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RC-210 Repeater Controller

Hardware Manual

Hardware Version 2.5

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TABLE OF CONTENTS

Introduction

Congratulations on your purchase of the RC-210 Repeater Controller. By harnessing the power of state-of-the-art RISC microprocessor technology in a sophisticated 3 port design and the resulting reduction in required components, the RC-210 provides your repeater with a rugged, reliable and expandable controller with features usually found in controllers costing hundreds of dollars more.

The RC-210 continues the Arcom tradition started with our RC-110 Repeater Controller by making updates to the operating firmware available for free to purchasers of the RC-210. As updates become available, they are posted on our website and available free of charge to any RC-210 owner. Installing updates requires no more than a computer running Windows 95/98/NT/2000/XP with a parallel (printer) port. With the RC-210, you just download the free update and upload it into your RC-210 in minutes!

Features

- Three port design - Each port may be operated independently with its own hang time, ID's and Courtesy Tones.
- Selectable Control Receiver port which has complete priority.
- Selectable Monitor Mute/Monitor Mix audio for each link port and selectable cross linking ability between ports
- Each port may be defined as half or full-duplex
- 240+ word vocabulary in real human speech for command confirmation and radio status
- On-board DVR for recording your own custom messages over the air (may be used in any programmable message)
- Fully programmable command codes up to 8 digits each
- Automatic ID rotation with Initial and Pending ID's and timers.
- Programmable CW messages, tone, speed
- Gated audio on all ports with selectable de-emphasis - you may tap directly off the discriminator without regard for squelch action or de-emphasis on any port
- True sine wave microprocessor generated tones
- Use of low-noise, high-impedance JFET op amps for exceptional audio quality
- 40 Macros that can store up to 15 commands each, including other macros
- Each port has its own dedicated DTMF decoder
- Selectable CTCSS/Carrier squelch modes on all ports.
- Each port may be defined to require CTCSS or not require CTCSS for DTMF operation
- Selectable Enable/Disable of DTMF on all ports
- Selectable polarity of COS and CTCSS signals on each port
- Selectable CTCSS encode control output with programmable delay dropout for controlling external CTCSS encoder on each port

- Frequency agile Remote Base operation, including transmitter offset and CTCSS selection.
- 8 A/D inputs for voltage or current measurements with 6 custom definable meter faces
- 3 auxiliary audio inputs for use with a weather receiver, autopatch or other external audio source
- A/D inputs protected against over or negative voltages
- Scheduler with 20 setpoints
- Choice of DB9 or RJ45 connectors for radio port connection.
- 5 digital inputs
- LED displays of controller status
- 7 user controllable digital outputs for remote control - expandable to 64
- Programmable timers, including hang time, timeout and ID interval
- Hardware watchdog timer
- Fan control with programmable shut off timer

Description of Features

The RC-210 provides 3 radio "ports", each of which may be operated independently or in unison with the others. With simple programming, each port can be configured as follows:

A Standalone Repeater

A signal received on that port's receiver is retransmitted out that port's transmitter. Each port has its own independent hang timer, timeout timer, 10 courtesy tones and dedicated DTMF decoder, so you may operate one RC-210 to control 3 independent repeaters. On command, any port may be tied to any other port for linking purposes.

Half-Duplex Or Full-Duplex Link

If a port is configured as half-duplex, a signal received on that port's receiver is NOT retransmitted out that port's transmitter. Through DTMF commands, the receiver's COS (and CTCSS signal, if so equipped) and audio is routed to either - or both - of the other ports. This is useful for linking to other sites or connecting your system to an EchoLink©, IRLP© or other such system.

Control Receiver

Port 3 may alternately be configured for use as a control receiver. If so configured, this port has priority over all DTMF decoders and transmit audio.

Remote Base

Any port can be used for a remote base - a half-duplex (or simplex) radio connected to the repeater system that allows the repeater users to remotely operate on a different frequency/mode/band than the repeater. Frequency, transmitter offset and CTCSS may all be remotely programmed over the air. The RC-210 also supports control of Kenwood mobiles that provide for DTMF control through their microphone port. The complete list of supported remote base radios can be found in Appendix A.

Regardless of how you configured a port, each one provides all signals needed for the radio connected to it (COS, transmit and discriminator audio, CTCSS encode and decode). You have a choice of either DB9's or RJ45 modular jacks as your radio port connector. COS and CTCSS decoder input polarity is selectable through easy-to-use push-pin jumper blocks, so the RC-210 can accommodate just about any radio available.

Audio gating is provided on each radio port so you may obtain audio directly from the receiver's discriminator without the worry of finding a source of gated audio in the receiver. De-emphasis is also provided on each port. However if you don't need de-emphasis on any particular port, it's a simple matter to change a jumper (no soldering required) and obtain "flat" audio (20 hz to 15Khz) throughout the audio chain. The use of low-noise JFET operational amplifiers ensures good gain, high input impedance, and very clean audio.

DTMF tones are normally muted on ALL ports however you can turn off muting on a port-by-port basis. This allows for passing DTMF tones out a link.

Any port can be used for entering DTMF commands, even programming commands for other ports. Since each port has its own, dedicated DTMF decoder, a command can be entered from any port uninterrupted regardless of activity on other ports.

Many timers are provided, such as repeater transmitter hang time, timeout, ID intervals, how long the cooling fan should remain on after the transmitter unkeys, and more. These timers are remotely programmable.

The RC -210 incorporates true human speech. A custom, repeater oriented vocabulary is provided for use in IDs, alarm and other controller messages. In addition, the on-board digital voice recorder allows the recording of up to 20 custom recordings which may also be used in these messages.

All parameters of the controller can be remotely programmed using DTMF. Timers, control codes, port configuration and messages can all be changed at the whim of the repeater owner. All the command codes may be programmed to your own, special and unique code. This makes the RC-210 very easy to incorporate into existing systems without users having to relearn code structures. All parameters are stored in non-volatile EEPROM, so your settings are retained even if the controller loses power.

The controller's programming is protected from unauthorized access by the use of 3 different 5-digit secret passcodes - one used for each port. Each port may be programmed independently without affecting the others.

The RC -210 represents all numbers in standard decimal notation. In other words, you don't need to worry about converting programming parameters to hexadecimal notation before actually programming anything.

There are 7 buffered general-purpose digital outputs also provided that can be used to remotely control devices at the repeater. Alternately these outputs can be programmed to perform other tasks. With the addition of simple external shift registers, these can be expanded to 64 outputs.

The controller uses flash memory to store its operating program. Just plug your computer into the RC -210's programming port and you can upload updates in minutes.

A Word About Identification

The RC-210 provides an intelligent algorithm for ID sequences to minimize disruption to ongoing repeater communications, while providing entertaining messages and meeting FCC requirements for repeater identification.

If the repeater has not been in use for a period of time and a new user keys the repeater, the controller will ID after he unkeys with one of the three Initial ID messages (these messages automatically rotate). This message could say "Welcome" followed by the callsign, or some other such "friendly" message.

After the Initial ID is finished, the Pending ID timer starts to run. After it times out, it looks to see if any repeater activity has occurred since the Initial ID played. If there has been activity and no user is currently talking, the Pending ID is played. Otherwise, the controller waits for no user and then will send the Pending ID message.

Initial ID's are voice identifications while Pending ID's are done in cw to minimize disruption to users.

Specifications

Microprocessor:	Atmel ATMega128 RISC processor running at 16 Mhz
Program Memory:	128K Bytes - Flash EEPROM
Running Memory:	4K Bytes RAM, 4K Bytes EEPROM
Speech Method:	ISD 4003 series VoiceCorder© IC
Logic Inputs:	Low < .8 volts
	High: 5 to 15 volts
Analog Inputs:	0 - 5 vdc maximum
Logic Outputs:	90v @ 500 ma open collector
Audio Inputs:	High impedance >10K
Audio Outputs:	up to 6 volts p-p
Power Requirement:	11.5 to 15V dc @ 60 ma.
Operating Temp:	-15 to +55 degrees C (5 to 150 degrees F)
Board size:	9.0 x 5.2 inches (9.0 x 5.4 inches including connectors)
Connectors:	Phoenix 4 pin power connector (mating plug included with RC-210)
	DB-25 female for I/O and A/D. Radio ports are DB9 or RJ45

Hardware Reference

Power

The RC-210 requires anywhere from +11.5 to +15 vdc at 60 ma. This voltage source should be clean, filtered DC. Power connection is made through a Phoenix power connector and the mating plug is included with the RC-210. There is no need to worry about using a fuse, as the RC-210 is protected by an on-board, self-resetting fuse. Once the overload condition is cleared, the fuse will automatically reset.

Table 1 shows the connections.

Table 1

Pin Number	Description
1	+11.5 to 15 V DC @ 60 ma
2	Battery backup
3	Digital Gnd
4	Analog Gnd

There are two grounds provided to prevent digital noise from appearing on the audio channels - digital ground and analog ground. ***It is important that these two grounds are kept separate and run directly to the negative (-) terminal of the power source. Failure to do so could result in noise appearing on the audio outputs.*** The battery backup pin may be used to insure the controller remains powered during power outages. This will allow the RC-210 to continue to function and the on-board real time clock will not lose time. If this connection is made, the RC-210 automatically and instantaneously switches power.

Carrier Operated Switch

The signal from the receiver which indicates that a signal is present is called COS. The RC-210 can accommodate a COS signal that presents either a logic high (5 to 15 volts dc) or a logic low (< .8 vdc) when a signal is present. Table 2 shows the settings of the corresponding jumpers.

Table 2

Jumper	Description	Pins 1 & 2	Pins 2 & 3
JP1	Port 1 CTCSS	Active Low	Active High
JP2	Port 1 COS	Active Low	Active High
JP3	Port 2 CTCSS	Active Low	Active High
JP4	Port 2 COS	Active Low	Active High
JP5	Port 3 CTCSS	Active Low	Active High
JP6	Port 3 COS	Active Low	Active High

The RC-210 presents a high impedance on its logic inputs (>10K ohms), you can choose a point in the receiver without concern that the controller will "load it down". These specifications apply to all logic inputs used with the RC-210.

Sub-Audible Tone Decoder

In addition to the COS signal, the controller can optionally use a signal derived from an external CTCSS (*continuous tone controlled squelch switch*) decoder on each port. If this option is used, the controller can be commanded to require users to use sub-audible tone with their transmissions on that port. The RC-210 accomodates either a logic high (5 to 15 vdc) or a logic low (< .8 v) when a valid tone is detected. This is set using the jumper settings, as shown in Table 2.

Push-To-Talk

The controller provides a solid-state switch closure to ground, capable of sinking 500 ma from a positive source at a voltage of up to 100 vdc. This should accommodate just about any radio on the market.

Receiver Audio

Audio from the receivers needs to be supplied to the controller and is controlled by a crosspoint switch matrix under microprocessor control. Each receiver's audio is routed to the appropriate transmitter(s) as needed.

The audio circuitry in the controller allows for a variety of signal levels and impedances. It is capacitively coupled, which means that a dc level may be present on the signal provided. The level is internally adjustable, so a fairly wide range of levels is acceptable, but for best results the level should be between .5 and 2.5 volts peak-to-peak. This should accommodate just about any receiver.

The input impedance is high (>10K) , so that audio may be picked off anywhere inside the receiver without loading problems. Supplied audio does not need to be de-emphasized nor gated, as the controller takes care of this for you. If you choose a point inside the receiver that is already de-emphasized, you can remove the jumper to disable the controller's de-emphasis circuitry. In this case the controller's audio input stage will provide flat audio. Table 3 shows how to configure these jumpers

Table 3

JUMPER	PORT #	DE-EMPHASIS	FLAT
JP10	1	ON	OFF
JP11	2	ON	OFF
JP12	3	ON	OFF

Transmitter Audio

Audio is supplied from the controller to the various transmitters. This audio consists of receiver, speech and tone audio, switched and mixed under control of the CPU in the controller.

The audio is high level and medium impedance, so it's easy to find a good place to inject it into the transmitter. The high level minimizes hum and noise pickup and may be knocked down at the transmitter if necessary. However the level is internally adjustable and this option should rarely be necessary. The output is capacitively coupled, so you connect it without concern of dc voltage at the point of connection to the transmitter.

DTMF Decoders

Each port has its own dedicated DTMF decoder, with each decoder being connected full time to its respective port. DTMF may be entered at any time from any port without regard to activity on the other ports. The controller will store the commands and act on them in the order they were received.

The exception to this is if Port 3 has been defined as the control receiver port. In this case if there is an active signal on that port, it will have total priority over DTMF and other functions (this is explained in detail in the Control Receiver section of this manual).

Indicator LEDs

LED's are provided for monitoring all the Port's COS, CTCSS, PTT and Valid DTMF signals. These can be useful for setting up and verifying operation of these various signals and are marked directly on the PC board.

In order to reduce power consumption when the LEDs do not have to be powered up, the push-on jumper on JP14 may be removed. If mounting the RC-210 in a cabinet, a switch may be connected to JP14 to allow the operator to conveniently turn the LEDs on and off as needed.

Expansion Connectors

There are several pin header connectors on the PC board which allow for easy access to several data lines in the RC-210. The connectors and their pinouts are as follows:

Auxiliary Audio Inputs

These inputs allow you to add external audio devices without using one of the radio ports. For example, you could connect a weather receiver to one and be able to monitor weather conditions on demand. If the weather receiver has an output that is triggered when a S.A.M.E. Alert is issued, you can use one of the Alarm inputs on the RC-210 to automatically trigger one (or all) of the transmitters.

The Auxiliary Audio Inputs do not provide any means for adjusting their level, so you must provide this capability in your interface between your audio source and the RC-210. The impedance of these inputs is approximately 20K and the level should be adjusted to approximately 100 mv peak-to-peak.

J8 - DTMF EXPAND		J7 - I/0 EXPAND		J9 - AUDIO EXPAND	
Pin 1	BCD Output Q1	Pin 1	Shift Register Data	Pin 1	Digital Gnd
Pin 2	BCD Output Q2	Pin 2	Shift Register Clock	Pin 2	Vcc (+5)
Pin 3	BCD Output Q4	Pin 3	Shift Register Latch	Pin 3	Record input to ISD
Pin 4	BCD Output Q8	Pin 4	LED Serial Data	Pin 4	Auxiliary Audio Input 3
Pin 5	Decoder Strobe Port 1	Pin5	Vcc (+5)	Pin 5	Auxiliary Audio Input 2
Pin 6	Decoder Strobe Port 2	Pin 6	Digital GND	Pin 6	Auxiliary Audio Input 1
Pin 7	Decoder Strobe Port 3				
Pin 8	Decoder Select Port 1				
Pin 9	Decoder Select Port 2				
Pin 10	Decoder Select Port 3				

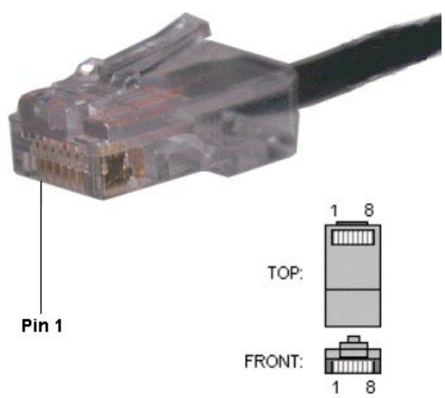
The RAC/LED Header - JP13

In normal operation, JP13 ***must*** have a jumper installed between Pins 2 & 3. Failure to have this jumper in place will prevent the Digital Voice Recorder (DVR) from functioning properly.

Radio connections

Each port connector provides all connections needed for your radios. The RC-210 comes with two versions of connectors - DB9 computer style connectors or RJ45 modular jacks.

9-Pin	RJ-45	Direction	Name/Description
1	1	-----▶	**CTCSS Encode** Control OUT
2	2	◀-----	**CTCSS Decoder** Logic IN
3	3	-----▶	**TX PTT** radio control OUT
4	4	-----▶	**TX Audio** output to radio
5	**8**	◀-----	**RX Audio** input from radio
6	6	◀-----▶	Ground
7	7	◀-----	**RX COS** Logic IN
8	**5**	◀-----▶	Ground
9		◀-----▶	Ground



Note: RX Audio is Pin 5 on DB9, and Pin 8 on RJ-45 and
GND is Pin 8 on DB9 and PIN 5 on RJ-45 on RC-210 Rev 2.5

I/O Connections

The RC-210 supports connecting external devices (other than radios of course) by the use of a DB25 connector. The pinout is as follows:

Pin	Name	Description	Pin	Name	Description
1	AD1	Analog Channel 1	14	UF6	Logic Output 6
2	AD2	Analog Channel 2	15	UF7	Logic Output 7
3	AD3	Analog Channel 3	16	IN1	Logic Input 1
4	AD4	Analog Channel 4	17	IN2	Logic Input 2
5	AD5	Analog Channel 5	18	IN3	Logic Input 3
6	AD6	Analog Channel 6	19	IN4	Logic Input 4
7	AD7	Analog Channel 7	20	IN5	Logic Input 5
8	AD8	Analog Channel 8	21	N/C	Vcc (+5 for ADC reference)
9	UF1	Logic Output 1	22	SI	Serial Data In (future use)
10	UF2	Logic Output 2	23	SO	Serial Data Out (future use)
11	UF3	Logic Output 3	24	Fan	Fan Output
12	UF4	Logic Output 4	25	GND	Analog Ground
13	UF5	Logic Output 5			

Analog Inputs

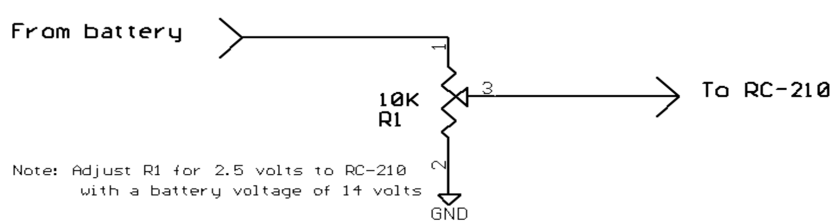
The RC-210 allows you to connect external analog devices and readback their value on command. This is typically used for remote monitoring of such things as backup battery voltage, transmitter power, etc. There are 8 "meters" corresponding to the 8 Analog inputs. There are 6 meter faces you may define (this is explained in the Programming section) to any of these meters; the selection of which properly scales the reading as well as properly "announcing" the meterface when readback of the value is requested.

Volts
Amps
Watts
Degrees
MPH
Percent

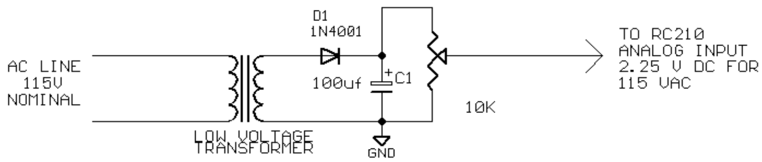
NOTE: While these inputs are protected against reasonable overload conditions, care should nevertheless be taken never to apply a voltage that exceeds +5.2v or any voltage that is below ground (negative).

Voltage

The major task involved in using a meter face is to design a sensor circuit that generates a sensor voltage in the approximate range of 0 to 5 Vdc that is linearly related to actual physical measurement, such as a 12 volt battery. A simple device to measure battery voltage would be a 10K potentiometer (pot). The actual voltages would be across the entire pot, and the sensor voltage would be taken off the wiper. To adjust the pot correctly, it might be set to produce 2.5 volts output at the wiper when 20 volts is put across the entire 10K. Since the typical battery used in a repeater is unlikely to produce 20 volts, this would be a safe “transducer” or sensor circuit for a typical 12 volt battery.



Or perhaps you'd like to monitor AC line voltage:



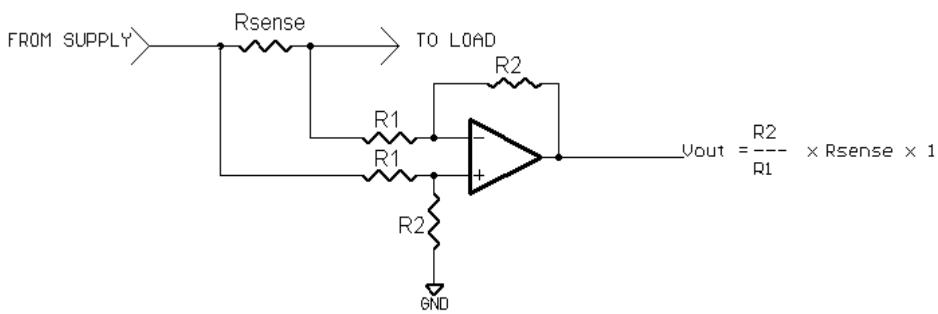
Current

Measuring current requires a circuit which develops a voltage proportional to current. This can easily be accomplished with a small value current sensing resistor and a differential type operational amplifier and 4 resistors. The output of the op amp is equal to the current times the value of the sensing resistor, times the voltage gain of the amplifier. The value of the sensing resistor that should be used depends on the maximum load current, since the4 voltage drop across the resistor reduces the voltage to the load. BE sure to calculate the worst caser power dissipation of the resistor (I^2R) and use an appropriately rated resistor.

Ideally, a power supply with remote sensing would be used, with the sense return after the sensing resistor. This way, the voltage drop through the sensing resistor would be compensated for by the power supply.

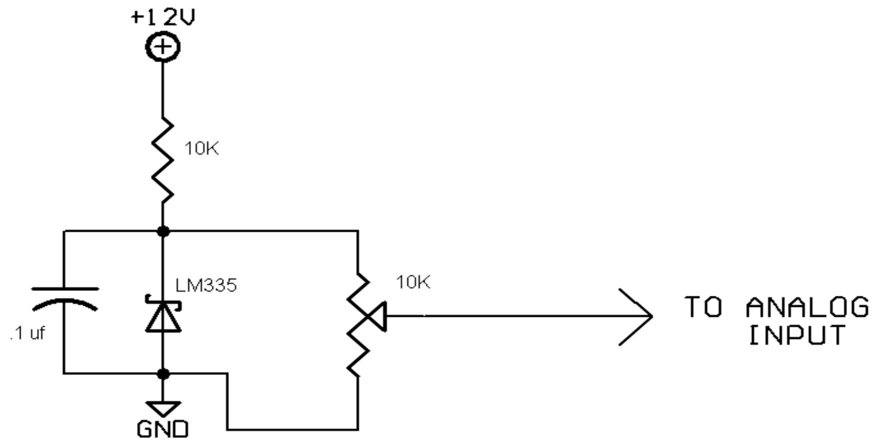
The 4 resistors used in the op amp circuit should be 1% metal film types. Be sure that the common mode input voltage range of the op amp will accommodate the operating voltages that result from the resistor/gain selection. For example, an LM324 or LM358 op amp, operating at a single ended supply of +12 will operate properly with input voltages between 0 and 10 volts.

The following shows how to measure current



Measuring Temperature

It's a simple matter to measure temperature at the repeater site, using an LM335 Precision Temperature Sensor. The LM335 is electrically like a zener diode with a precision temperature/voltage characteristic. It will provide a resolution of ±2 degrees.

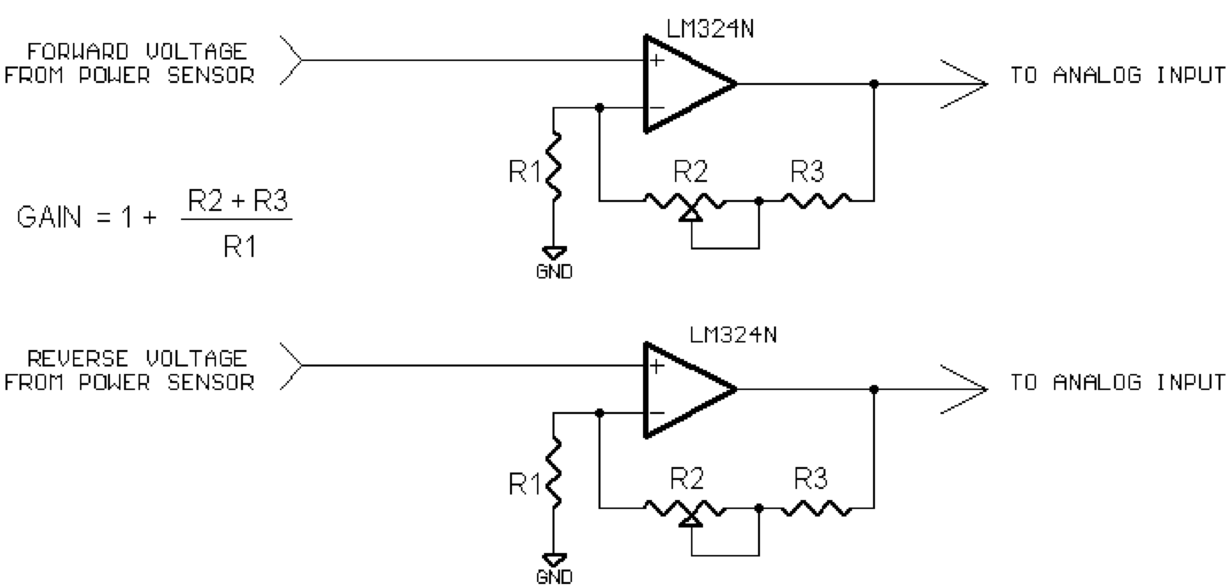


Measuring Power

Power is different than other types of measurements in that meter deflection is not linearly proportional to power level. The scale is expanded out at the low end and "compressed" at the high end. This is due to the fact that power is proportional to voltage or current squared (this is known as a *logarithmic* scale). The power meter face in the RC-210 takes this into account when taking a measurement.

Many watt meters provide a dc voltage output relational to forward and reflected power. In this example, we'll show how to use these outputs to interface to the RC-210.

Resistors are selected on the basis of the power level to be measured to provide 0 to 5 volt dc levels to the controller's analog inputs and should be adjusted for accurate reading at the normal power level.



Alarms

The RC-210 incorporates 5 alarm logic inputs that when used with the proper sensors, can monitor various things around the repeater site. For example, you could install a switch on the door to the building, so you'd know when someone opens the door. More details may be found in the Programming Reference section of this manual.

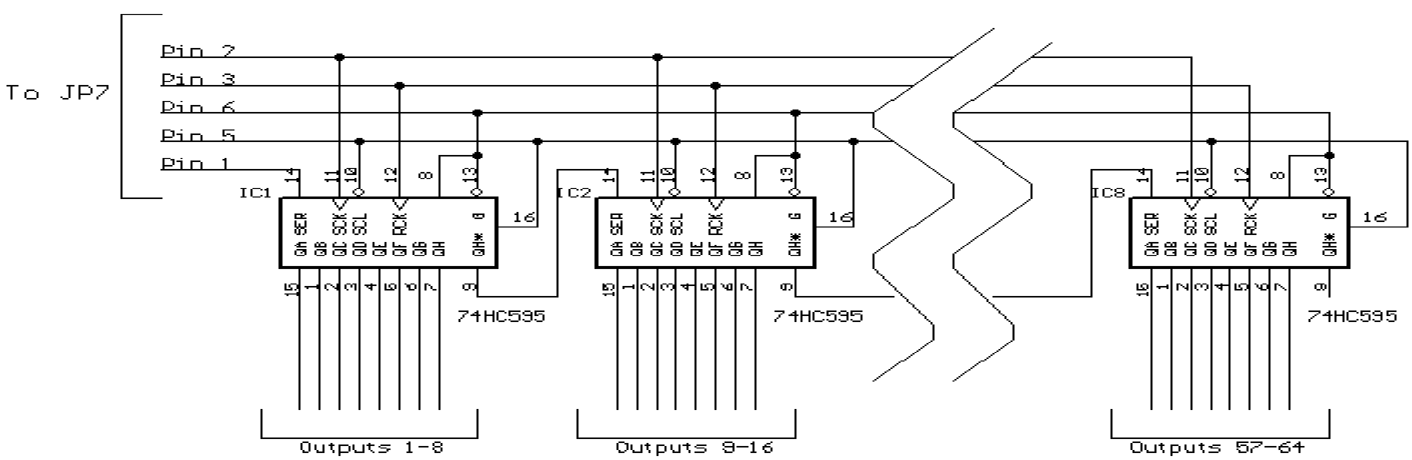
All logic inputs are triggered on a logic low (pulled to ground) and remain triggered until that Alarm is turned off. In other words, if the trigger signal is only momentary, the Alarm will remain triggered even though the input signal returns to its non-triggered state, until it is manually (or by a macro) turned off. More details may be found in the Command Reference section of this manual.

<u>WARNING: NEVER apply more than +5 volts to any logic input pin.</u>

Logic Outputs

The RC-210 provides 7 general purpose outputs (expandable to 64) that you can use to switch electronic devices on and off at your repeater site. While these outputs are buffered by open collector transistors, care should be used so as not to exceed their ratings (90V dc @ 500 ma). If you're switching an inductive load, be sure to use a quenching diode across it.

If you need more logic outputs, you can connect external shift registers and obtain up to 64 outputs. Fig 1 shows how this can be accomplished.



Only some of the stages needed to recover those functions have to be used. Each shift register used adds 8 outputs. So if you only need an additional 16 outputs (above and beyond the 7 "on-board" outputs), you only need add 2 stages. If you want all additional 64, you'll need a total of 8 shift registers (74HC595). Remember that these outputs are logic level and cannot drive loads.

The outputs of the shift registers cannot drive outside devices directly. You will need some kind of driver in order to drive other than TTL level devices. When an output of the shift register is selected by command, that output goes to a logic high.

A good option would be to use a ULN2003A Darlington array transistor array, which can drive up to half an amp (500 ma) load at a voltage of up to 90vdc.

Fan Output

The controller also provides a switched fan output that can be used to control a cooling fan for the repeater transmitter. To avoid unnecessary wear and tear on the fan, the fan only comes on when any transmitter is keyed, and remains on for 1 to 60 minutes after the last transmitter drops. The amount of time the fan remains on is selected in programming mode.

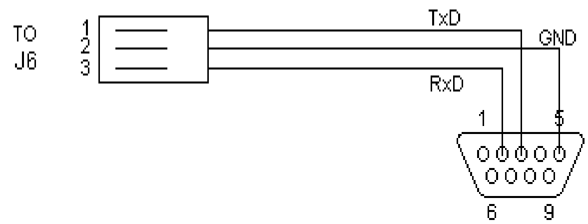
This output is not meant to drive a fan directly, but rather an external relay or driver transistor which is then used to drive the fan. It's signal is available on Pin 24 of J1, the I/0 connector

Serial Data Input/Output

The RC-210 supports the use of remote base radios that require RS-232 EIA levels. Many radios on the market allow for direct connection to a computer's comport. ***Note: For radios that don't support direct connection to a computer, you'll need a level converter. Either homebrewed or one of the many commercially available ones.***

To make the connection, you use the RS-232 serial connector (J6) on the RC-210 and the "computer" connector on your radio. In order to make this connection, you will need to fabricate a cable with a DB9 male on one end and a 3 pin header connector on the other. It is suggested you use a shielded cable.

DB9 Pin	3 Pin Header Pin J6
2	1 (Txd)
3	3 (Rxd)
5	2 Gnd



Audio Delay Expansion Headers

Audio from the receiver buffers is routed through pin header connectors on the PC board to allow connection of the Arcom *repeater audio delay* (RAD) board. This board provides a selectable amount of audio delay (from 1 ms to 60 seconds), which removes DTMF bursts and squelch tail crashes from the transmitted audio. If the board is not connected, there must be jumpers in place between the two center pins (pins 2 & 3) of JP6, JP7 and JP8 to complete the audio path from receivers to the crosspoint switch.

Checking COS And PTT Operation

Once connections are made, the next step is to verify that COS and PTT are operating properly. There are a series of LED's on the RC-210 that are used to indicate the status of various functions. Their function is marked on the PC board. They may be turned off to save power when you don't need them by removing the jumper from JP14. By observing the LED's, you can easily verify COS, PTT, CTCSS and DTMF operation.

Setting Audio Levels

Refer to the PCB layout at the end of this manual while making adjustments. If you do not have a signal generator or oscilloscope, you might want to explore the use of a Sound Card based Audio Spectrum Analyzer program available from InterFlex Systems Design Corporation. It can be helpful to measure audio levels, look for distortion, twist in the DTMF tones, etc. See the appendix for details.

Using a signal generator, generate a signal on the receiver's frequency with 1000 Hz modulation @ 3 Khz deviation. Keep in mind that for best quality audio and to avoid clipping, we want the minimum amount of amplification necessary. An oscilloscope should be used to measure the voltage. Following the Table 5, adjust the appropriate trimpot for a level of .75 volt peak-to-peak at the corresponding test point.

Table 5

PORT	TRIMPOT	TESTPOINT
1	"Port1 Disc"	TP1
2	"Port2 Disc"	TP2
3	"Port3 Disc"	TP3

Once the receiver levels are adjusted, it's time to adjust the transmitter audio levels. While still generating a signal on the receiver frequency, adjust the corresponding trimpot for +/- 5 Khz of the appropriate transmitter.

Table 6

PORT	TRIMPOT
1	"P1 Tx"
2	"P2 Tx"
3	"P3 Tx"

Using a radio equipped with a DTMF pad, transmit on the receiver frequency and while transmitting a DTMF tone (it is suggested you use either a "3" or a "5" for this adjustment, as these are the most difficult tones to decode. The corresponding LED should light with every DTMF key press.

> *Note: If you don't have access to test equipment, you can temporarily adjust the receiver buffer trimpots to the midpoint and adjust the transmit trimpots so the repeated audio "sounds the same" as does your radio when transmitting direct. But be sure to set these levels with the proper test equipment before deploying your repeater!*

The Tone trimpot adjusts the level of courtesy tones and CW ID's. You should adjust it for +/- 3 Khz deviation.

The Play trimpot adjusts the level of the output of the speech chip. You can adjust this for a comfortable level while the controller is speaking (you can enter a command that causes the controller to speak in order to adjust this level).

Note: If you have set the discriminator and transmit audio levels correctly, the levels of tones and speech should be identical on all 3 ports.

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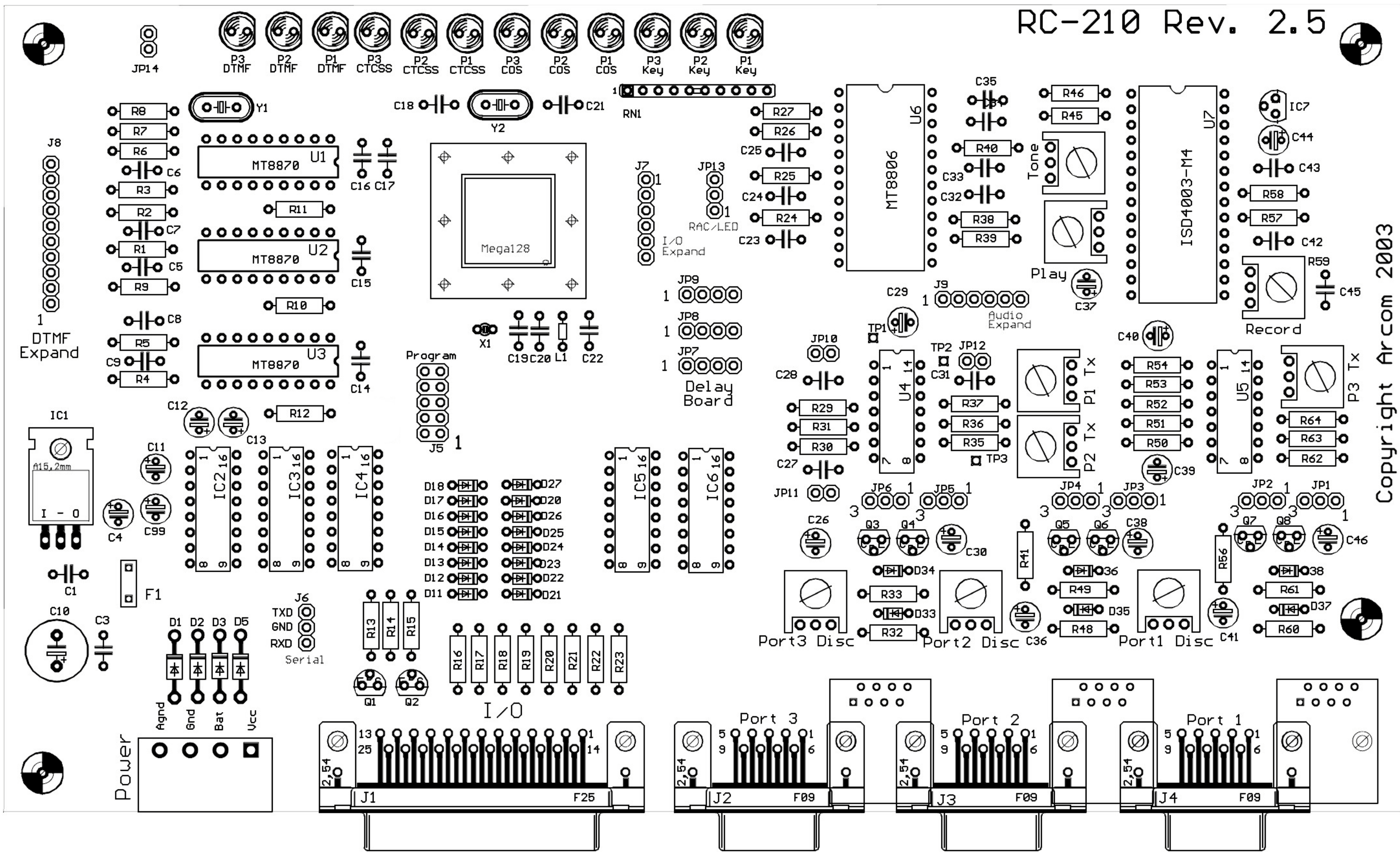
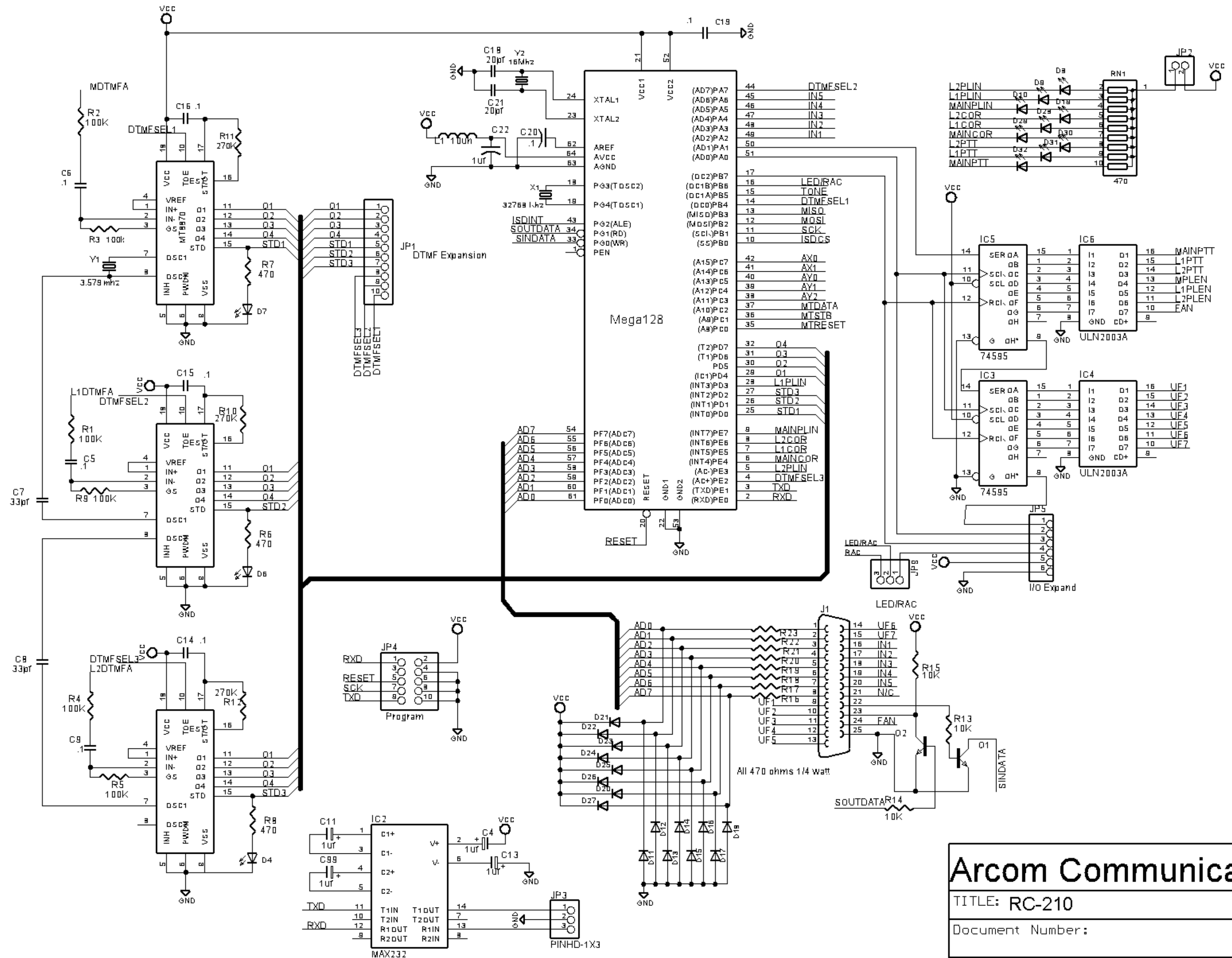
PC Board Component Layout





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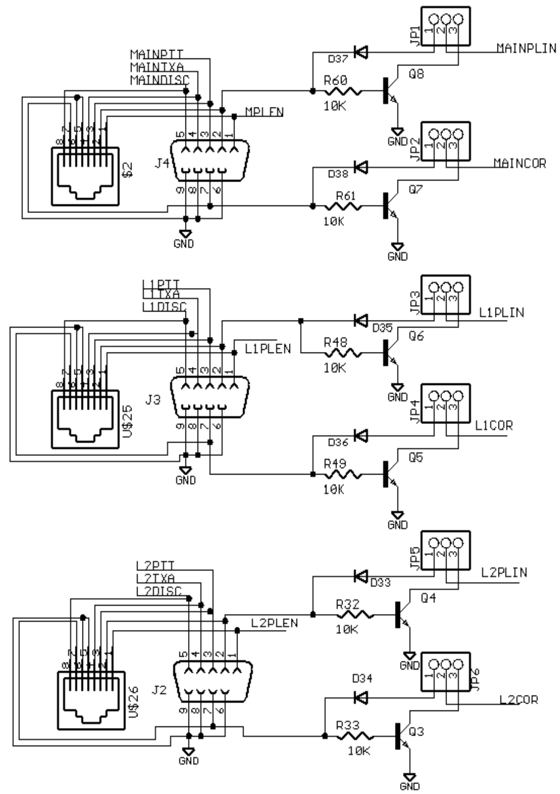
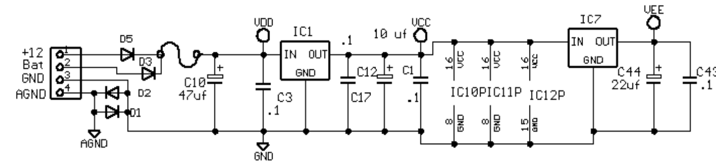
Date: 6/17/2003

Sheet: 1/3





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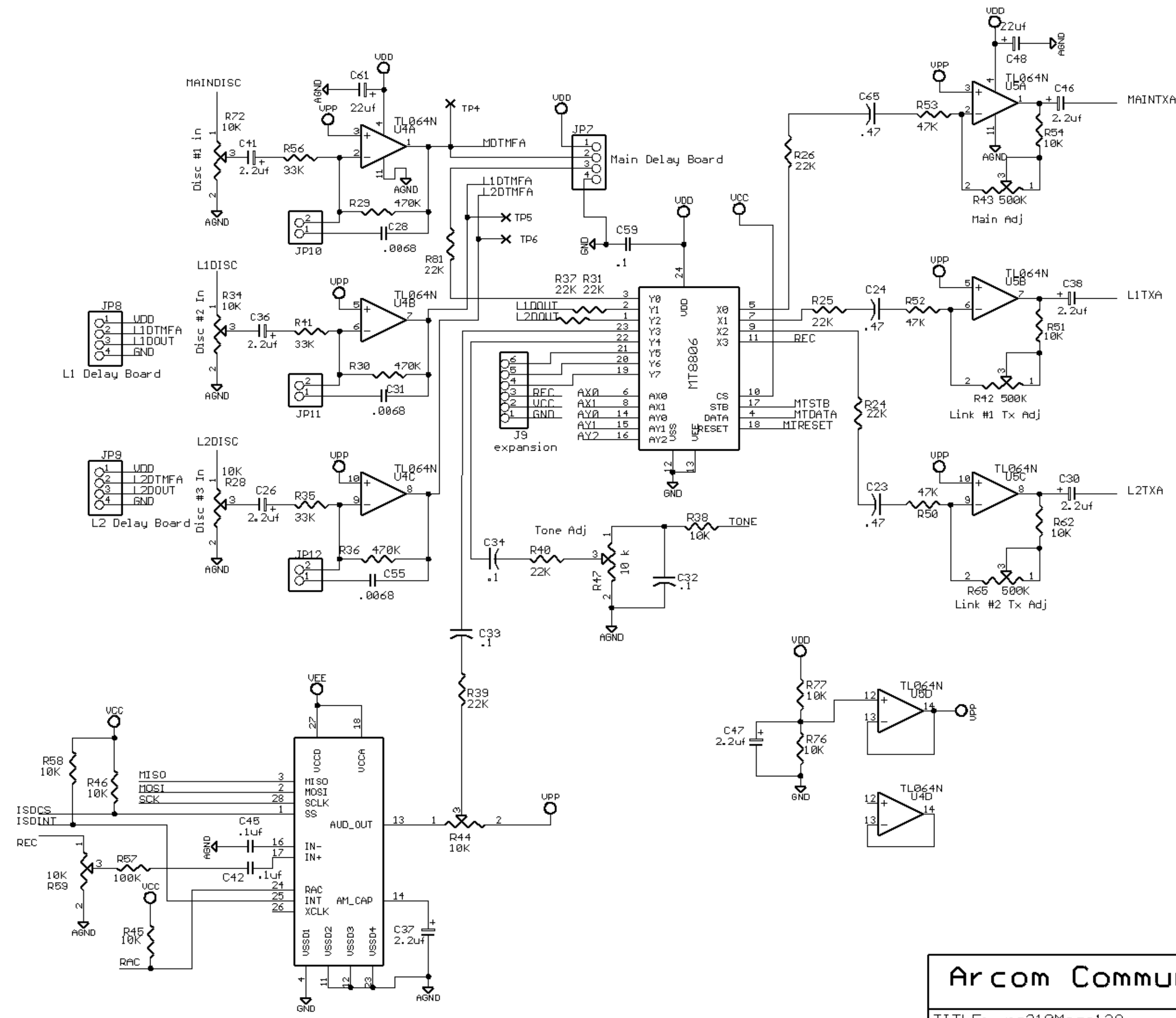
Sheet: 3/3



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