Chapter 4

Control Heads/Control Microphones Specific Information

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Control Head for Radio Model N4

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Introduction/Theory of Operation

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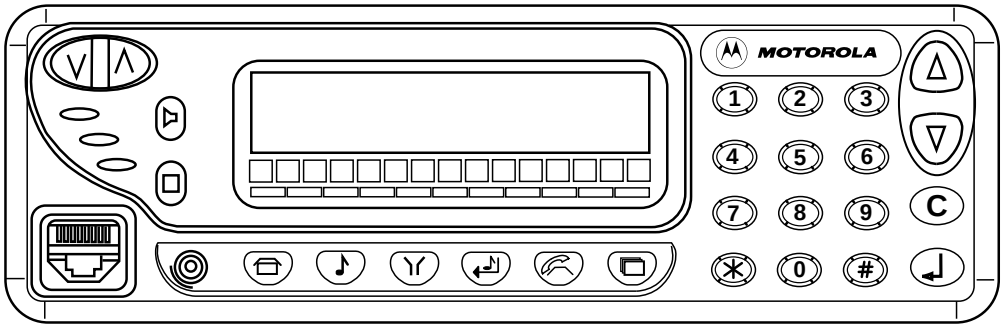
1.0 Overview

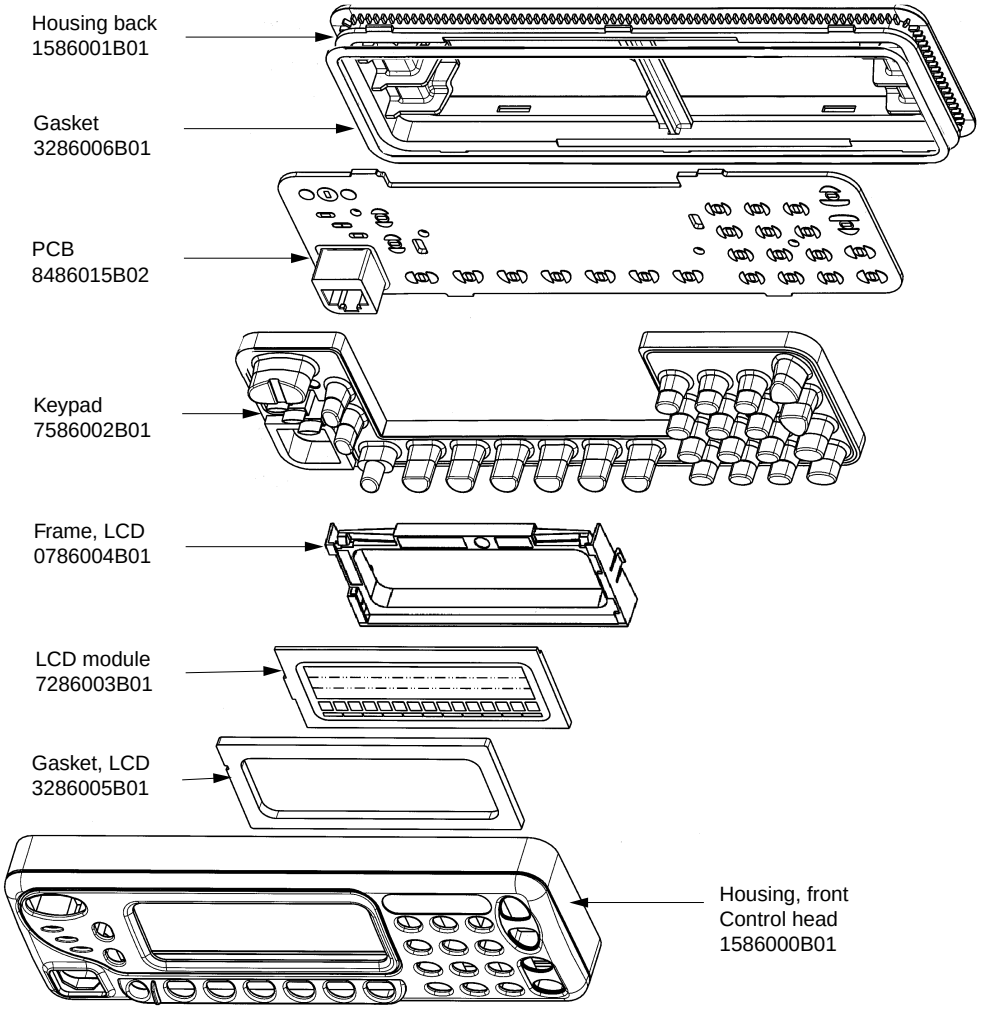
128 Channel, Radio Model N4 Control Head



The features of the N4 radio control head are as follows:

- ❑ On/Off Button
- ❑ Rocker Type Volume Up/Down Control
- ❑ Dot matrix, Backlit LCD display
- ❑ 3 LEDs (Red, Yellow, Green)
- ❑ Up/Down keys for Channel Increment/Decrement
- ❑ 7 Dealer Programmable Option Buttons
- ❑ Clear and Select Buttons
- ❑ Full DTMF keypad
- ❑ Microphone socket

2.0 Exploded View Diagram



3.0 Theory of Operation

3.1 General

The control head contains 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 19 pre - defined symbols, 11 bars and a 24x120 dot matrix for graphical or alpha - numerical information e.g. channel number, select code, call address name. To control the LEDs and the LCD, and to communicate with the host radio, the control head uses the Motorola 68HC11E9 or 68HC11E20 (dependent on the used character set) microprocessor.

3.2 Power Supplies

The power supply to the control head is taken from the host radio FLT A+ voltage via connector J0901 pin 2. The voltage FLT A+ is at battery level and is used for the LEDs, the back light, to power up the radio via On / Off button and to supply the voltage regulator circuit. The regulator circuit provides the stabilized +5 volt which is used for the microprocessor circuit, the display, the display driver and the keypad buttons. The voltage +5V USW also provided by the regulator circuit is used to buffer the internal RAM of the microprocessor (U0901). The regulated +5V taken from the host radio via connector J0901 pin 10 (line +5V SOURCE) is only used to switch on or off the voltage regulator in the control head.

3.3 Voltage Regulator Circuit

Voltage regulator U0891 provides 5V for the control head. The supply voltage FLT A+ for the voltage regulator is fed via parallel resistors R0893/4 and dual diode D0891 to pin 8 of U0891. The +5 volt output is switched on and off by the host radio's 5 volt source via line +5V SOURCE and control transistor Q0891. When the host radio is switched off the voltage on line +5V SOURCE is at ground level and switches off transistor Q0891. Pull up resistor R0892 pulls input SHUTDOWN (pin 3) of the voltage regulator U0891 to FLT A+ level and switches off the output of U0891 (pin 1). When the host radio is switched on the voltage on line +5V SOURCE of about +5 volts switches on transistor Q0891 which in turn pulls input SHUTDOWN (pin 3) to ground and switches on the output of U0891. Input and output capacitors (C0892 / C0893 and C0895 - C0896) are used to reduce high frequency noise and provide proper operation during battery transients. Diode D0891 prevents discharge of C0893 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 (U0901) and the display driver (U0902) to prevent improper operation.

The voltage +5V USW derived from voltage FLT A+ is stabilized using resistor R0896 and diode VR0891 This voltage is used to buffer the microprocessor's internal RAM. C0898 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Diode D0892 prevents radio circuitry from discharging this capacitor. The +5V at the second anode of D0892 speeds up charging of C0898 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.

3.4 Power On / Off

The On/Off button when pressed switches the radio's voltage regulators on by pulling ON OFF CONTROL to high via D0931 and connects the base of Q0932 to FLT A+. This transistor pulls the line ANALOG 3 low to inform the µP that the On/Off button is pressed. If the radio is switched off, the µP will switch it on and vice versa. If the On/Off button is pressed and held while the radio is on, the software detects a low state on line ANALOG 3 and switches the radio off. If the radio is switched on either manually or automatically its +5V source switches on the control head voltage regulator U0891 via line +5 SOURCE and transistor Q0891 and the control head microprocessor starts execution.

3.5 Microprocessor Circuit

The control head uses the Motorola 68HC11E9 or 68HC11E20 (dependent on the used character set) microprocessor (µP) (U0901) to control the LEDs, the LCD and to communicate with the host radio. RAM and ROM are contained within the microprocessor itself.

The clock generator for the microprocessor can use two different configurations:

1. The oscillator inside the microprocessor (U0901) along with a 4 MHz ceramic resonator (Y0922) and R0920 generate the clock.

2. The oscillator inside the microprocessor (U0901) along with some external components (C0922-C0924, L0921, R0922, Y0921) generate the 7.9488 MHz clock. Q0921 is used to alter the clock frequency slightly under software control if there is a possibility of harmonics of this clock source interfering with the desired radio receive frequency.

The microprocessor E9/E20 (U0101) contains internal 12 (E9) or 20 (E20) Kbytes ROM, 512 (E9) or 768 (E20) bytes SRAM and 512 bytes EEPROM.

The microprocessor's RAM is always powered to maintain parameters such as the last operating mode. This is achieved by maintaining 5V at U0901-25. Under normal conditions, when the radio is off +5V USW is formed by FLT A+ via D0892. C0898 allows the battery voltage to be disconnected for a couple of seconds without losing RAM parameters. Diode D0892 prevents radio circuitry from discharging this capacitor.

There are 8 analogue to digital converter ports (A/D) on U0901. They are labelled 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.

U0901-22 is the high reference voltage for the A/D ports on the µP. Resistor R0927 and capacitor C0925 filter the +5V reference. If this voltage is lower than +5V the A/D readings will be incorrect. Likewise U0901-21 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 MODB (U0901-25) input of the µP must be at a logic '1' for it to start executing correctly. The XIRQ (U0901-45) and the IRQ (U0901-46) pins should also be at a logic '1'.

The microprocessor can determine the keypad type used, by reading the voltages at pins 63 and 64. Connections JU0911 and JU0912 are provided by the individual keypads.

Capacitors C0927 and C0928 serve to filter out any AC noise on +5V line at U0901.

3.6 Serial Peripheral Interface (SPI)

The host radio (master) communicates to the control head µP (slave) through its SPI port (BUS). This port consists of SPI TRANSMIT DATA (SPI MOSI) (U0901-52), SPI RECEIVE DATA (SPI MISO) (U0901-51), SPI CLK (SPI CLCK BUF) (U0901-53) and a control head select line (CNTL HD CE) (U0901-54). This BUS is a synchronous bus, in that the timing clock signal SPI CLCK is sent while SPI data (SPI TRANSMIT DATA or SPI RECEIVE DATA) is sent. Therefore, whenever there is activity on either SPI TRANSMIT DATA or SPI RECEIVE DATA there should be a uniform signal on SPI CLK. The SPI TRANSMIT DATA is used to send serial from the host radio to the control head µP, and SPI RECEIVE DATA is used to send data from the control head µP to the host radio.

When the host radio needs to communicate to the control head µP it brings the control head select line (CNTL HD CE) to a logic ‘0’ and then sends the proper data and clock signals. After the data has been sent the control head select line is returned to a logic ‘1’. When the control head µP wants to communicate to the host radio the µP brings request line CNTL HD REQ to a logic ‘0’ by switching on transistor Q0931 via µP pin 11. The host radio then starts communication by activating the control head select line (CNTL HD CE), sending the clock signal and sending data via SPI MOSI or receiving data via SPI MISO and buffer U0931-1.

3.7 Keypad Keys

The control head keypad is a 26 - key keypad. All keys are configured as 6 analogue lines (AN 0 - 5) to the control head µP. Lines AN 0 - 3 each control four keys, lines AN 4, 5 each control five keys. The voltage on the analogue lines varies between 0V and +5V depending on which key has been pressed. If a button is pressed, it will connect one of the 6 lines AN 0 - 5 to a resistive voltage divider R0807 - R0811 connected to +5V. The voltages of the lines are A/D converted inside the µP (ports PE 0 - 5) and specify the pressed button.

3.8 Status LED and Back Light Circuit

All the indicator LEDs (D0881 - D0884) are driven by current sources Q0881 - Q0883. To change the LED status the host radio sends a data message via SERIAL PERIPHERAL INTERFACE (SPI) to the control head µP. The control head µP determines the LED status from the received message and switches the LEDs on or off via pins 5, 6, 7. 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 backlight for the LCD and the keypad is controlled by the host radio the same way as the indicator LEDs using µP pins 8, 9, 10. The keypad backlight current is drawn from the FLT A+ source and controlled by transistor Q0851. The current flowing through the LEDs cause a proportional voltage drop across the parallel resistors R0861, R0862. This voltage drop is amplified by the op-amp U0831-2. U0831-2 and Q0852 form a differential amplifier. The voltage difference between the base of Q0852 and the output of U0831-2 determines the current from the base of the LED control transistor Q0851 and in turn the brightness of the LEDs. The µP can switch the LEDs on and off by a logic high or low level at the port connected to the base of Q0852. If the base of Q0852 is at ground level, Q0852 is switched off and no current flows through Q0851 and the LEDs. If the µP port changes to +5V a current flows through Q0852 and in turn through Q0851 causing the LEDs to turn on and a rising voltage drop across R0861, R0862. The rising voltage causes the output of the op-amp to rise and to reduce the base to emitter voltage of Q0852. This decreases the current of Q0852 until the loop has settled. The backlight for the LCD uses a similar circuit. By using two µP ports (pin 8, 9) and different weighting resistors R0837 and R0838 the base of Q0832 can be set to four different voltage levels. This allows to switch the LEDs off or to select among three levels of brightness.

3.9 Liquid Crystal Display (LCD)

The LCD module U0902 consists of the display and the display driver. The display is a single layer super twist nematic (STN) LCD display. It has a dot matrix of 24 x120 dots for displaying graphics and alpha - numerical information, a line with 19 pre - defined icons below the dot matrix and line with 11 bars below the icon line. Six of the bars can be used to display the status of the keys located below.

The display driver is fixed on the flex which connects the display to the PC board. 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 RES (U0902-9). Resistor R0946 sets the driver's internal oscillator to about 18 kHz. By connecting U0902 pin 12 to +5V the driver's µP interface is configured to accept 8 bit parallel data input (U0902-D0-D7) from the control head µP (U0901 port PC0-PC7). Pin 15 connected to +5V sets the 6800 µP control mode.

To write data to the driver's RAM the µP sets chip select (U0902-14) to logic '1' via U0901-59 and R/W (U0902-17) to logic '0' via U0901-56. With input A0 (U0902-16) set to logic '0' via U0901-58 the µP writes control data to the driver. Clock signal E at pin 18 generated by µP pin 57, shifts 8 bit parallel data into 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 voltage supply for the display is provided by the display driver power circuit. This circuit consists of a voltage multiplier, voltage regulator and a voltage follower. To use an external voltage supply the built-in power circuit can be turned off by a control command. The settings of the inputs T1 (U0902-36) and T2 (U0902-35) select among the various functions of the power circuit. With both inputs set to ground level by resistors R0955 and R0956 the voltage multiplier, the voltage regulator and the voltage follower are activated and no external voltage supply is required for the LCD. The external capacitors C0951 - C0953 configure the multiplier to triple the supply voltage. If R0957 is used instead of C0952 the multiplier doubles the supply voltage. In this configuration the multiplier output VOUT (U0902-42) 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 (U0902-43) this voltage is divided by the resistors R0958 and R0959 and feed back to the reference input VR (U0902-44). 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 -3V. 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 driver circuit can be configured to use externally generated voltages for VOUT and V1 - V5. In this case the +5V supply voltage is multiplied by the µP (U0901-62) along with the multiplier circuit D0911, C0911, C0912, R0911 and R0913. The µP provides a square wave signal at pin 62 to drive the multiplier circuit. The voltages V1-V4 are generated from VOUT or V5 by the resistive divider R0941 - R0945 and supplied to the driver ports V1 - V5. Dependent on the configuration the level of VOUT or V5 can be measured by one of the µP's analogue to digital converters (U0901-20) via resistive divider R0914, R0915. To stabilize the display brightness over a large temperature range the µP measures the temperature via analogue to digital converter (U0901-18) using thermistor R0918 and resistor R0917. Dependent on the measured temperature the µP adjusts the driver output voltage V5, and in turn the display brightness, via parallel interface.

3.10 Microphone Connector

Signals BUS+, PTT, HOOK, MIC HI, HANDSET AUDIO and FLT A+ available at the microphone connector J0903, are connected to the radio's controller section via connector J0901.

3.11 Electrostatic Transient Protection

Electrostatic transient protection is provided for the sensitive components in the control head by diodes VR0901 - VR0905, VR0931 - VR0935. The diodes limit any transient voltages to tolerable levels. The associated capacitors provide Radio Frequency Interference (RFI) protection.

Chapter 4D.2

PCB/Schematic Diagram and Parts List

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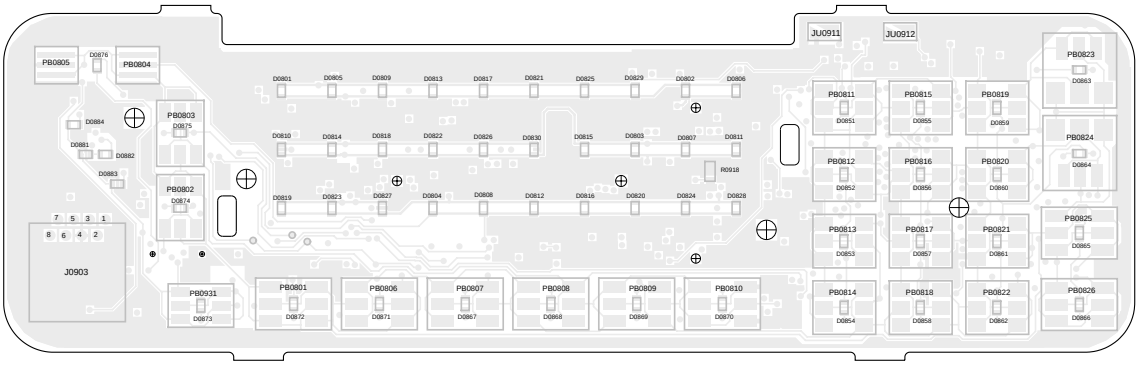
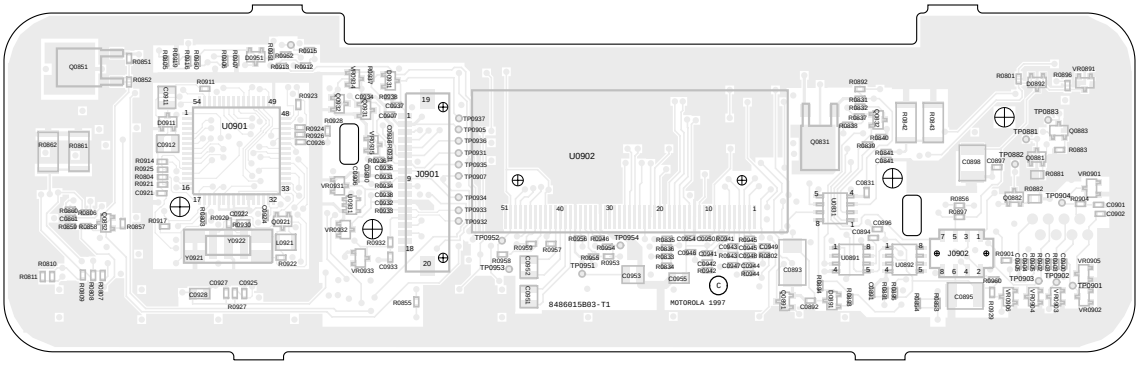
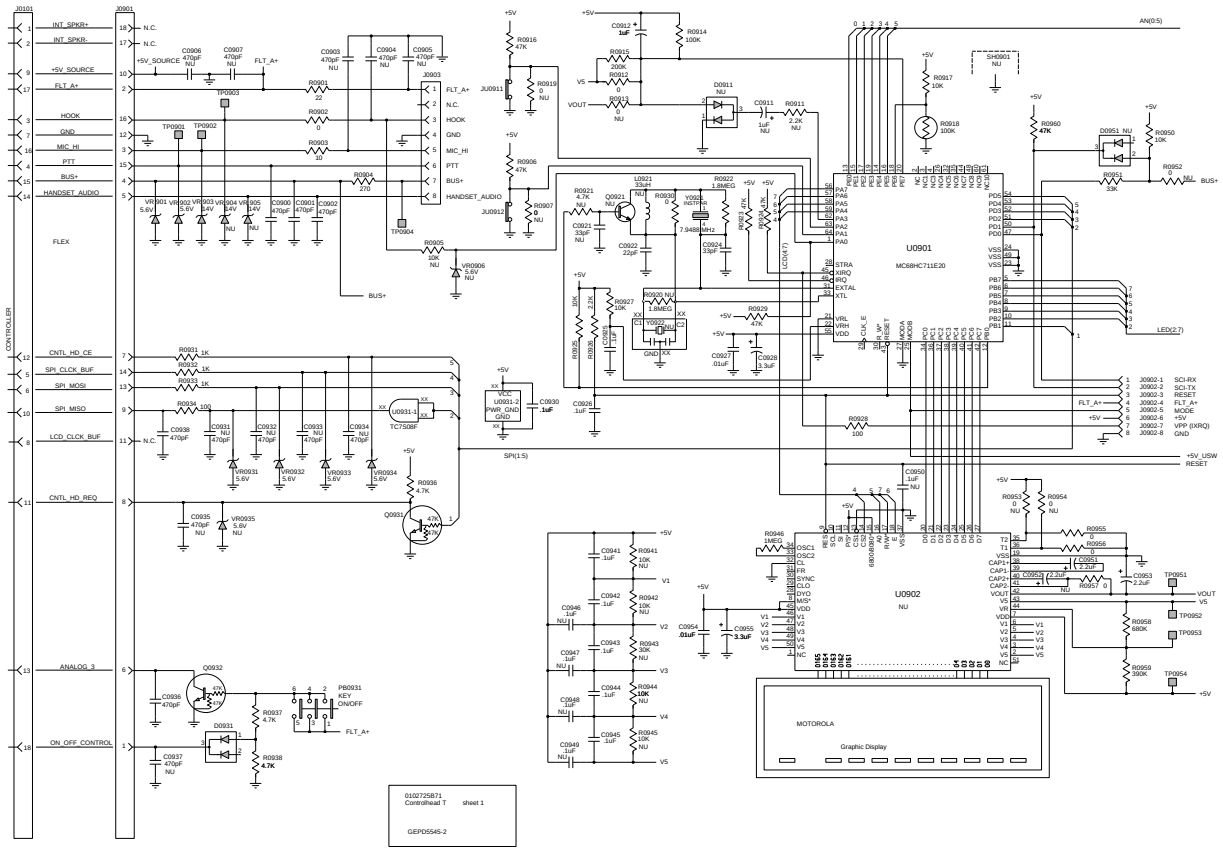


Top Side



Bottom Side

Control Head (N4)
PCB No. 8486015B03_T1



Control Head (N4) Schematic Diagram
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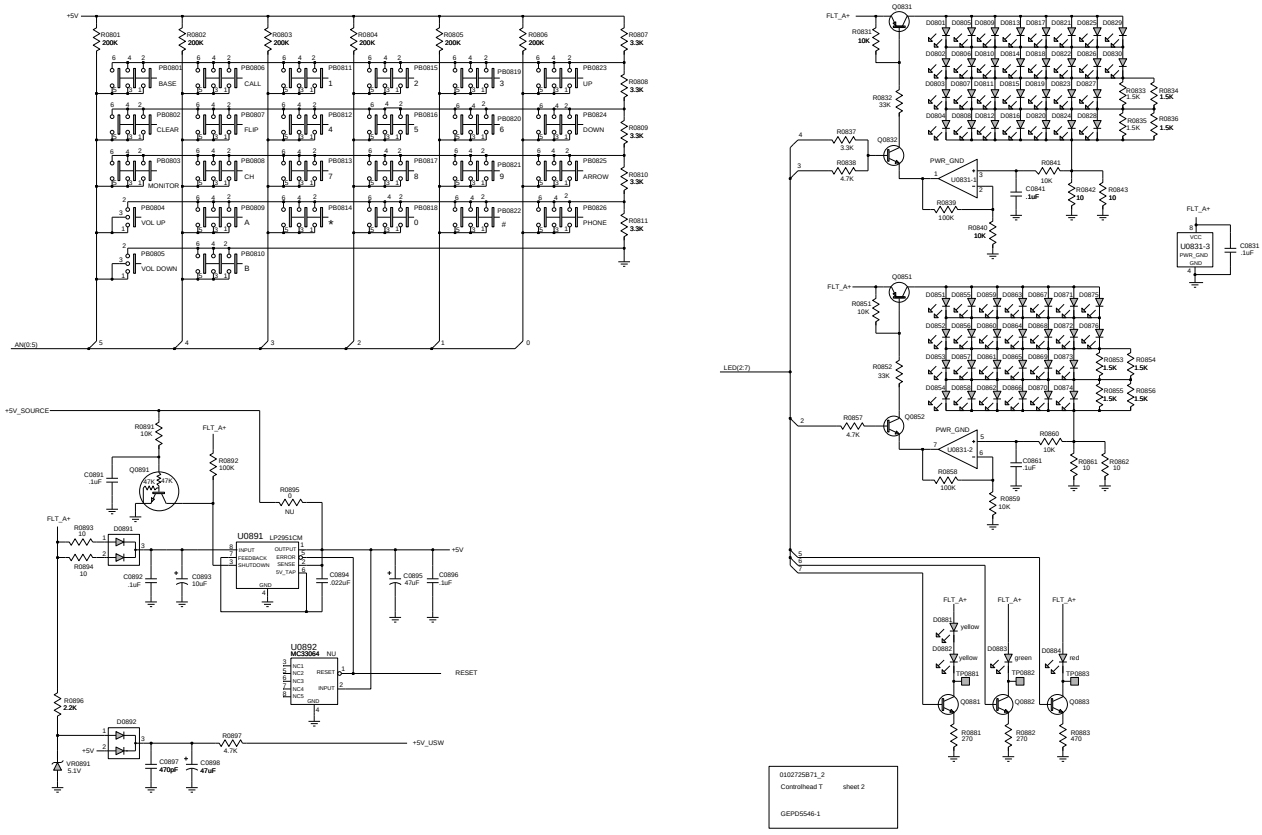

Control Head (N4) Schematic Diagram
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Control Head (N4) Parts List

Circuit Ref	Motorola Part No.	Description
C0831	2113743E20	100nF 16V
C0841	2113743E20	100nF 16V
C0861	2113743E20	100nF 16V
C0891	2113743E20	100nF 16V
C0892	2113743E20	100nF 16V
C0893	2311049A45	TANT 10uF 10% 35V
C0894	2113743E07	22nF 16V
C0895	2311049A99	TANT 47uF 20% 10V
C0896	2113743E20	100nF 16V
C0897	2113741F17	470pF 50V
C0898	2311049A99	TANT 47uF 20% 10V
C0901	2113741F17	470pF 50V
C0902	2113741F17	470pF 50V
C0912	2311049A09	TANT 2.2uF 10% 20V
C0922	2113740F35	22pF 5% 50V NP0
C0924	2113740F39	33pF 5% 50V NP0
C0925	2113743E20	100nF 16V
C0926	2113743E20	100nF 16V
C0927	2113741F49	10nF 50V
C0928	2311049A42	TANT 3.3uF 10% 6V
C0930	2113743E20	100nF 16V
C0936	2113741F17	470pF 50V
C0938	2113741F17	470pF 50V
C0941-C0945	2113743E20	100nF 16V
C0951	2311049A09	TANT 2.2uF 10% 20V
C0953	2311049A09	TANT 2.2uF 10% 20V
C0954	2113741F49	10nF 50V
C0955	2311049A42	TANT 3.3uF 10% 6V
D0801-D0830	4805729G75	LED GREEN HP
D0851-D0876	4805729G75	LED GREEN HP
D0881	4805729G73	LED YEL HP
D0882	4805729G73	LED YEL HP
D0883	4805729G75	LED GREEN HP
D0884	4805729G74	LED RED HP
D0891	4813833C02	DUAL SOT MMBD6100
D0892	4813833C02	DUAL SOT MMBD6100
D0931	4813833C02	DUAL SOT MMBD6100
J0901	0902636Y01	Connector Flex Side Entry
J0903	2805924V01	CONNECTOR MIC
Q0831	4813822A08	
Q0832	4813824A10	NPN 40V .2A B=50-150
Q0851	4813822A08	
Q0852	4813824A10	NPN 40V .2A B=50-150
Q0881	4813824A10	NPN 40V .2A B=50-150
Q0882	4813824A10	NPN 40V .2A B=50-150
Q0883	4813824A10	NPN 40V .2A B=50-150
Q0891	4880048M01	NPN DIG 47k/47k
Q0931	4880048M01	NPN DIG 47k/47k
Q0932	4880048M01	NPN DIG 47k/47k
R0801-R0806	0662057B05	200k 1/16W
R0807-R0811	0662057A61	3k3 1/16W 5%
R0831	0662057A73	10k 1/16W 5%
R0832	0662057A85	33k 1/16W 5%
R0833	0662057A53	1k5 1/16W 5%
R0834	0662057A53	1k5 1/16W 5%
R0835	0662057A53	1k5 1/16W 5%
R0836	0662057A53	1k5 1/16W 5%
R0837	0662057A61	3k3 1/16W 5%
R0838	0662057A65	4k7 1/16W 5%
R0839	0662057A97	100k 1/16W
R0840	0662057A73	10k 1/16W 5%
R0841	0662057A73	10k 1/16W 5%
R0842	0680194M01	10 1W 5%
R0843	0680194M01	10 1W 5%
R0851	0662057A73	10k 1/16W 5%
R0852	0662057A85	33k 1/16W 5%
R0853	0662057A53	1k5 1/16W 5%
R0854	0662057A53	1k5 1/16W 5%
R0855	0662057A53	1k5 1/16W 5%
R0856	0662057A53	1k5 1/16W 5%
R0857	0662057A65	4k7 1/16W 5%
R0858	0662057A97	100k 1/16W
R0859	0662057A73	10k 1/16W 5%
R0860	0662057A73	10k 1/16W 5%
R0861	0680194M01	10 1W 5%
R0862	0680194M01	10 1W 5%
R0881	0660076A35	270 5 1/8
R0882	0660076A35	270 5 1/8
R0883	0662057A41	470 1/16W 5%
R0891	0662057A73	10k 1/16W 5%
R0892	0662057A97	100k 1/16W
R0893	0662057A01	10 1/16W 5%
R0894	0662057A01	10 1/16W 5%
R0896	0662057A57	2k2 1/16W 5%
R0897	0662057A65	4k7 1/16W 5%
R0901	0662057A09	22 1/16W 5%
R0902	0662057B47	0 1/16W
R0903	0662057A01	10 1/16W 5%
R0904	0662057A35	270 1/16W 5%
R0906	0662057A89	47k 1/16W 5%
R0912	0662057B47	0 1/16W
R0914	0662057A97	100k 1/16W
R0915	0662057B05	200k 1/16W
R0916	0662057A89	47k 1/16W 5%
R0917	0662057A97	100k 1/16W 5%
R0918	0680149M02	THERMISTOR 100K @25C
R0922	0662057B28	1.8M 1/16W 5%
R0923	0662057A89	47k 1/16W 5%
R0924	0662057A89	47k 1/16W 5%
R0925	0662057A73	10k 1/16W 5%
R0926	0662057A57	2k2 1/16W 5%
R0927	0662057A73	10k 1/16W 5%
R0928	0662057A25	100 1/16W 5%
R0929	0662057A89	47k 1/16W 5%
R0930	0662057B47	0 1/16W
R0931	0662057A49	1k 1/16W 5%
R0932	0662057A49	1k 1/16W 5%
R0933	0662057A49	1k 1/16W 5%
R0934	0662057A25	100 1/16W 5%
R0936	0662057A65	4k7 1/16W 5%
R0937	0662057A65	4k7 1/16W 5%
R0938	0662057A65	4k7 1/16W 5%
R0946	0662057B22	1M 1/16W 5%
R0950	0662057A73	10k 1/16W 5%
R0951	0662057A85	33k 1/16W 5%
R0955	0662057B47	0 1/16W
R0956	0662057B47	0 1/16W
R0957	0662057B47	0 1/16W
R0958	0662057B18	680K 1/16W 5%
R0959	0662057B12	390k 1/16W 5%
R0960	0662057A89	47k 1/16W 5%
U0891	5105469E65	IC VLTG REGLTR LP2951C
U0901	5102226J16	68HC711E20 64PQFP OTP
U0931	5105279V65	TC7S08F
VR0891	4813830A14	5.1V 5% 225mW
VR0901	4813830A15	5.6V 5% 225mW
VR0902	4813830A15	5.6V 5% 225mW
VR0903	4813830A27	14V 5% 225mW MMB
VR0904	4813830A27	14V 5% 225mW MMB
VR0931-VR0934	4813830A15	5.6V 5% 225mW
Y0921	4880113R01	CRYSTAL 7.9488