MAS9191EB

EVALUATION BOARD FOR CELLULAR BASEBAND ICs

- **Audio/Data Processor and all necessary external components**
- **Battery Management IC and battery protection/charging circuit**
- **VCTCXO with DAC voltage control**
- **uP with evaluation software**

DESCRIPTION

The Cellular Baseband evaluation board includes MAS9191A (Audio/Data Processor), MAS9129 (Battery Management) and MS8323 (VCTCXO) ICs with all needed external components and software. The two regulators of MAS9129 provide all the power for the board. The board has BNC connectors for typical MAS9191A interfaces. By using customised software and external RF parts the complete evaluation of an AMPS/ ETACS/ NAMPS phone can be performed. A general purpose micro controller is used to control the MAS9191A internal registers through a serial bus interface. For the micro controller there is 32kB SRAM, 64kB FLASH, an LCD, a keypad and an RS-232-C interface for software downloading to SRAM or FLASH. There is also a direct interface to the MAS9191A serial bus allowing an external controller to be used.

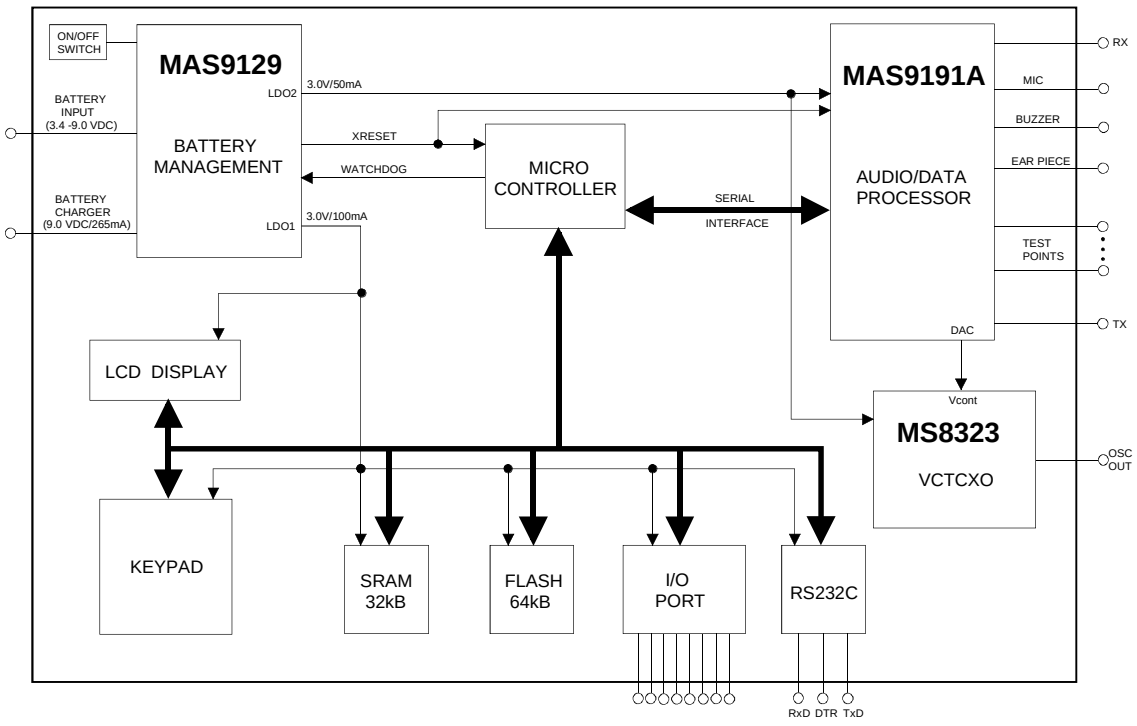
FEATURES

- Fully operational system (only NiCd/NiMH battery or power supply needed)
- Connectors to Rx,Tx,microphone, ear piece, etc.
- Several test points for audio block
- Battery charger input (9.0VDC/265mA)
- Micro controller with 32kB SRAM, 64kB FLASH
- Keyboard and 2-line/16-character LCD
- RS-232-C interface for software downloading
- External micro controller connector
- 3.4 - 9.0 NiCd/NiMH battery input or power supply

MEASUREMENTS

- Regulator voltage and current
- Receive and transmit frequency responses
- Send and receive messages
- Microphone and Rx audio levels
- SAT detection and generation
- Signalling Tone level
- DTMF detection and generation
- Gain control levels
- Expander and compressor functionality
- VCTCXO output signal

BLOCK DIAGRAM



SYSTEM REQUIREMENTS

For the complete evaluation of MAS9191A, MAS9129 and MS8323 ICs the following equipment is needed:

- Cellular Baseband Evaluation Board
- NiCd/NiMH Battery or DC power supply (3.4 to 9.0 VDC)
- Battery charger (9.0VDC/265mA)
- Radio test system (e.g. Marconi 2965)
- RF parts for AMPS/TACS/NAMPS cellular phone or a radio test system with an IF interface
- PC with RS-232-C interface with serial cable (optional)

START UP

Connect the supply voltage or a battery to plus and minus battery terminals. Turn on switch S1 to power up the board. The power consumption of the MAS9129 regulators can be measured by inserting an ammeter between the pins at CM1 and CM2. After powering up the system, the installed evaluation software sets up and the evaluation board is now ready for use. The power down modes of MAS9191A are controlled by register 07_{HEX}. The default values are set by entering Register Write. See the **Register write** function in the next section. Rough testing of the microphone, earphone, and buzzer interfaces can be done with the MAS9191A internal loop back modes. For more detailed evaluation, a radio test set is needed. The board is assembled so that the micro controller will operate at 8.0 MHz. The micro controller can also be operated at 4.8 MHz by inserting jumper P6 and disconnecting parts X2, R23, C50 and C51. Current consumption of MAS9191A is measured at jumper CM3.

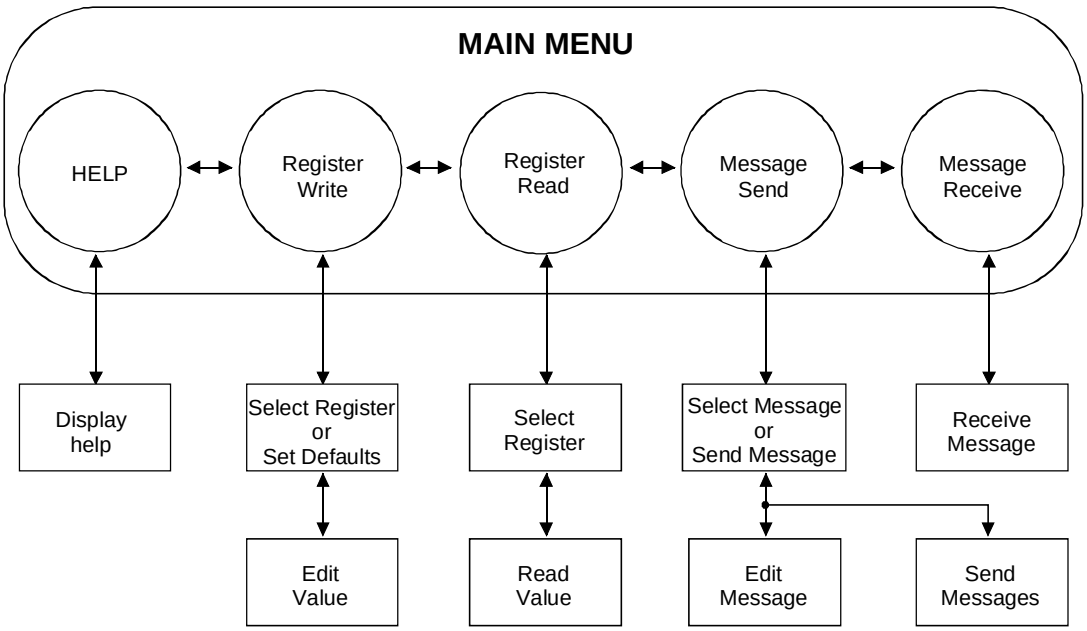
EVALUATION SOFTWARE

The evaluation software has the following features:
- write function for changing the values of the MAS9191A registers
- read function for reading the values of the MAS9191A status registers
- message send
- message receive

A keypad serves as the software interface.
The key definitions are as follows:
- BACKWARD = 4
- TOGGLE = 5
- FORWARD = 6
- EXIT = *
- ENTER = #
- UP = 2
- DOWN = 8

After a reset the internal registers of the MAS9191A are set to zero and the program returns to the main menu, which will display the following message on the LCD:

```
MAS9191EB
Press # for HELP
```



Program flow diagram

EVALUATION SOFTWARE

◆ **Help**

Pressing "#" will display instructions for the keys shown on the LCD. Press EXIT to return to the main menu.

◆ **Main menu**

The FORWARD and BACKWARD keys will select "register read", "register write", "message send" or "message read". The given function is executed by pressing ENTER.

◆ **Register write**

When entering this function the register address will be shown at the top right. After entering the write function, pressing "#' will automatically set the default values (gain controls at nominal levels and necessary switches in proper positions) to measure the transmit and receive frequency responses. The register address can be changed with the FORWARD and BACKWARD keys. The lower line will show the current contents of the register. Press EXIT to return to the main menu. The ENTER key will remove the brackets around the register address and the cursor will move to the first nibble of the hex byte on the lower line. The UP and DOWN keys will increment or decrement the nibble. If the value of the register has been changed there will be an asterisk next to the register address. The FORWARD and BACKWARD keys will move the cursor left and right, respectively. When the cursor points to a bit of a register the TOGGLE key will change the value of the bit. After a bit has been edited the top line will display the function of the bit. The ENTER key will write any new values to the MAS9191A. Press EXIT to exit from the editing mode. If the function is terminated without writing any new values, the previous values are retained.

◆ **Register read**

This function is quite similar to the register write function. The register address is selected with FORWARD and BACKWARD keys from the main menu. The register can be read with the ENTER key. Pressing the ENTER key a second time will update the contents of the status register. The FORWARD and BACKWARD keys will move the cursor and display the function of each bit. Return to the top line or to the main menu with the EXIT key.

◆ **Message receive**

This function waits for 10 messages to be received. When the messages are received they can be examined with the FORWARD and BACKWARD keys. The function can be terminated with the EXIT key. An >N= in the upper right hand corner indicates NAMPS mode.

◆ **Message send**

In this function six messages can be entered. First the desired message number must be chosen with the FORWARD and BACKWARD keys. Then the ENTER key will advance to the edit mode. With the FORWARD and BACKWARD keys the nibbles of each byte can be chosen and the value incremented or decremented with the UP and DOWN keys. The ENTER key will store the message into memory. The EXIT key will move the cursor to the upper row. After all messages are edited the LCD reads "SEND MESSAGES". The ENTER key will move the cursor to the lower row and the FORWARD and BACKWARD keys will choose the message. The TOGGLE key will alternate between the plus and minus signs. The plus sign indicates that the message will be transmitted. When all messages are chosen the ENTER key will start the transmission, and may be done repeatedly. The transmission can be terminated with the EXIT key. An >N= in the upper right hand corner indicates NAMPS mode.

◆**Micro Controller and Interfaces**

The 68HC11 micro controller can be reset with the reset button, with DTR or by switching power off and on. In the last case the voltage regulator internal reset circuit will perform the reset. When the MOD jumper is open the controller executes the software from the FLASH ROM. When the jumper is closed the controller enters the boot-strap mode after reset. In this mode the software which contains the hl.exe program can be loaded into the FLASH ROM or SRAM through the RS-232-C interface. The syntax of the software is:

el [-p<X>] <filename>

Where X is the serial port number: 1 for COM1 and 2 for COM2 and the file name is the same as the S-record file without the extension. For downloading the serial cable with the following connections are needed:

PC		MAS9191A
2	-----	2
3	-----	3
7	-----	7
20	-----	20

More information about the 68HC11 is available from the reference manual.

P9 contains six inputs to the micro controller port PE. These inputs can be used as digital inputs or as analog inputs for the A/D-converter.

When the micro controller is writing to address 0x1FFC and 0x1FFD the data is also written to the LCD command register. Write cycles to memory address 0x1FFD also change the state of the port at 0x1FFE. The port has eight outputs, ground and supply voltage. The maximum load for the power supply pin is 20 mA when operating at 3V. Keypad interface is done with port PA. Pins PA0, PA1 and PA2 are inputs from the 4x3 keypad and pins PA3-PA6 are outputs to the matrix. PA7 is the output pulse for MAS9129 watchdog circuit. All PA outputs are driven with the external buffer IC3.

FUNCTIONS

◆ **Battery Charging**

If a battery is used to power MAS9129, the battery may be charged by connecting the battery charger to the charger input. The battery charging circuit monitors the battery voltage level. When a negative slope in the charging curve is detected, the charging is stopped. The battery will be charged to 1 volt above the nominal battery voltage level. The current into MAS9129 can be monitored by jumper CM4.

◆ **MAS9129 Regulators**

The voltage and current levels of the MAS9129 regulators can be measured at test points CM1 and CM2. Remove the jumper and insert an ammeter to monitor the current values. Regulator 2 is enabled by jumper J2.

◆ **Microphone Interface**

On the evaluation board there are three possibilities for testing the microphone amplifier interface. The first way is with an on-board microphone interface, which may not be used in normal mode, but exhibits one way of implementing an interface to a microphone by using an external anti-aliasing filter. This microphone uses a DC voltage from a basic voltage divider. The diagram for this interface can be found in the schematic section. Another possibility is to use external microphone circuitry with the MAS9191A microphone amplifier using connector J1. This is done by removing the jumpers and connecting the microphone signal to pin 2 and the feedback signal to pin 1. The third possibility is to use the external microphone input EXTMIC. The electrical characteristics of the EXTMIC and MIC pins are found from the MAS9191A data sheet.

◆ **Earphone Interface**

The BNC-type and the header type connectors are assembled for differential type earphone output. An external earphone is supplied with the evaluation board. The board is capable of driving this earphone as well as other models directly at a 3V operation voltage. Use the BNC connector EXTEARP for external earphones. Detailed electrical descriptions of these interfaces are found from the MAS9191A data sheet.

◆ **Buzzer Interface**

The buzzer is driven by transistor Q1. The model of Q1 and the value of resistors R9 and R10 will affect the levels of the buzzer tone significantly. To test an external buzzer, connect it to the buzzer input pin.

◆ **Side Tone Circuit**

The source of the side tone is recommended to be taken from MICOUT of the MAS9191A located at pin T2. The level of the side tone is controlled by the external circuitry shown in the schematic section. The level and the frequency response of the side tone can be controlled by changing the values of components R11, R12,C43 and C44.

◆ **RX and TX Interfaces**

Two BNC connectors allow easy interface to RF sections or to a radio test system. The transmit audio signal as well as DTMF, ST, SAT and send messages may be monitored at the Tx connector. The receive audio signal as well as SAT and receive messages are measured by applying the signals to the RX connector. There are 22nF DC blocking capacitors on both interfaces. The electrical characteristics can be found from the MAS9191A data sheet.

◆ **Microphone and Rx Audio Level Measurement**

The two internal operational amplifiers of the MAS9191A are used to measure audio levels. The level measurement is done with the circuit shown in the schematic section. The level detection output is monitored by the micro controller A/D converter. To examine the operation of the level detector, measure test points T6 and T7.

◆ **Test Points**

There are seven test points along the Rx and Tx audio section. These test points can be used to measure gain control levels and the performance of the compressor, expander, limiter and all filters. The pin description section defines all test points.

◆ **CTRL Interface**

The CTRL connector consists of the control signal TXCTRL for the transmitter and two test indicators BUSY and TXON. TXCTRL is an open collector output and is low only when a transmission collision occurs. After a collision TXCTRL goes to a high impedance state and the TX block of the MAS9191A is reset with TXRST.

◆ **Three 8-bit DAC Outputs**

The DAC connector contains a direct interface to the three MAS9191A internal 8-bit DACs.

◆ **MAS9191A Serial Bus Interface**

The five row jumper for the MAS9191A serial bus to the micro controller is normally closed. Remove the jumpers for external control. The STB, SCL, SRXD, STXD and XINT signals are located at pins 1, 2, 3, 4 and 5 respectively.

◆ **MS8323 Output Frequency**

The output frequency of the VCTCXO can be measured from test pin OSCOUT. The DAC1 output from MAS9191A is the voltage control for the VCTCXO which adjusts the output frequency. Jumper J3 connects DAC1 to V_{CONT}. The current consumption of the VCTCXO can be measured through jumper CM5.

CONNECTOR DESCRIPTION

Connector name	Pin	Function
Battery	NiCd Battery or external DC power supply capable of driving at least 200 mA current is connected to battery input.	
	B+	Positive supply voltage from 3.4 V to 9.0V DC.
	B-	Ground.
S1	ON/OFF power switch for MAS9129 voltage regulators.	
CM1	This jumper is normally closed, but can be opened to use an external current meter to measure the power consumption of the digital section.	
	1	Regulator 1 output.
	2	VDD input.
CM2	This jumper is normally closed, but can be opened to use an external current meter to measure the power consumption of the analog section.	
	1	Regulator 2 output.
	2	VDD input.
MIC	The microphone is normally connected to this connector. See the microphone function.	
	1	Microphone input.
	2	Ground.
J1	The internal/external microphone select switches.	
	1	Microphone amplifier feedback signal. Connect to pin 3 to use the mounted microphone. Otherwise, connect the external microphone circuit feedback signal to this pin.
	2	Microphone amplifier input. Connect this to pin 4 to use the mounted microphone. Otherwise, connect the external microphone output signal to this pin.
	3	Feedback signal input for the assembled microphone circuit.
	4	Microphone output signal for the assembled microphone circuit.
J2	Use jumper to enable regulator 2.	
EXTMIC	BNC-type connector for external microphone source.	
	1	External microphone input.
	2	Ground.
T2	MICOUT signal is the output from the section which contains the following blocks: Filter F8, Gain Control GC3 and Filter F9. The source for the signal is either from SGND, Microphone amplifier A6, EXTMIC input or from DTMF generator.	
T3	COUT is the compressor output signal. The compressor and all the blocks before T2 can be measured by using this test point.	
T4	LPFIN test point can be used as an output to measure gain controls GC4 and GC5, the filter F10 and all the blocks before T3.	
T5	TAUDOUT is the output from the TX audio block.	
CM3	1	VDD from regulator 2.
	2	MASVDD. Power input for MAS9191A. Current measurement point.
CM4	1	Battery and charging voltage output.
	2	Power input for MAS9129. Current measurement point.
CM5	1	VDD from regulator 2.
	2	Power input for MS8323. Current measurement point.

CONNECTOR DESCRIPTION

Connector name	Pin	Function
TX	BNC-type connector for IF output.	
	1	TX output signal, which can contain data, audio, SAT and Signalling tone.
	2	Ground.
T6	Output of the peak level detector circuit for MICOUT. See Op Amp schematic.	
T7	Output of the peak level detector circuit for EXPIN. See Op Amp schematic.	
RX	BNC-type connector for received IF signal.	
	1	RX signal input from the external IF source.
	2	Ground.
T8	DEOUT is the de-emphasis filter output. The output can be used to measure blocks GC1, F1, F3 and F4. Special test modes can be used to connect the outputs of the filter F2 and comparators C1 and C2 to this output.	
T9	RBPFIN input.	
T10	EXPIN is the test point where expander input can be measured.	
T11	EXPOUT test point can be used to measure the expander output.	
EXTEARP	BNC-type connector for external ear piece.	
	1	The output signal for the external ear piece.
	2	Ground.
EARP		Connector for the ear piece. Note that there are already capacitors C41 and C42 connected to the ground on each output signal.
	1	Differential output for the ear piece.
	2	Differential output for the ear piece.
BUZZER	Buzzer interface. Connect the external buzzer between these points.	
	1	Power supply voltage from connector T1.
	2	Q1 collector.
DACs	This connector contains the MAS9191A DAC outputs. MAS9191A has three 8-bit DACs.	
	DAC1	Output of DAC 1. This output is also connected to Vcont input of the VCTCXO.
	DAC2	Output of DAC 2.
	DAC3	Output of DAC 3.
	GROUND	System ground.
OSCOUT	MS8323 VCTCXO output frequency	
J3	Use jumper to connect DAC1 output to MS8323 Vcont input.	
CTRL	TXON	Transmission is active when output is high.
	BUSY	RECC is busy if pin is low.
	TXCTRL	Open-drain type output. The output goes low when a transmit collision occurs. In any other case the output is in a high impedance state.

CONNECTOR DESCRIPTION

Connector name	Pin		Function
SBUS	MAS	uP	The SBUS interface. When using an external uP, leave the jumpers open and connect the external uP to pins 1,2,3,4 and 5.
	1	10	STB is the strobe signal input for the MAS9191A. Connect the pins together when on-board uP is used.
	2	9	SCL is the serial clock input for the MAS9191A. Connect the pins together when on-board uP is used.
	3	8	SRXD is the received data input for the MAS9191A. Connect the pins together when on-board uP is used.
	4	7	STXD is the transmit data output from MAS9191A. Connect the pins together when on-board uP is used.
	5	6	XINT interrupt line from MAS9191A. Connect the pins together when on-board uP is used.
P4			This connector has six pins, which are connected to micro controller port E. All the pins are inputs for the micro controller. The pin can either be an analog input for the uP internal A/D-converter or general purpose digital input.
	1		Input PE2.
	2		Input PE3.
	3		Input PE4.
	4		Input PE5.
	5		Input PE6.
	6		Input PE7.
P5	This connector is closed when MAS9191A generates the clock to the uP. In this case C50,C51, X2 and R23 should not be mounted.		
	1 and 2 shorted		uP uses 4.8MHz clock from MAS9191A.
	1 and 2 open		uP uses crystal X2

P2 — Keypad connector. The keypad is a 4 x 3 matrix, which has the following truth table. The outputs are driven by 74HC244.

Key	Output				Input		
	PA6	PA5	PA4	PA3	PA2	PA1	PA0
1	1	1	1	0	1	1	0
2	1	1	1	0	1	0	1
3	1	1	1	0	0	1	1
4	1	1	0	1	1	1	0
5	1	1	0	1	1	0	1
6	1	1	0	1	0	1	1
7	1	0	1	1	1	1	0
8	1	0	1	1	1	0	1
9	1	0	1	1	0	1	1
•	0	1	1	1	1	1	0
0	0	1	1	1	1	0	1
#	0	1	1	1	0	1	1

CONNECTOR DESCRIPTION

Connector name	Pin	Function	
P7		LCD connector. The HD44780 LCD controller command register exits at address 0x1FFC and the data register is at address 0x1FFD.	
	1	Ground.	
	2	+5Vdc power supply.	
	3	Contrast control.	
	4	Register select. Connected to uP line A0 = address 0.	
	5	LCD enable input.	
	6	R/W input. Connected to ground. Always in write mode.	
	7	Data line 0.	
	8	Data line 1.	
	9	Data line 2.	
	10	Data line 3.	
	11	Data line 4.	
	12	Data line 5.	
	13	Data line 6.	
	14	Data line 7.	
RAM MEMORY	FLASH	P6	Physical Flash memory area
0-7FFFH	8000H	1-2	8000H-FFFFH
0-7FFFH	8000H	2-3	0000H-7FFFH
P8	The digital output port at address 0x1FFE.		
	1	Ground.	
	2	Data output 0.	
	3	Data output 1.	
	4	Data output 2.	
	5	Data output 3.	
	6	Data output 4.	
	7	Data output 5.	
	8	Data output 6.	
	9	Data output 7.	
	10	VDD	
P3	RS-232-C interface.		
	2	Received data from DTE.	
	3	Transmit data to DTE.	
	7	Data terminal ready input. Note that this line can be used to reset the entire evaluation board.	
	20	Signal ground.	

ELECRICAL CHARACTERISTICS

◆ **Digital Inputs**

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input voltage high PE2-6, PA0-2	V_{IH}	V_{DD}=3V"5%	0.7xV_{DD}		V_{DD}+0.3	V
Input voltage low PE2-6, PA0-2	V_{IL}	V_{DD}=3V"5%	GND-0.3		0.2xV_{DD}	V
Input capacitance	C_{in}	V_{DD}=3V"5%			8	pF

◆ **Digital outputs**

Output Voltage high, port 1FFE, keypad	V_{OH}	V_{DD} =4.5V I_{OH}=-6mA	3.84			V
Output Voltage low, port 1FFE, keypad	V_{OL}	V_{DD} =4.5V I_{OL}=6mA			0.33	V
Output Voltage high, LCD interface	V_{OH}	V_{DD}=4.5V I_{OH}=--0.8mA	V_{DD}-0.8			V
Output Voltage low, LCD interface	V_{OL}	V_{DD} =4.5V I_{OI}=1.6mA			0.4	V

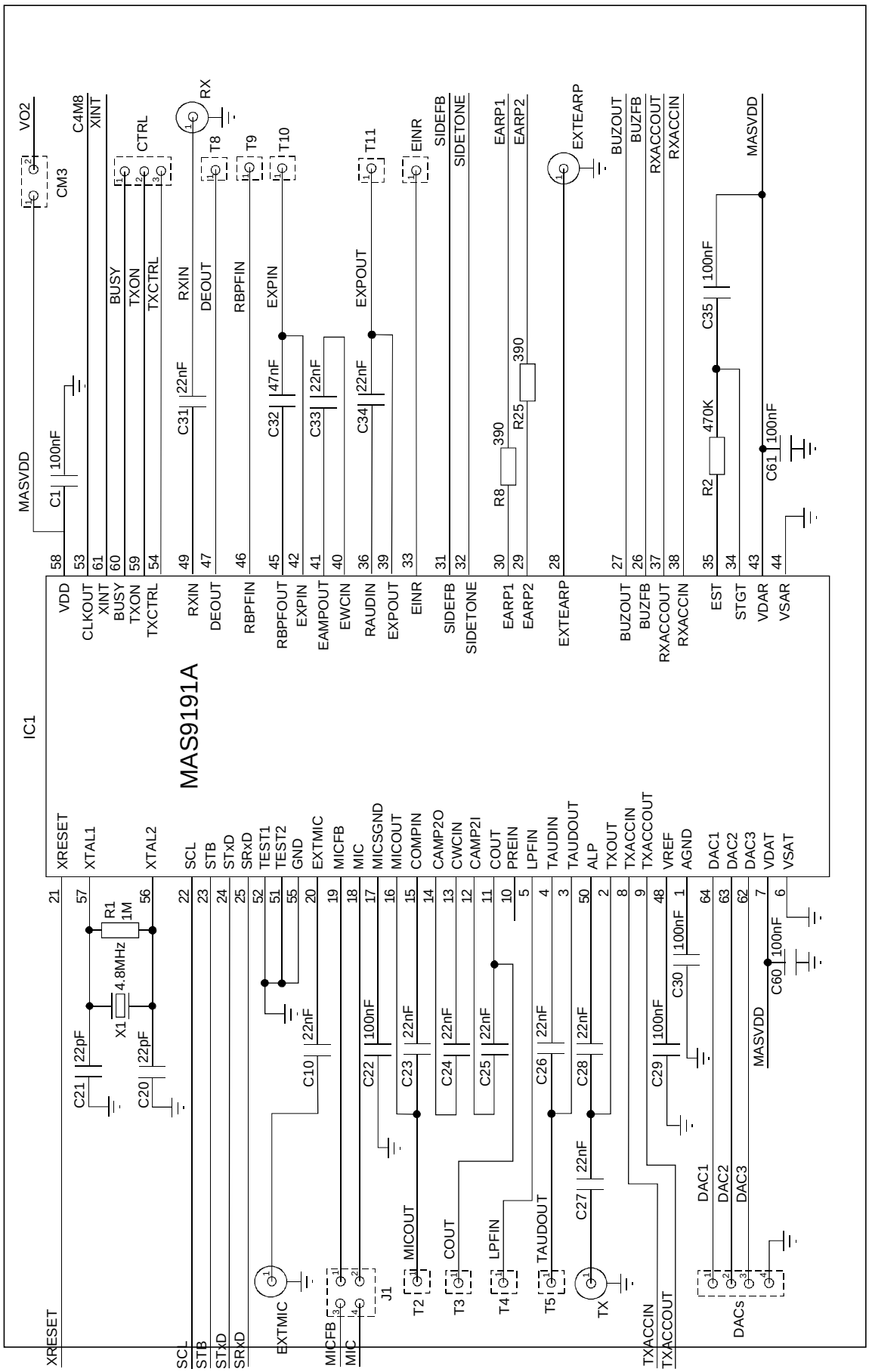
◆ **Analog inputs**
The characteristics of the MIC, EXTMIC, RX, IFIN, SIDE TONE etc. can be found from the MAS9191A data sheet.

◆ **Analog outputs**
The characteristics of the DAC1-3, TX, EARP, BUZZER, MICFB, SIDEFB etc. can be found from the MAS9191A data sheet.

RECOMMENDED OPERATING CONDITIONS

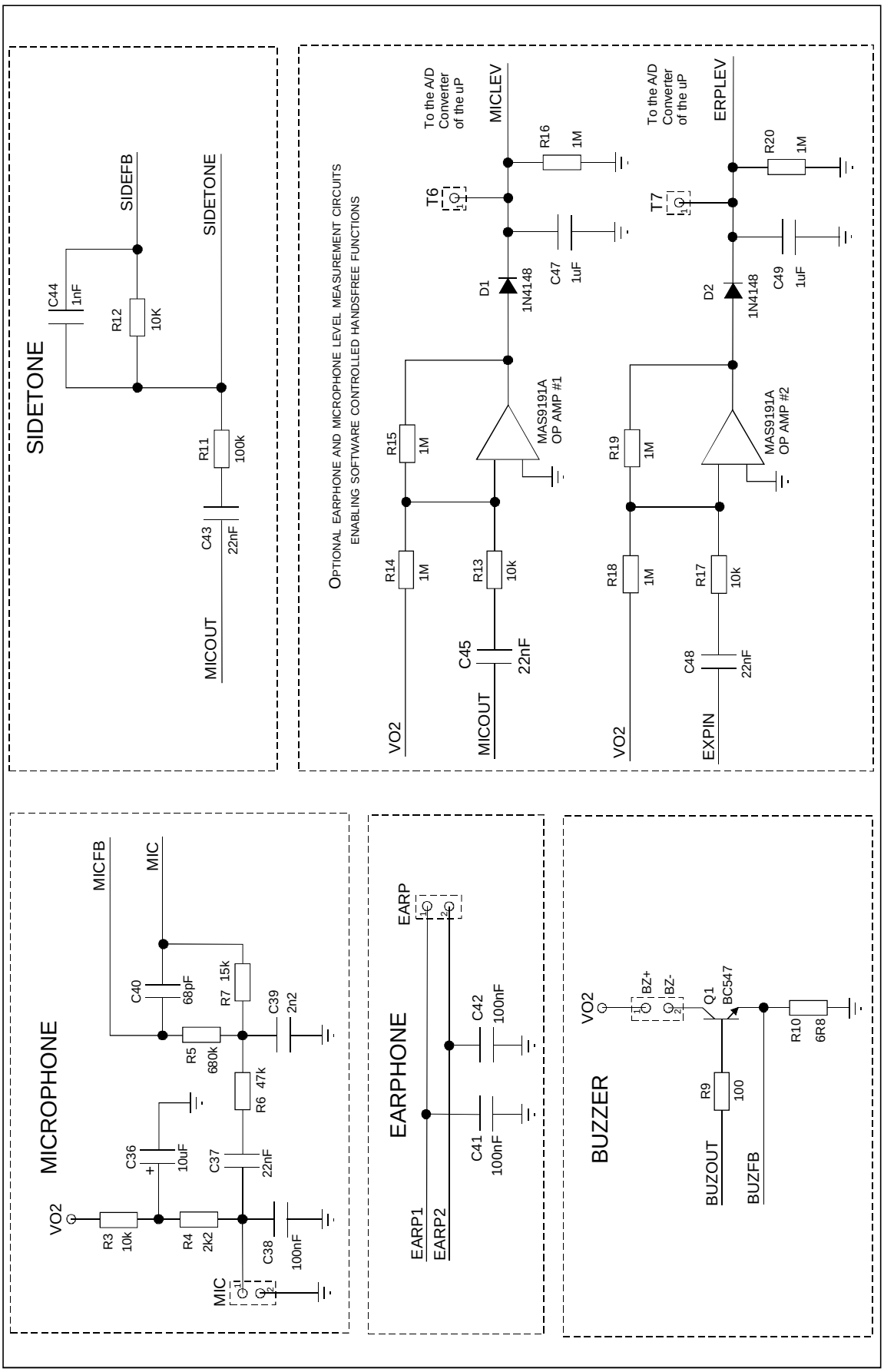
Parameter	Symbol	Conditions	Min	Max	Unit
Supply Voltage			3.4	9.0	V
Storage Temperature	Ts	With LCD module	-20	70	^{o}C
Operating Temperature	To	With LCD module	0	50	^{o}C

SCHEMATIC DIAGRAMS

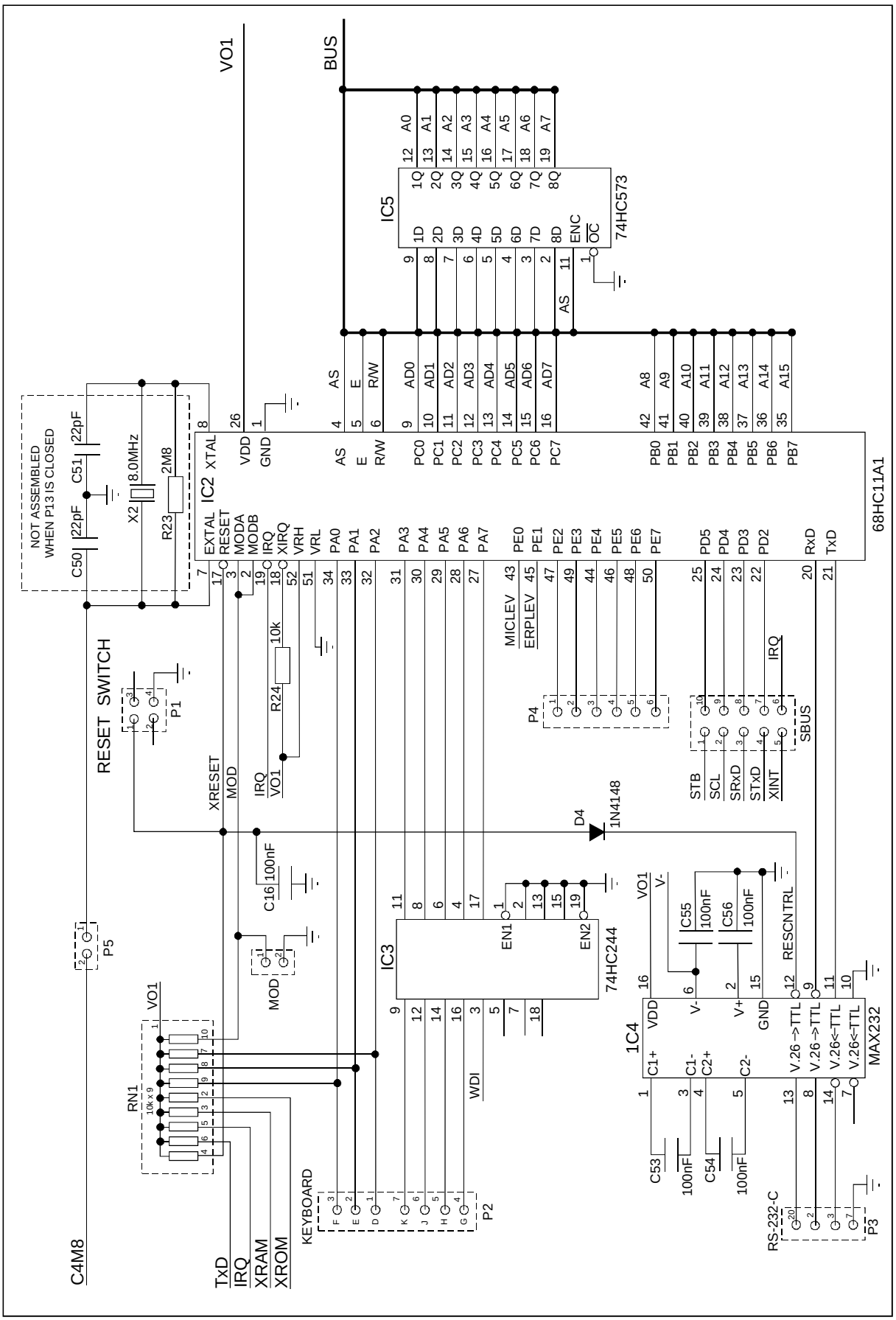


MAS9191A

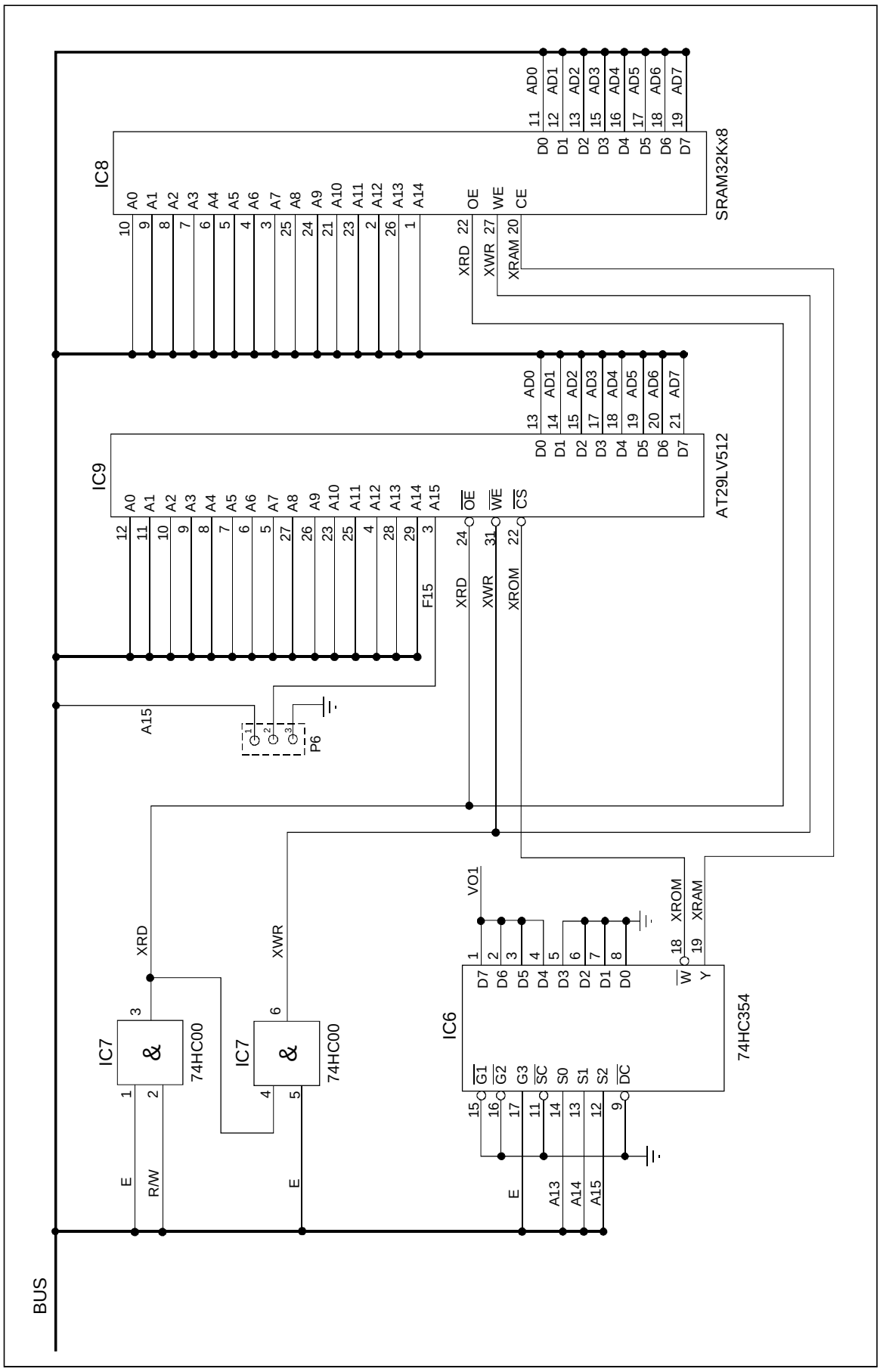
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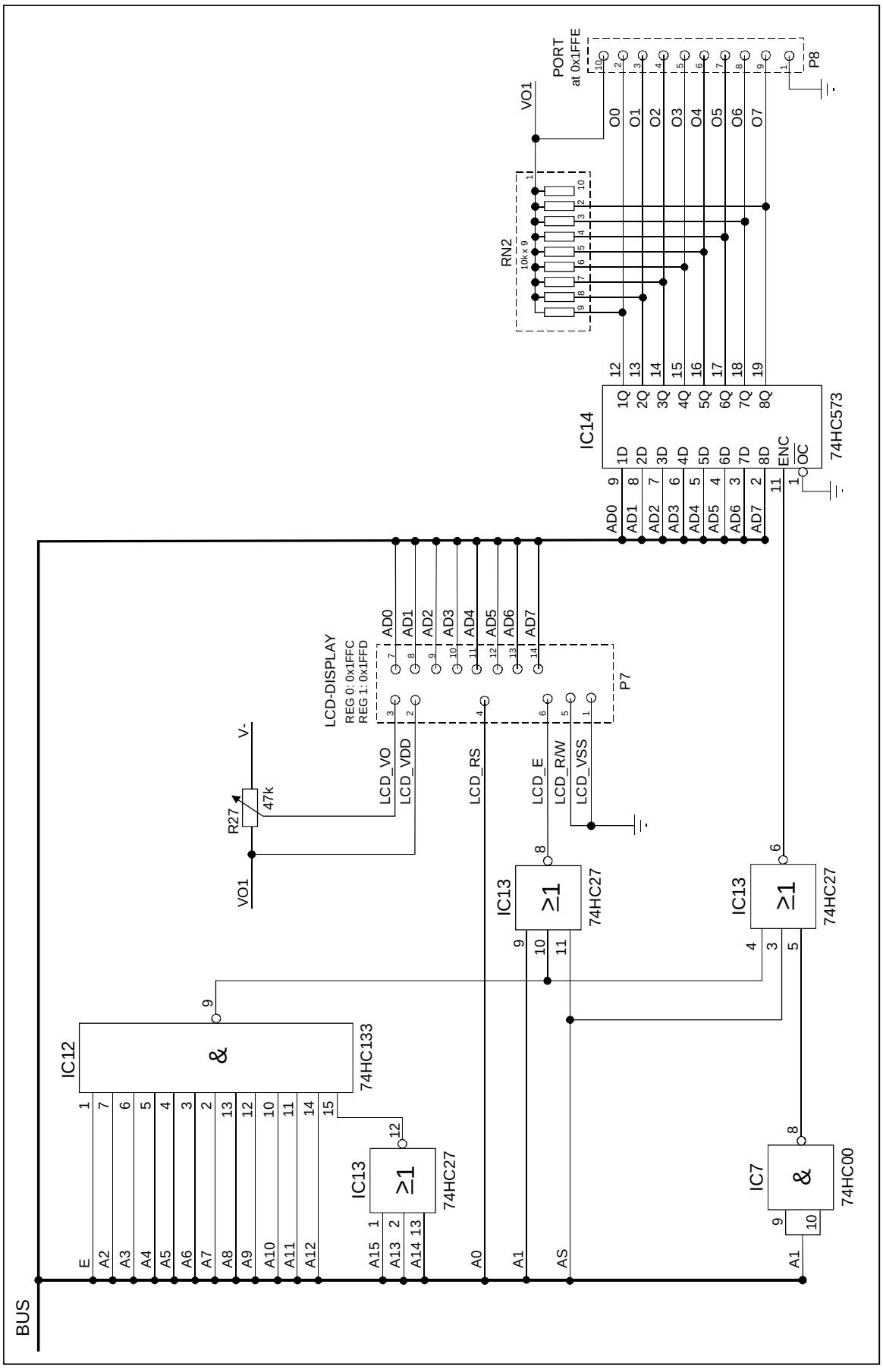
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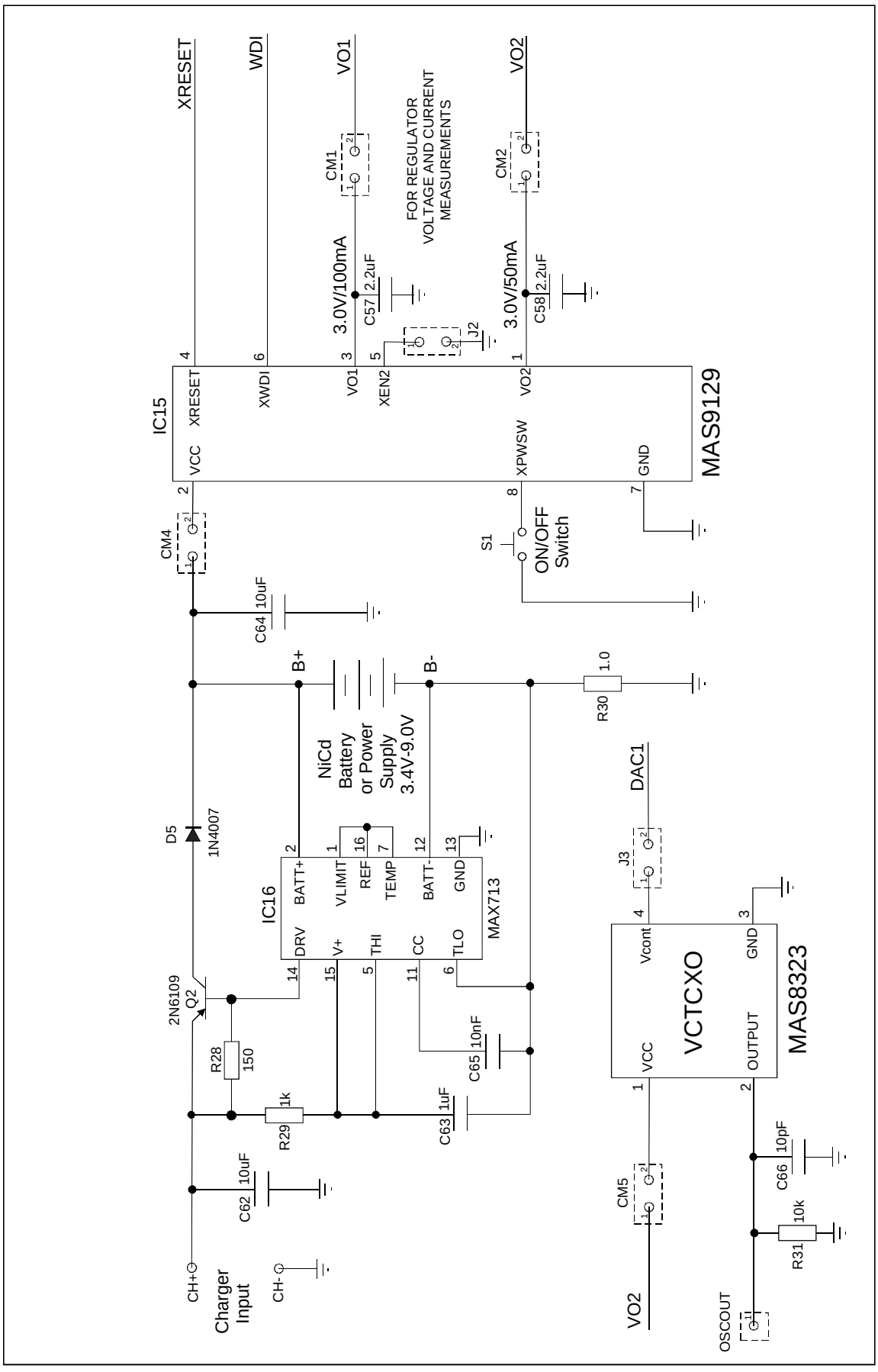
SCHEMATIC DIAGRAMS



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ORDERING INFORMATION

Product Code	Product	Comments
MAS9191EB	Evaluation Board for MAS9191A, MAS9129, and MAS8323	The kit includes: PCB, software and documentation

LOCAL DISTRIBUTOR

MICRO ANALOG SYSTEMS OY CONTACTS

Micro Analog Systems Oy
Kamreerintie 2, P.O.Box 51
FIN-02771 ESPOO, FINLAND

Tel. (09) 80521
Tel. Int. +358 9 80521
Telefax +358 9 8053213
E-mail: info@mas-oy.com

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