio the same way as the indicator LED's using µP port PA 5. This port is a Pulse Width Modulator (PWM) output. The output signal charges capacitor C0843 through R0847. By changing the pulse width under software control, the dc voltage of C0843 and thereby, the brightness of the back light can be changed in four steps. The keypad back light current is drawn from the FLT A+ source and controlled by transistor Q0933. The current flowing through the LED's cause a proportional voltage drop across the parallel resistors R0947, R0948. This voltage drop is amplified by the op-amp U0931-2. U0931-2 and Q0934 form a differential amplifier. The voltage difference between the base of Q0934 and the output of U0931-2 determines the current from the base of the LED control transistor Q0933 and in turn the brightness of the LED's. The µP can control the LED's by changing the dc level at the base of Q0934. If the base of Q0934 is at ground level, Q0934 is switched off and no current flows through Q0933 and the LED's. If the base voltage of Q0934 rises a current flows through Q0934 and in turn through Q0933 causing the LED's to turn on and a rising voltage drop across R0947, R0948. The rising voltage causes the output of the op-amp to rise and to reduce the base to emitter voltage of Q0934. This decreases the current of Q0933 until the loop has settled.

3.7 Liquid Crystal Display (LCD)

The LCD H0971 uses the display driver U0971. The display is a single layer super twist nematic (STN) LCD display. It has 14 characters with a 5*8 dot matrix for displaying alpha - numerical information and a line with 21 pre - defined icons above the dot matrix

The driver contains a data interface to the µP, an LCD segment driver, an LCD power circuit, an oscillator, data RAM and control logic. At power up the driver's control logic is reset by a logic „0" at input SR2 (U0971-15). The driver's internal oscillator is set to about 20 kHz and can be measured at pin 22. The driver's µP interface is configured to accept 8 bit parallel data input (U0971-D0-D7) from the controlhead µP (U0831 port PC0-PC7).

To write data to the driver's RAM the µP sets chip select (U0971-20) to logic „0" via U0831-11, RD (U0971-18) to logic „1" via (U0831-10) and WR (U0971-17) to logic „0" via U0831-9. With input A0 (U0971-21) set to logic „0" via U0831-12 the µP writes control data to the driver. Control data

includes the RAM start address for the following display data. With input A0 set to logic „1" the µP then writes the display data to the display RAM. When data transfer is complete the µP terminates the chip select, RD and WD activities.

The display driver's power circuit provides the voltage supply for the display. This circuit consists of a voltage multiplier, voltage regulator and a voltage follower. The external capacitors C0971 - C0973 configure the multiplier to double the supply voltage. In this configuration the multiplier output VOUT (U0971-8) supplies a voltage of -5V (2* -5V below VDD). The multiplied voltage VOUT is sent to the internal voltage regulator. To set the voltage level of the regulator output V5 (U0971-5) this voltage is divided by the resistors R0973 and R0974 and fed back to the reference input VR (U0971-6). In addition the regulator output voltage V5 can be controlled electronically by a control command sent to the driver. With the used configuration the voltage V5 is about –2V. The voltage V5 is resistively divided by the driver's voltage follower to provide the voltages V1 - V4. These voltages are needed for driving the liquid crystals. The level of V5 can be measured by one of the µP's analogue to digital converters (U0831-20) via resistive divider R0975, R0976. To stabilize the display brightness over a large temperature range the µP measures the temperature via analogue to digital converter (U0831-18) using temperature sensor U0834. Dependent on the measured temperature the µP adjusts the driver output voltage V5, and in turn the display brightness, via parallel interface.

3.8 Microphone Connector Signals

Signals BUS+, PTT IRDEC, HOOK, MIC, HANDSET AUDIO, FLT A+, +5V and 2 A/D converter inputs are available at the microphone connector J0811. Signal BUS+ (J0811-7) connects to the SBEP bus for communication with the CPS or the Universal Tuner. Line MIC (J0811-5) feeds the audio from the microphone to the radio's controller via connector J0801-4. Line HANDSET AUDIO (J0811-8) feeds the receiver audio from the controller (J0801-6) to a connected handset. FLT A+, which is at supply voltage level, and +5V are used to supply any connected accessory like a microphone or a handset.

The 2 A/D converter inputs (J0811-9/10) are used for a microphone with keypad. A pressed key will change the dc voltage on both lines. The voltages depend on which key is pressed. The µP determines from the voltage on these lines which key is pressed and sends the information to the host radio.

Line PTT IRDEC (J0811-6) is used to key up the radio's transmitter. While the PTT button on a connected microphone is released, line PTT IRDEC is pulled to +5 volts level by R0843. Transistor Q0843 is switched on and causes a low at µP port PA2. When the PTT button is pressed, signal PTT IRDEC is pulled to ground level. This switches off Q0843 and the resulting high level at µP port PA2 informs the µP about the pressed PTT button. The µP will inform the host radio about any status change on the PTT IRDEC line via SBEP bus.

When line PTT IRDEC is connected to FLT A+ level, transistor Q0821 is switched on through diode VR0821 and thereby pulls the level on line ON OFF CONTROL to FLT A+ level. This switches on the radio and puts the radio's µP in bootstrap mode. Bootstrap mode is used to load the firmware into the radio's flash memory (See controller sub section for more details).

The HOOK input (J0811-3) is used to inform the µP when the microphone´s hang-up switch is engaged. Dependent on the CPS programming the µP may take actions like turning the audio PA on or off. While the hang up switch is open, line HOOK is pulled to +5 volts level by R0841. Transistor Q0841 is switched on and causes a low at µP port PA1. When the HOOK switch is closed, signal HOOK is pulled to ground level. This switches off R0841 and the resulting high level at µP port PA1 informs the µP about the closed hang up switch. The µP will inform the host radio about any status change on the HOOK line via SBEP bus.

3.9 Speaker

The controlhead contains a speaker for the receiver audio. The receiver audio signal from the differential audio output of the audio amplifier located on the radio's controller is fed via connector J0801-10, 11 to the speaker connector P0801 pin 1 and pin 2. The speaker is connected to the speaker connector P0801. The controlhead speaker can be disconnected if an external speaker, connected on the accessory connector, is used.

3.10 Electrostatic Transient Protection

Electrostatic transient protection is provided for the sensitive components in the controlhead by diodes VR0811 VR00812 VR0816 - VR0817. The diodes limit any transient voltages to tolerable levels. The associated capacitors provide Radio Frequency Interference (RFI) protection.

4.0 Controlhead Model for GM380, and GM1280

The controlhead contains the on/off/volume knob, the microphone connector, several buttons to operate the radio, several indicator Light Emitting Diodes (LED) to inform the user about the radio status, and a Liquid Crystal Display (LCD) with 21 pre - defined symbols and a 32*96 dot matrix for graphical or alpha - numerical information e.g. channel number, select code, call address name. To control the LED's and the LCD, and to communicate with the host radio the controlhead uses the Motorola 68HC11K4 microprocessor.

4.1 Power Supplies

The power supply to the controlhead is taken from the host radio's FLT A+ voltage via connector J0801 pin 3. The voltage FLT A+ is at battery level and is used for the LED's, the back light, to power up the radio via on / off / volume knob and to supply the voltage regulator circuitry. The regulator circuitry provides the stabilized +5 volts which is used for the microprocessor circuitry, the display, the display driver and the keypad buttons. The regulated +5V taken from the host radio via connector J0801 pin 7 (line 5V SOURCE) is only used to switch on or off the voltage regulator in the control-head.

4.2 Voltage Regulator Circuit

Voltage regulator U0861provides 5V for the controlhead. The supply voltage FLT A+ for the voltage regulator is fed via parallel resistors R0861/2 and dual diode D0861 to pin 8 of U0861. The +5 volt output is switched on and off by the host radios's 5 volt source via line 5V SOURCE and control transistor Q0866. When the host radio is switched off the voltage on line +5V SOURCE is at ground level and switches off transistor Q0866. Pull up resistor R0863 pulls input SHUTDOWN (pin 3) of the voltage regulator U0861 to FLT A+ level and switches off the output of U0861 (pin 1). When the host radio is switched on the voltage on line 5V SOURCE of about +5 volts switches on transistor Q0866 which in turn pulls input SHUTDOWN (pin 3) to ground and switches on the output of U0861. Input and output capacitors (C0861 / C0862 and C0864 / C0865) are used to reduce high frequency noise and provide proper operation during battery transients. Diode D0861 prevents discharge of C0862 by negative spikes on the FLT A+ voltage. This regulator provides a reset output (pin 5) that goes to 0 volts if the regulator output goes out of regulation. This is used to reset the microprocessor (U0871) and the display driver (J0821-5) to prevent improper operation.

The voltage USW 5V derived from voltage FLT A+ is stabilized using resistor R0855 and diode VR0855 This voltage is used to buffer the microprocessor's internal RAM. C0856 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Diode D0855

prevents radio circuitry from discharging this capacitor. The +5V at the second anode of D0855 speeds up charging of C0856, when the host radio is turned on by a high level at the ignition input while the supply voltage is applied to the radio. This prevents the microprocessor from accidently entering bootstrap mode.

4.3 Power On / Off

The On/Off/Volume knob when pressed switches the radio's and the controlhead's voltage regulators on by connecting line ON OFF CONTROL to line UNSW 5V via D0852. Additionally, 5 volts at the base of digital transistor Q0853 informs the controlhead's microprocessor about the pressed knob. The microprocessor asserts pin 8 and line CH REQUEST low to hold line ON OFF CONTROL at 5 volts via Q0852 and D0852. The high line ON OFF CONTROL also informs the host radio, that the controlhead's microprocessor wants to send data via SBEP bus. When the radio returns a data request message, the microprocessor will inform the radio about the pressed knob. If the radio was switched off, the radio's µP will switch it on and vice versa. If the On/Off/Volume knob is pressed while the radio is on, the software detects a low state on line ON OFF SENSE, the radio is alerted via line ON OFF CONTROL and sends a data request message. The controlhead µP will inform the radio about the pressed knob and the radio's µP will switch the radio off. If the radio is switched on either manually or automatically it's +5V source switches on the controlhead's voltage regulator U0861 via line 5 SOURCE and transistor Q0866 and the controlhead's microprocessor starts execution.

4.4 Microprocessor Circuit

The controlheadcontrolhead uses the Motorola 68HC11K4 microprocessor (uP) (U0871) to control the LED's and the LCD and to communicate with the host radio. RAM and ROM are contained within the microprocessor itself.

The microprocessor generates it's clock using the oscillator inside the microprocessor along with a 8 MHz ceramic resonator (U0873) and R0873.

The microprocessor's RAM is always powered to maintain parameters such as the last operating mode. This is achieved by maintaining 5V at µP pin 76. Under normal conditions, when the radio is off, USW 5V is formed by FLT A+ running to D0855. C0856 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Diode D0855 prevents radio circuitry from discharging this capacitor.

There are 8 analogue to digital converter ports (A/D) on the µP. They are labeled within the device block as PE0-PE7. These lines sense the voltage level ranging from 0 to 5V of the input line and convert that level to a number ranging from 0 to 255 which can be read by the software to take appropriate action.

Pin VRH is the high reference voltage for the A/D ports on the µP. If this voltage is lower than +5V the A/D readings will be incorrect. Likewise pin VRL is the low reference for the A/D ports. This line is normally tied to ground. If this line is not connected to ground, the A/D readings will be incorrect.

The microprocessor can determine the used keypad type by reading the level at port PE5. Connections S0931 – S0935 are provided by the individual keypads.

The MODB / MODA input of the µP must be at a logic „1" for it to start executing correctly. The XIRQ and the IRQ pins should also be at a logic „1".

4.5 SBEP Serial Interface

The host radio (master) communicates to the controlhead µP (slave) through its SBEP bus. This bus uses only line BUS+ for data transfer. The line is bi-directional, meaning that either the radio or the

controlhead µP can drive the line. The microprocessor sends serial data via pin 79 and D0872 and it reads serial data via pin 78. Whenever the microprocessor detects activity on the BUS+ line, it starts communication.

When the host radio needs to communicate to the controlhead µP, it sends data via line BUS+. Any transition on this line generates an interrupt and the µP starts communication. The host radio may send data like display information, LED and back light status or it may request the controlheadcontrolhead ID or the keypad ID.

When the controlhead µP wants to communicate to the host radio, the µP brings request line CH REQUEST to a logic „0" via µP pin 8. This switches on Q0852, which pulls line ON OFF CONTROL high through diode D0852. A low to high transition on this line informs the radio, that the controlhead requires service. The host radio then sends a data request message via BUS+ and the controlhead µP replies with the data it wanted to send. This data can be information like which key has been pressed or that the volume knob has been rotated.

The controlhead µP monitors all messages sent via BUS+, but ignores any data communication between host radio and CPS or Universal Tuner.

4.6 Keypad Keys

The controlhead keypad is a 25 - key keypad. All keys are configured as 2 analogue lines read by µP pins 49 and 48. The voltage on the analogue lines varies between 0 volts and +5 volts depending on which key has been pressed. If no key is pressed, the voltage at both lines will be 5 volts. The key configuration can be thought of as a matrix, where the two lines represent one row and one column. Each line is connected to a resistive divider powered by +5 volts. If a button is pressed, it will connect one specific resistor of each divider line to ground level and thereby reduce the voltages on the analogue lines The voltages of the lines are A/D converted inside the µP (ports PE 0 - 1) and specify the pressed button. To determine which key is pressed, the voltage of both lines must be considered.

An additional pair of analogue lines and A/D µP ports (PE 3 – 2) is available to support a keypad microphone, connected to the microphone connector J0811. Any microphone key press is processed the same way as a key press on the controlhead.

4.7 Status LED and Back Light Circuit

All the indicator LED's (red, yellow, green) are driven by current sources. To change the LED status the host radio sends a data message via SBEP bus to the controlhead µP. The controlhead µP determines the LED status from the received message and switches the LED's on or off via port PA 6 - 4. The LED status is stored in the µP's memory. The LED current is determined by the resistor at the emitter of the respective current source transistor.

The back light for keypad is controlled by the host radio the same way as the indicator LED's using µP port PH 3. This port is a Pulse Width Modulator (PWM) output. The output signal charges capacitor C0943 through R0945. By changing the pulse width under software control, the dc voltage of C0943 and thereby, the brightness of the back light can be changed in 16 steps. The keypad back light current is drawn from the FLT A+ source and controlled by transistor Q0941. The current flowing through the LED's cause a proportional voltage drop across the parallel resistors R0955, R0957. This voltage drop is amplified by the op-amp U0941-1. U0941-1 and Q0943 form a differential amplifier. The voltage difference between the base of Q0943 and the output of U0941-1 determines the current from the base of the LED control transistor Q0941 and in turn the brightness of the LED's. The µP can control the LED's by changing the dc level at the base of Q0943. If the base of Q0943 is at ground level, Q0943 is switched off and no current flows through Q0941 and the LED's. If the base voltage of Q0943 rises a current flows through Q0943 and in turn through Q0941 causing the LED's to turn on and a rising voltage drop across R0955, R0957. The rising voltage causes the

output of the op-amp to rise and to reduce the base to emitter voltage of Q0943. This decreases the current of Q0941 until the loop has settled.

The back light for the LCD module uses a similar circuitry. The only differences are that µP port PH2 controls the back light brightness and that the LED's are located on the LCD module which is connected via J0821. Control line BL A GREEN connects to the anodes and control line BL K GREEN connects to the cathodes of the LED's.

4.8 Liquid Crystal Display (LCD)

The LCD module consists of the display and the display driver and is connected via connector J0821. The display is a single layer super twist nematic (STN) LCD display. It has a dot matrix of 32 * 96 dots for displaying graphics and alpha - numerical information and a line with 21 pre - defined icons above the dot matrix

The driver contains a data interface to the µP, an LCD segment driver, an LCD power circuit, an oscillator, data RAM and control logic. At power up the driver's control logic is reset by a logic „0" via pin 5 of J0821. The driver's µP interface is configured to accept 8 bit parallel data input (J0821-D0-D7) from the controlhead µP (U0871 port PC0-PC7).

To write data to the driver's RAM the µP sets chip select (J0821-6) to logic „0" via U0871-26, RD (J0821-10) to logic „1" via (U0871-40) and WR (U0821-9) to logic „0" via U0871-33. With input A0 (J0821-8) set to logic „0" via U0871-34 the µP writes control data to the driver. Control data includes the RAM start address for the following display data. With input A0 set to logic „1" the µP then writes the display data to the display RAM. When data transfer is complete the µP terminates the chip select and the clock activities.

The display driver's power circuit provides the voltage supply for the display. This circuit consists of a voltage multiplier, voltage regulator and a voltage follower. The regulator output voltage for the display can be controlled electronically by a control command sent to the driver. The voltage level can be measured by one of the µP's analogue to digital converters (U0871-42) via J0821-21. To stabilize the display brightness over a large temperature range the µP measures the temperature via analogue to digital converter (U0871-43) using a temperature sensor on the module (J0821-4). Dependent on the measured temperature the µP adjusts the driver output voltage, and in turn the display brightness, via parallel interface.

4.9 Microphone Connector Signals

Signals BUS+, PTT IRDEC, HOOK, MIC, HANDSET AUDIO, FLT A+, +5V and 2 A/D converter inputs are available at the microphone connector J0811. Signal BUS+ (J0811-7) connects to the SBEP bus for communication with the CPS or the Universal Tuner. Line MIC (J0811-5) feeds the audio from the microphone to the radio's controller via connector J0801-4. Line HANDSET AUDIO (J0811-8) feeds the receiver audio from the controller (J0801-6) to a connected handset. FLT A+, which is at supply voltage level, and +5V are used to supply any connected accessory like a microphone or a handset.

The 2 A/D converter inputs (J0811-9/10) are used for a microphone with keypad. A pressed key will change the dc voltage on both lines. The voltages depend on which key is pressed. The µP determines from the voltage on these lines which key is pressed and sends the information to the host radio.

Line PTT IRDEC (J0811-6) is used to key up the radio's transmitter. While the PTT button on a connected microphone is released, line PTT IRDEC is pulled to +5 volts level by R0880. Transistor Q0871 is switched on and causes a low at µP port PA2. When the PTT button is pressed, signal PTT IRDEC is pulled to ground level. This switches off Q0871 and the resulting high level at µP port PA2

informs the µP about the pressed PTT button. The µP will inform the host radio about any status change on the PTT IRDEC line via SBEP bus.

When line PTT IRDEC is connected to FLT A+ level, transistor Q0851 is switched on through diode VR0851 and thereby pulls the level on line ON OFF CONTROL to FLT A+ level. This switches on the radio and puts the radio's µP in bootstrap mode. Bootstrap mode is used to load the firmware into the radio's flash memory (See controller sub section for more details).

The HOOK input (J0811-3) is used to inform the µP when the microphone´s hang-up switch is engaged. Dependent on the CPS programming the µP may take actions like turning the audio PA on or off. While the hang up switch is open, line HOOK is pulled to +5 volts level by R0883. Transistor Q0872 is switched on and causes a low at µP port PA1. When the HOOK switch is closed, signal HOOK is pulled to ground level. This switches off R0883 and the resulting high level at µP port PA1 informs the µP about the closed hang up switch. The µP will inform the host radio about any status change on the HOOK line via SBEP bus.

4.10 Speaker (Remote Mount Configuration only)

The remote mount controlhead contains a speaker for the receiver audio. The receiver audio signal from the differential audio output of the audio amplifier located on the radio's controller is fed via connector J0801-10,11 to the speaker connector P0801 pin 1 and pin 2. The speaker is connected to the speaker connector P0801. The controlhead speaker can be disconnected if only an external speaker, connected on the accessory connector, should be used. If the controlhead is mounted directly on the radio, an external speaker is required.

4.11 Electrostatic Transient Protection

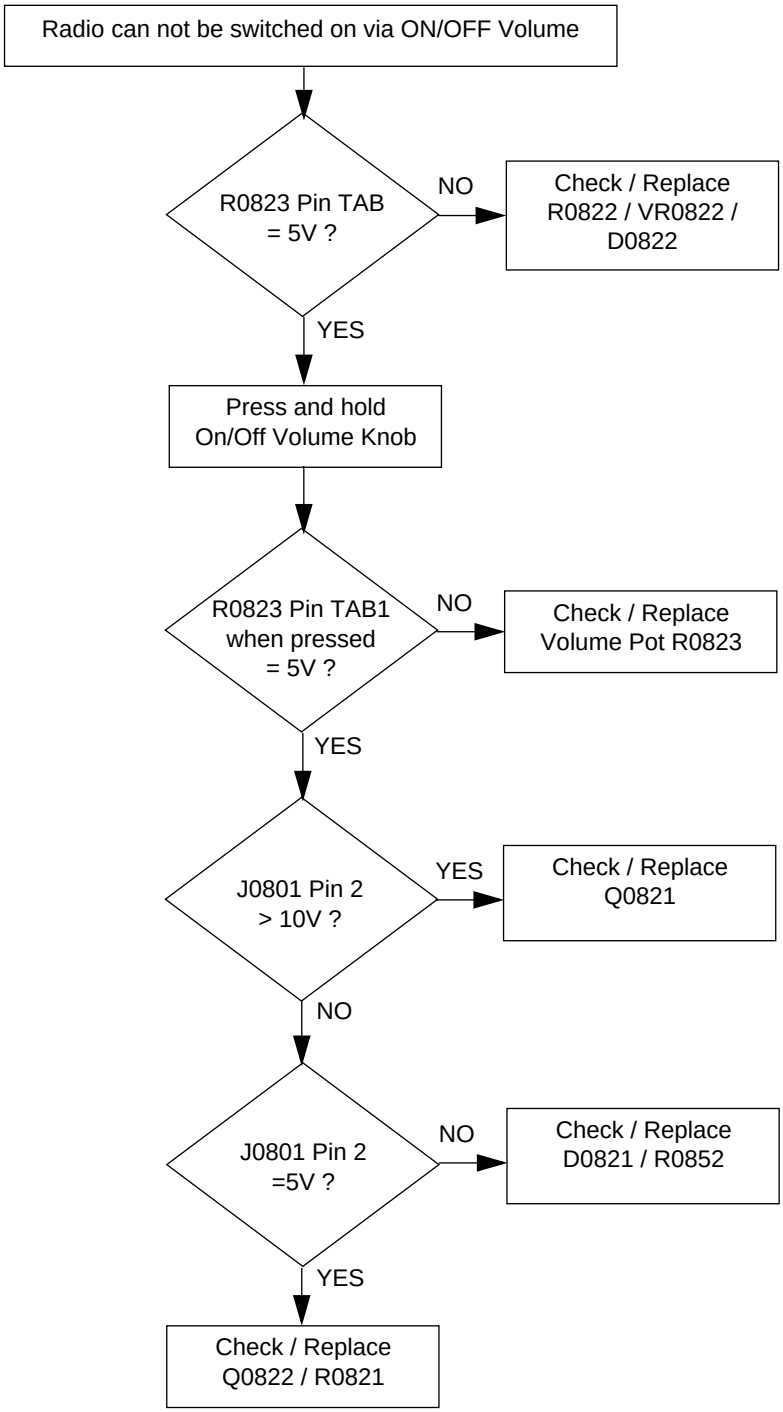
Electrostatic transient protection is provided for the sensitive components in the controlhead by diodes VR0811 - VR0814. The diodes limit any transient voltages to tolerable levels. The associated capacitors provide Radio Frequency Interference (RFI) protection.

Chapter 3

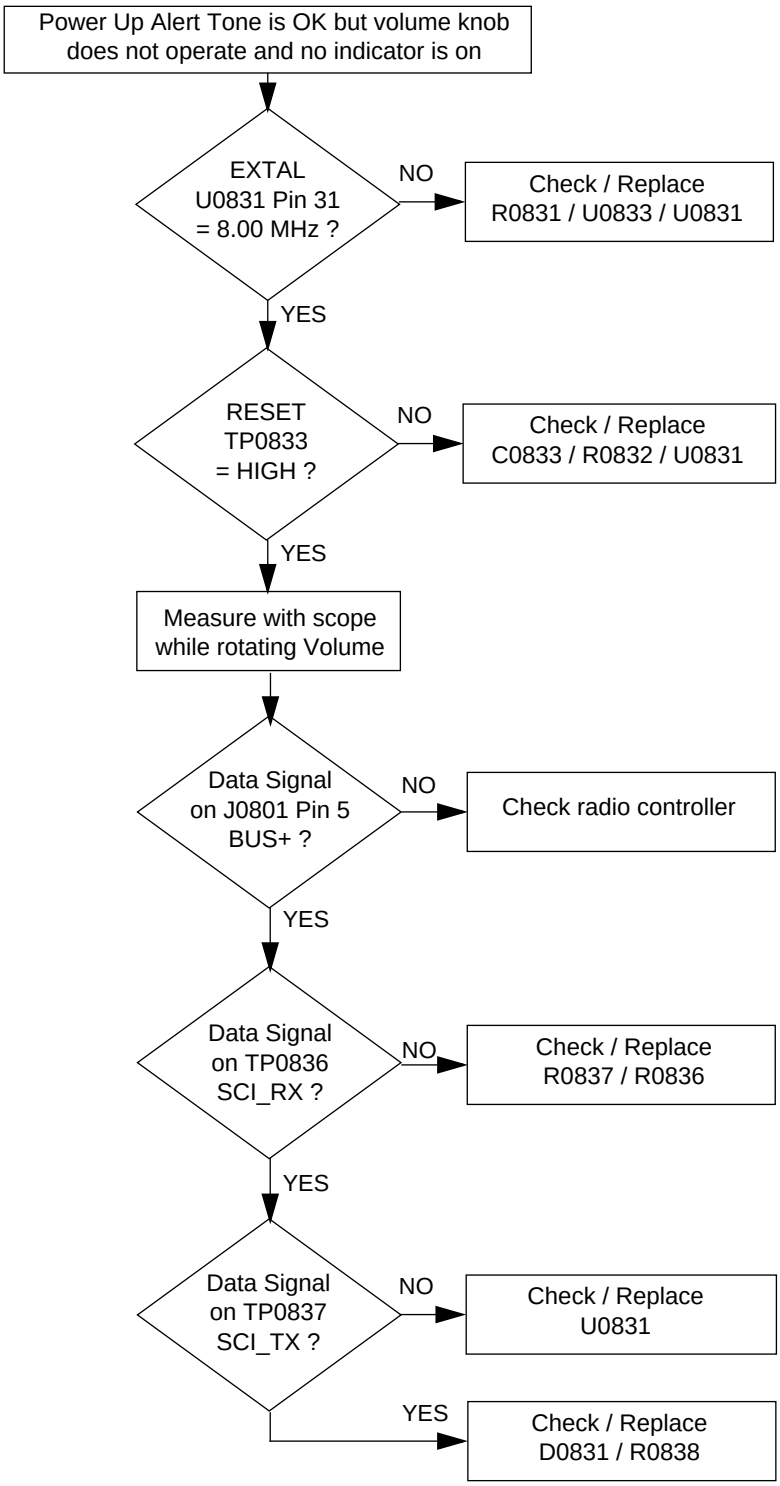
TROUBLESHOOTING CHARTS

1.0 Controlhead GM140/340/640 Troubleshooting Chart

1.1 On/Off

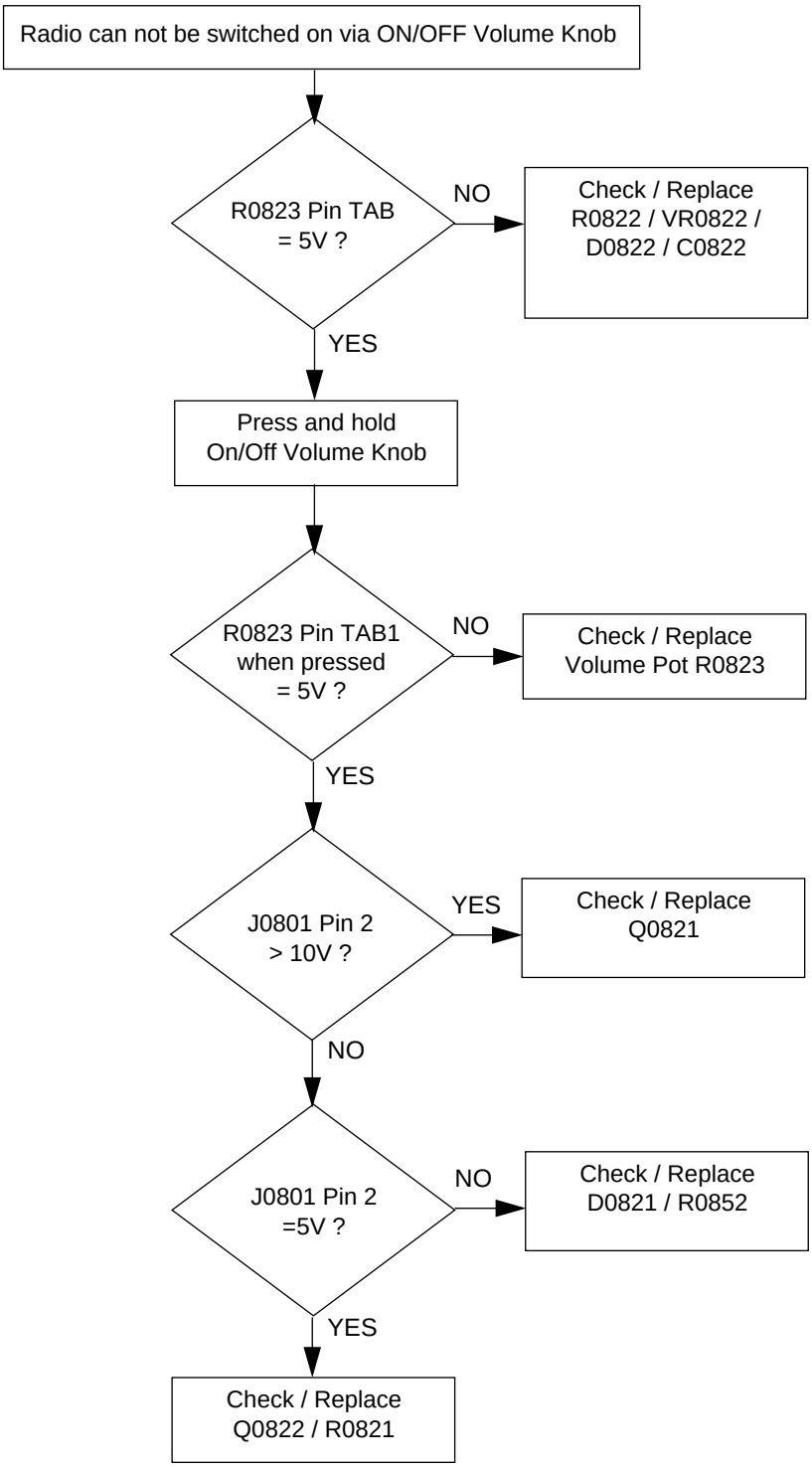


1.2 Microprocessor

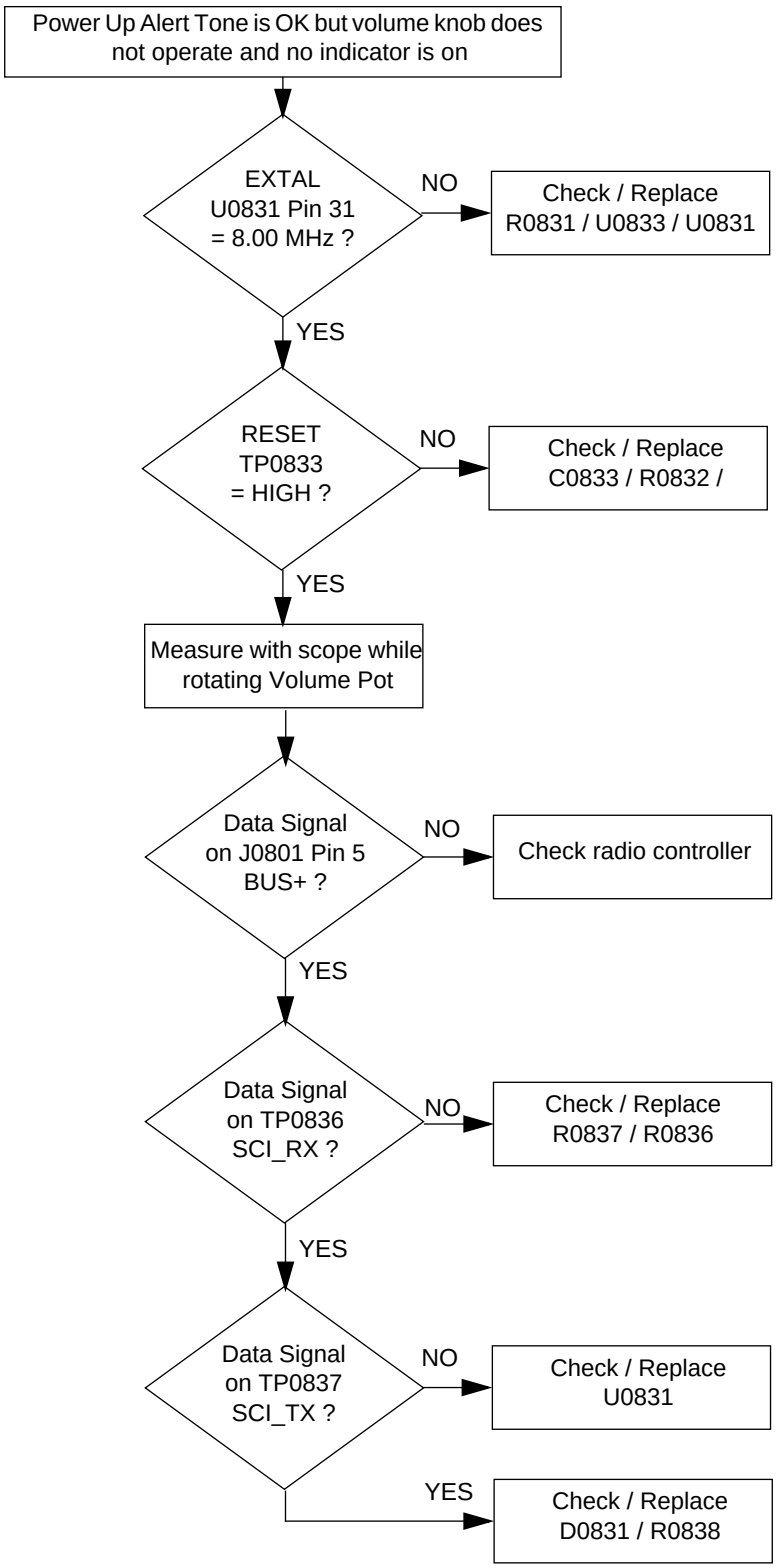


2.0 Controlhead GM160/360/660 Troubleshooting Flow Chart

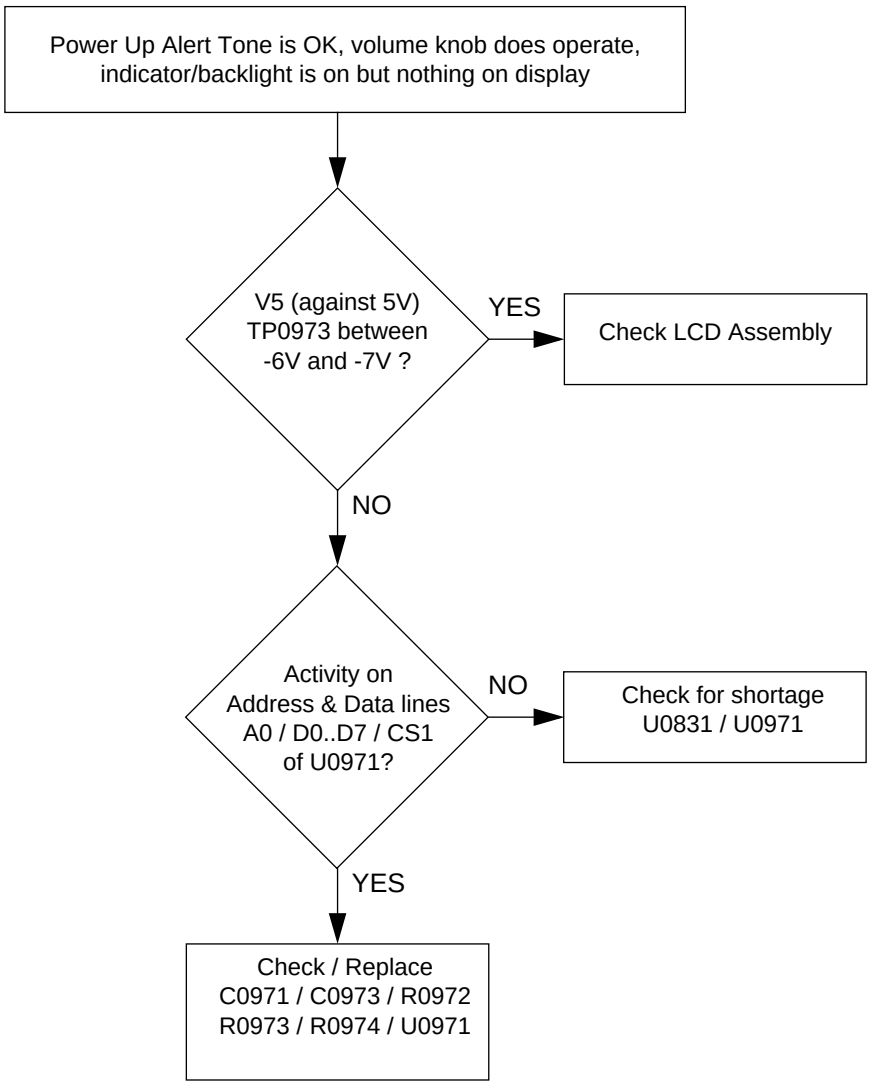
2.1 On/Off



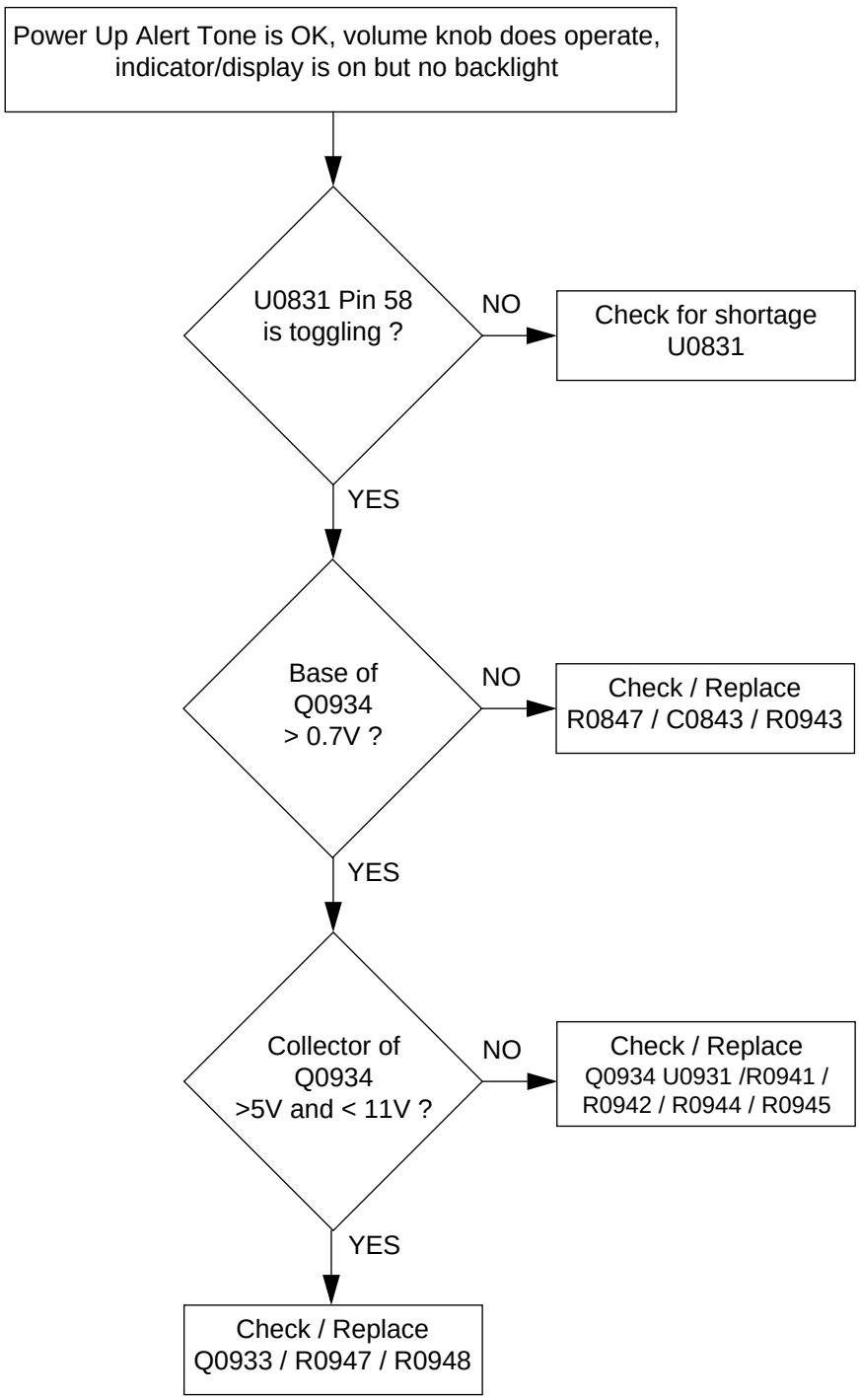
2.2 Microprocessor



2.3 Display

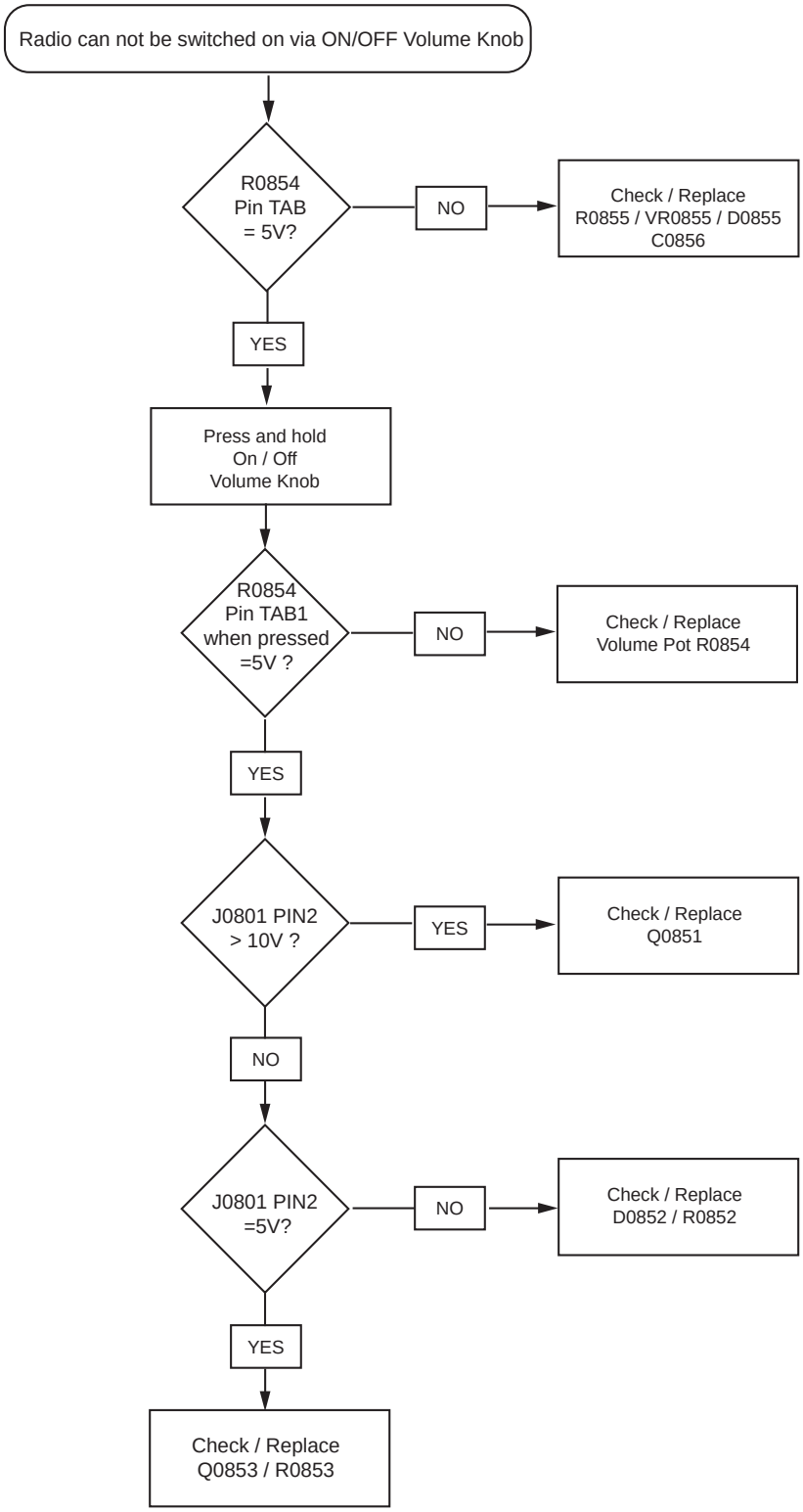

Power Up Alert Tone is OK, volume knob does operate, indicator/backlight is on but nothing on display
V5 (against 5V) TP0973 between -6V and -7V ?
YES
Check LCD Assembly
NO
Activity on Address & Data lines A0 / D0..D7 / CS1 of U0971?
NO
Check for shortage U0831 / U0971
YES
Check / Replace C0971 / C0973 / R0972 R0973 / R0974 / U0971

2.4 Backlight

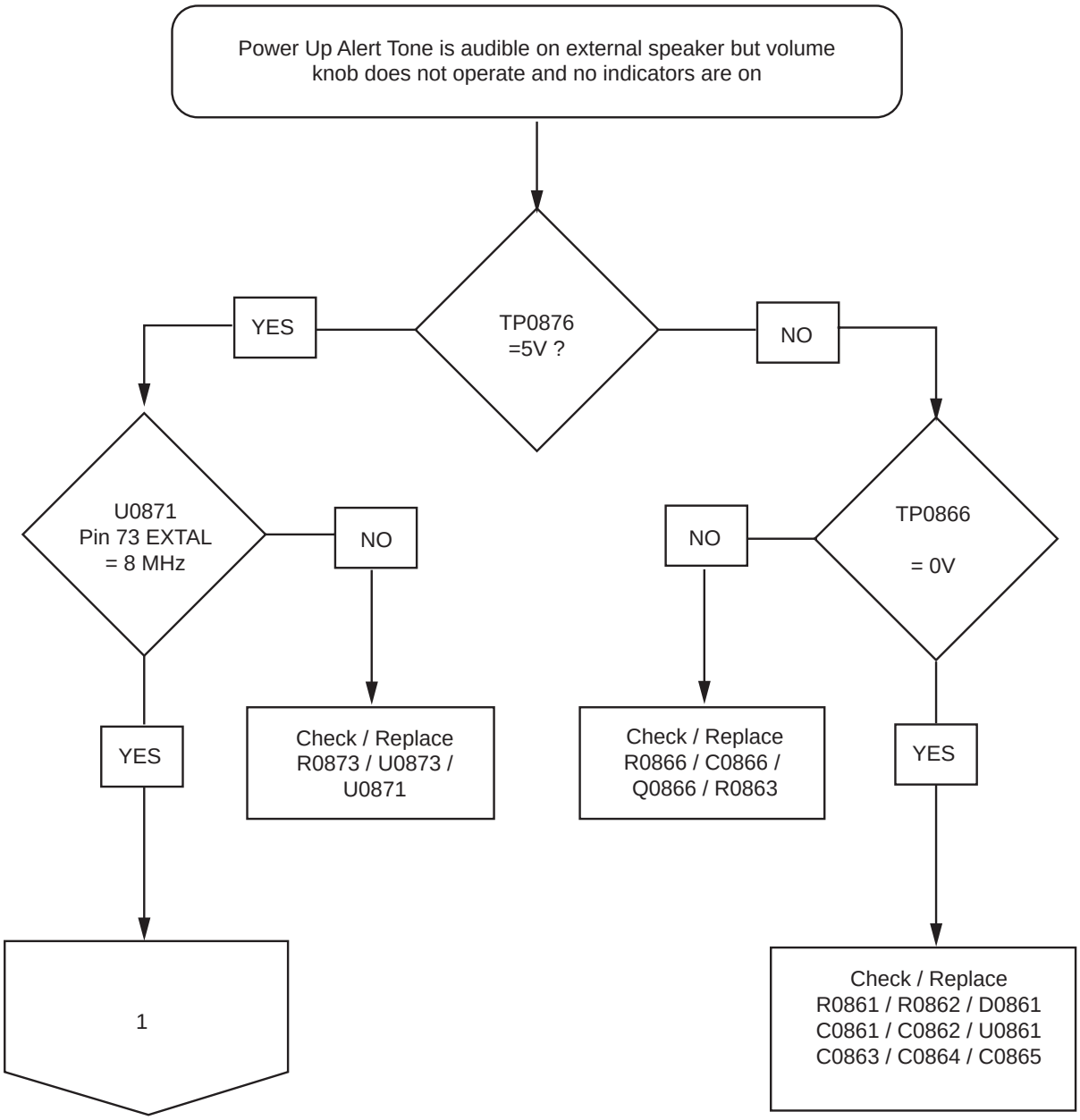


3.0 Controlhead GM380/1280 Troubleshooting Flow Chart

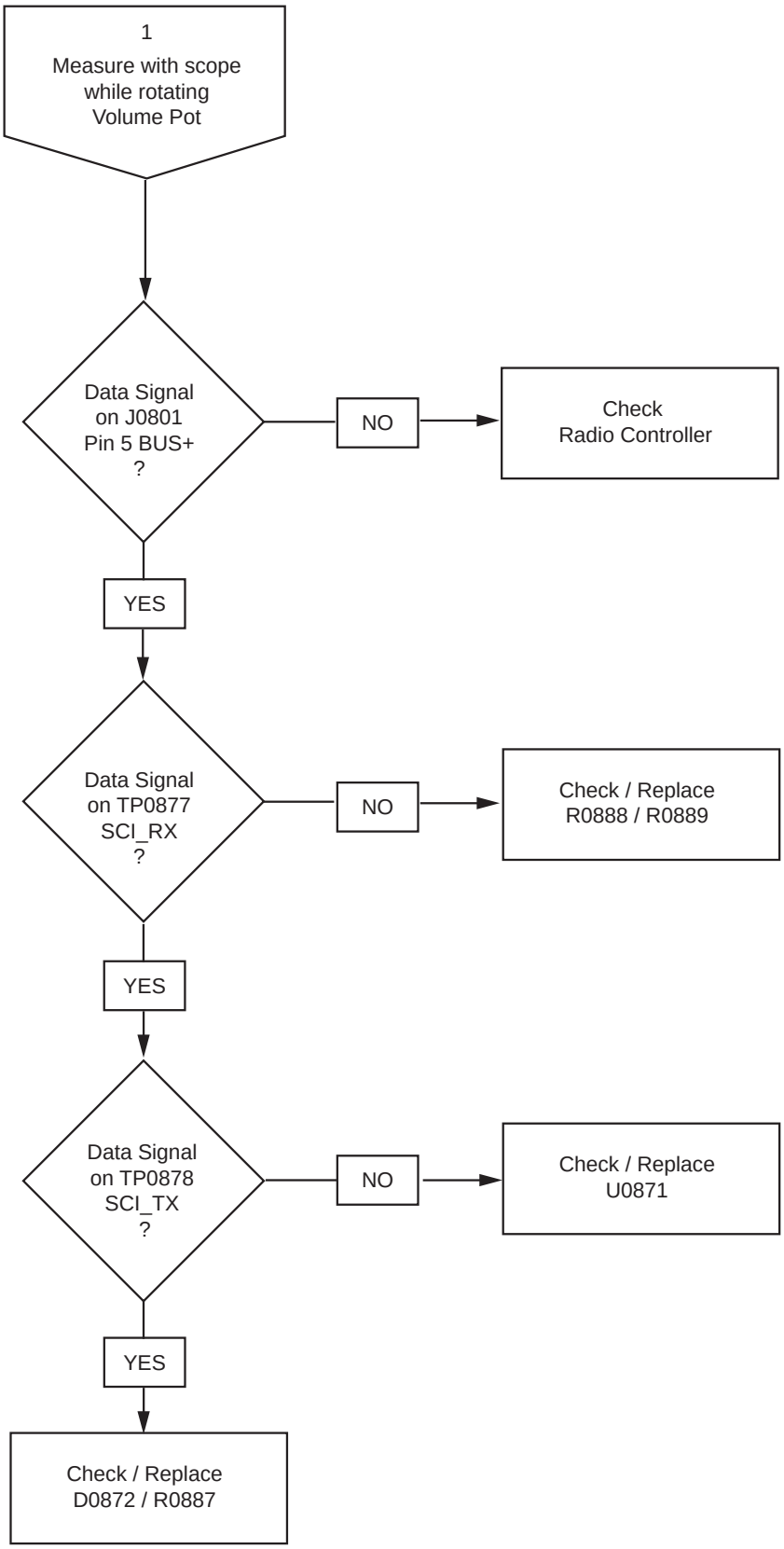
3.1 On/Off



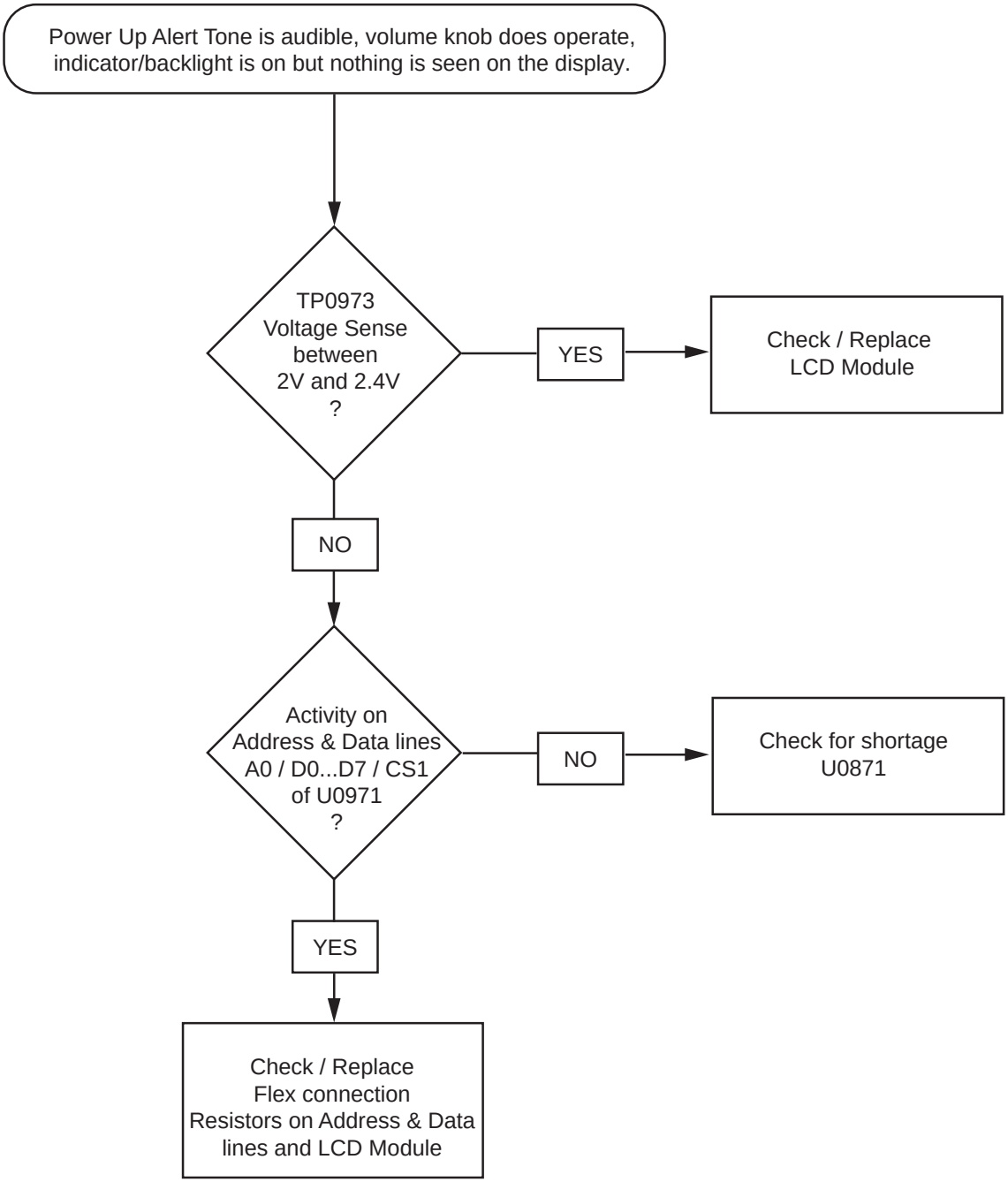
3.2 Microprocessor



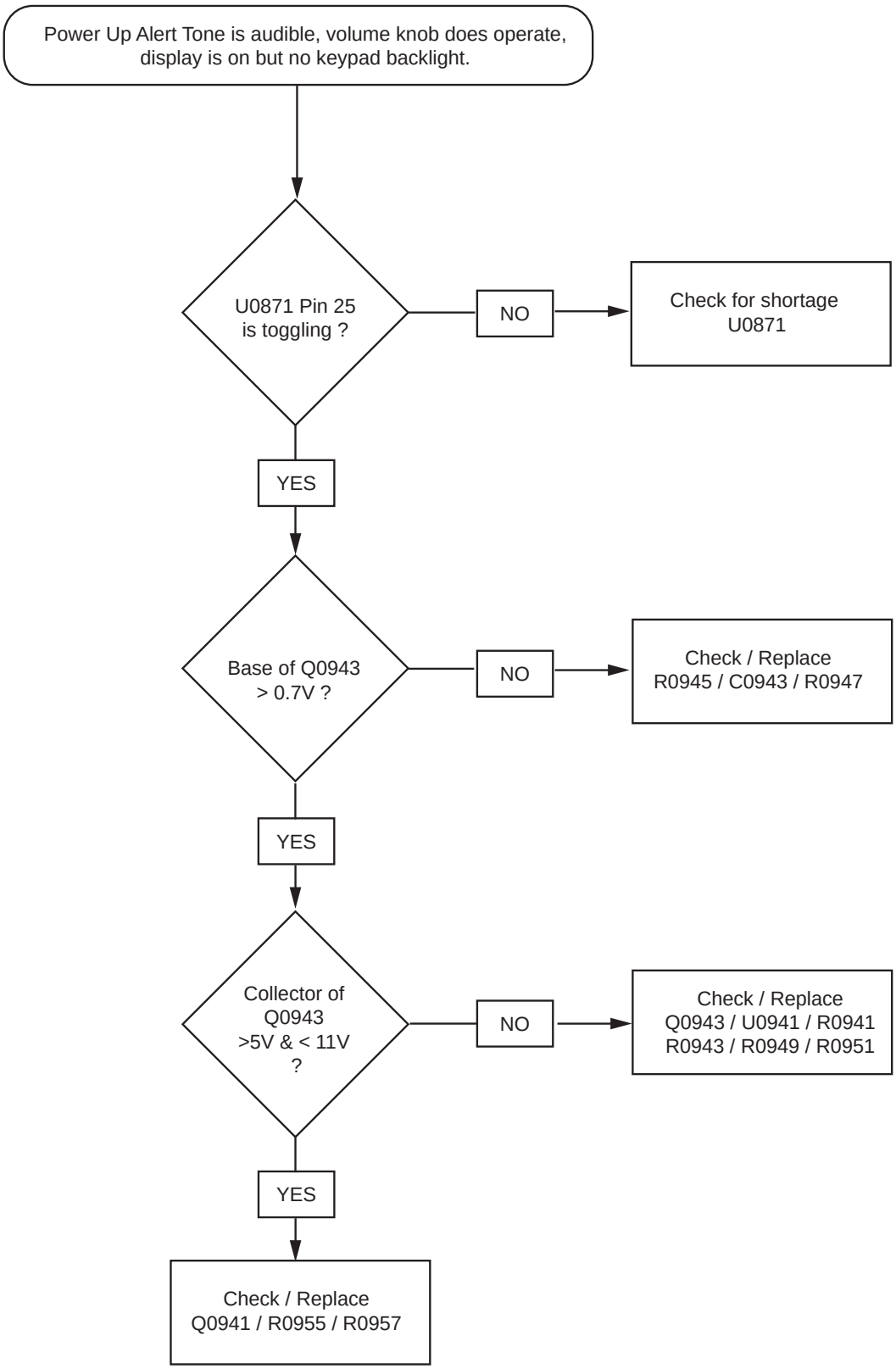
3.3 Microprocessor



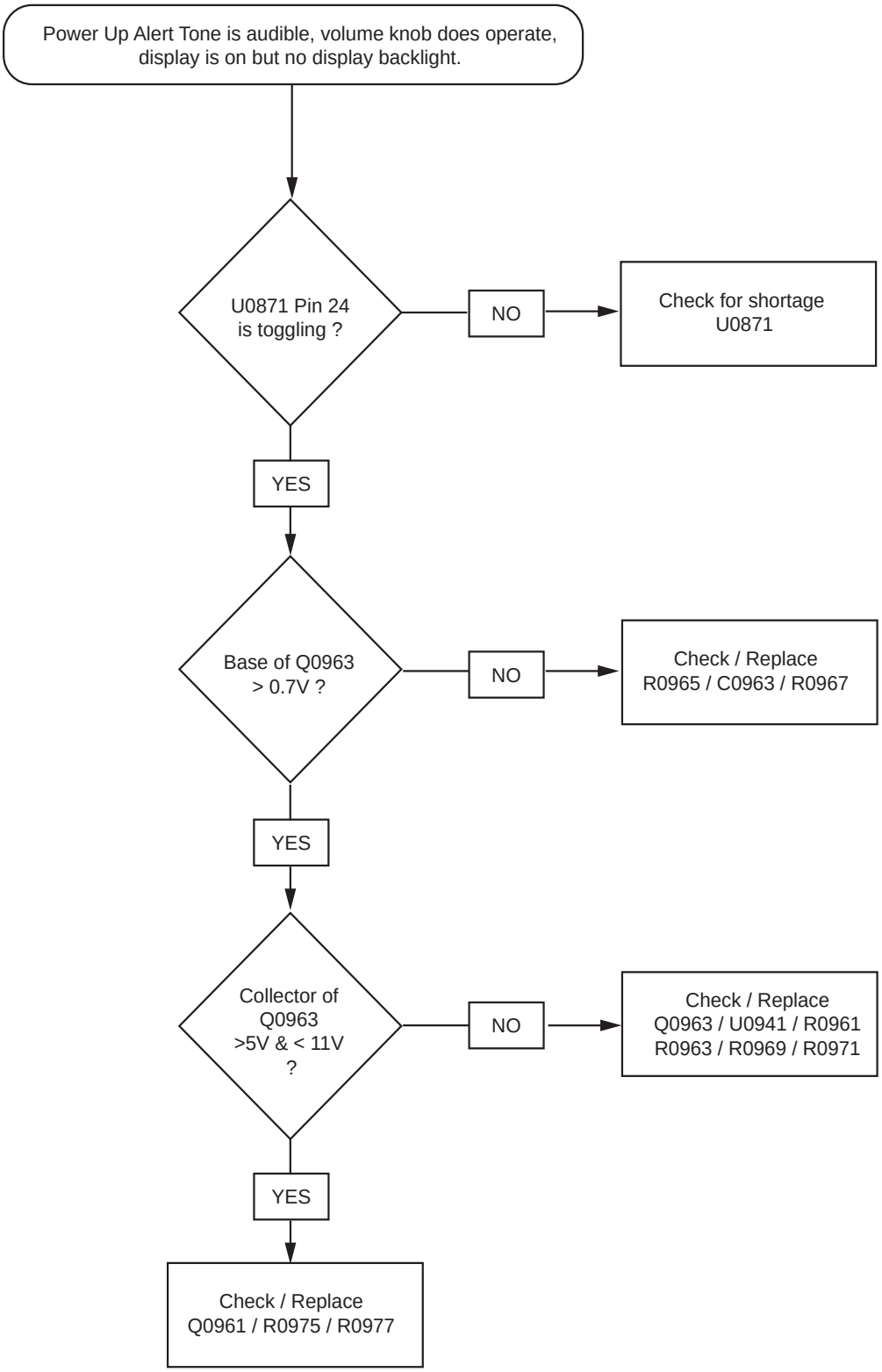
3.4 Display


Power Up Alert Tone is audible, volume knob does operate, indicator/backlight is on but nothing is seen on the display.
TP0973 Voltage Sense between 2V and 2.4V ?
YES
Check / Replace LCD Module
NO
Activity on Address & Data lines A0 / D0...D7 / CS1 of U0971 ?
NO
Check for shortage U0871
YES
Check / Replace Flex connection Resistors on Address & Data lines and LCD Module

3.5 Keypad Backlight



3.6 Display Backlight



Chapter 4

CONTROLHEAD PCB / SCHEMATICS / PARTS LISTS

1.0 Allocation of Schematics and Circuit Boards

Table 4-1 Controlhead Diagrams and Parts Lists

Table 4-2 Controlhead Diagrams and Parts Lists

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Table 4-3 Controlhead Diagrams and Parts Lists