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RC810 Repeater Controller Hardware Manual May 1, 2008

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Introduction

Congratulations on your purchase of the ground breaking Arcom RC810 Repeater Controller. The RC810 provides your repeater system with a rugged, reliable and expandable controller.

Arcom was the first controller manufacturer to provide easy field firmware upgrades and the RC810 continues this tradition by making updates to the operating firmware available for free to purchasers of the RC810. As updates become available, they are posted on our website and available free of charge to any RC810 owner. Installing updates requires no more than a computer running Windows 95/98/NT/2000/XP with a serial (or USB) port. With the RC810, you just download the free update and upload it into your RC810 in minutes!

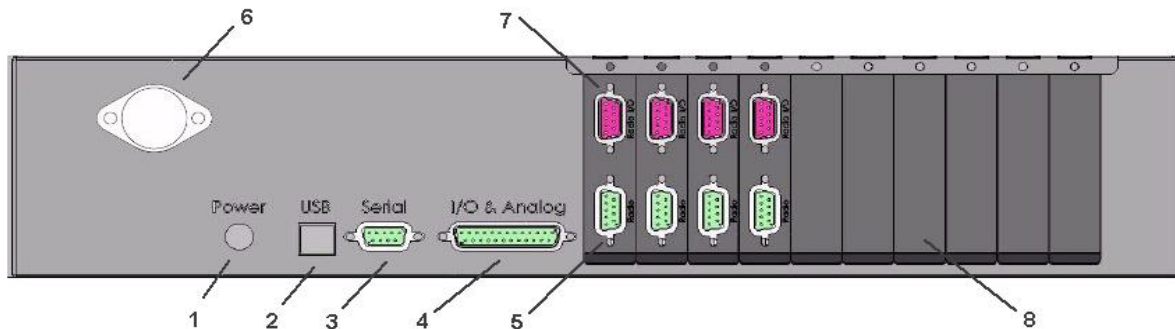
All inputs and outputs of the RC810 are RF filtered and protected against overvoltage and short circuits.

The RC810 utilizes a Motherboard / Daughterboard configuration. The Motherboard contains the power supplies, filtering, real time clock and calendar (and their battery backup), 8 channels of Analog-to-Digital (A/D) inputs. Alarm (logic) inputs and outputs and serial/USB ports. In addition, the Motherboard provides supervisory functions to the Radio Cards by routing audio and control signals between the Cards in order to provide for linking functions.

The Motherboard also provides additional storage space for Command Macros, Scheduler Setpoints and other firmware related features.

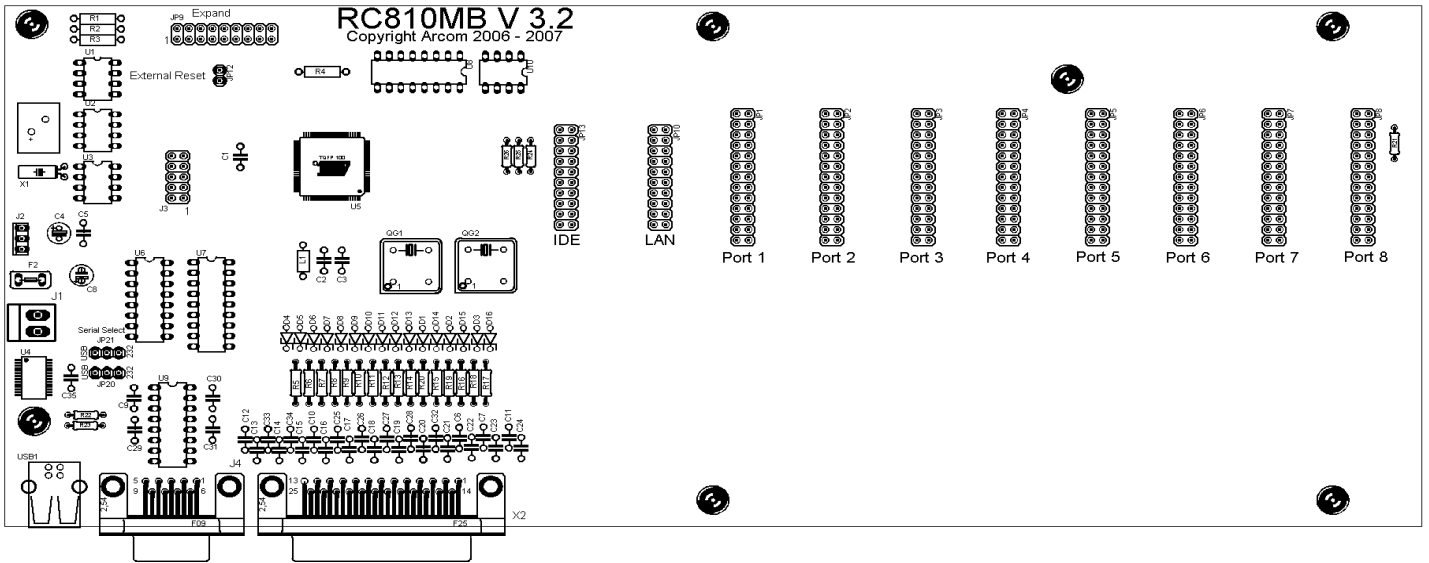
All adjustments and LED displays are accessible through a removal sub panel on the front panel of the rack mount enclosure. This means you can install the RC810 without regard to allowing any room above or below the controller, thereby saving valuable rack space.

Connections



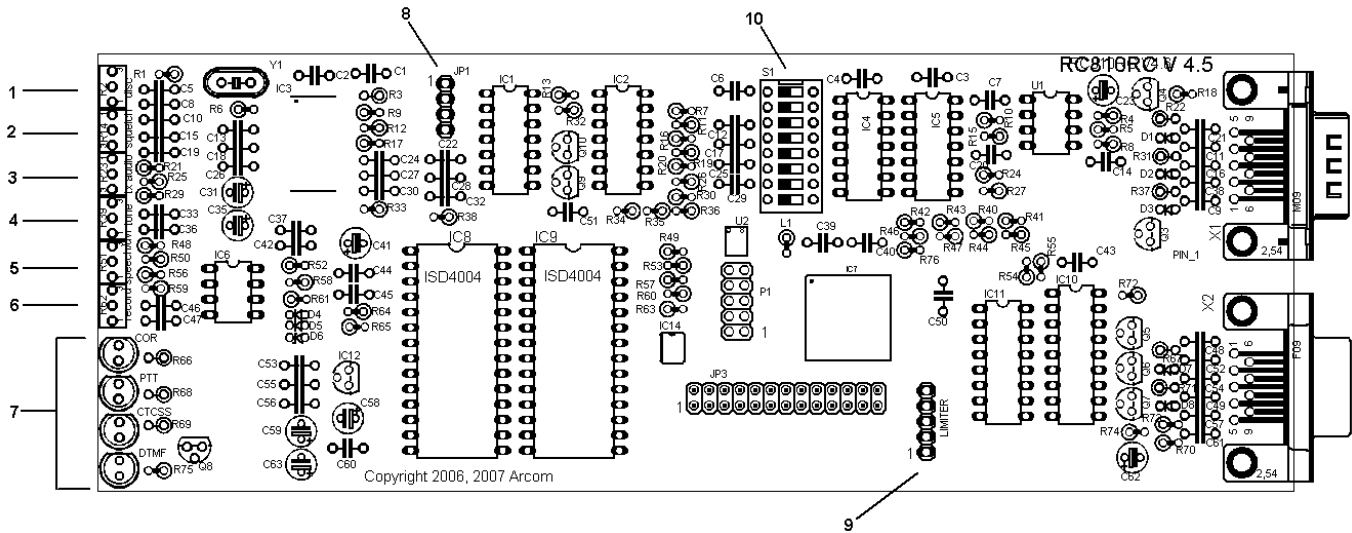
- 1 Coaxial power connector - +10.5 to +15 VDC @ 100 - 600 ma (amount of current needed dependent on installed options).
- 2 USB Port – used for serial communications with RC810
- 3 RS232 DB9 female – used for serial communications with RC810
- 4 I/O & Analog DB25 female – A/D inputs, logic outputs and Alarm inputs
- 5 Radio – DB9 female for radio connections, such as PTT, COS, etc
- 6 5 volt regulator mounted on rear panel for heat sinking
- 7 Radio I/O – DB9 male for fan output, serial connections to radio, Port specific Alarms and A/D
- 8 Blank Panels – to seal cabinet when no Port/Option Cards are installed in that position

Motherboard Jumpers and Connectors



- J1 – connects to coaxial power connector on rear panel
- J2 - connects to LM323 voltage regulator on rear panel
- JP9 – Expansion connector – Optional Monitor Panel connects here
- JP12 – Reset header
- JP20 & JP21 – selects either RS232 or USB for serial communications with RC810
- IDE - the optional IDE Card plugs into the Motherboard here
- LAN – the optional LAN Card plugs into the Motherboard here
- Port 1 through Port 8 - Radio Cards plug into the Motherboard here

Radio Card Jumpers, Switches and Adjustments



- 1 Audio In from receiver level adjust
- 2 On-board squelch threshold adjust
- 3 Transmit audio level adjust
- 4 Tone generator level adjust
- 5 Speech/DVR level adjust
- 6 DVR record level adjust

Note: all level adjustments are available through a removal plate on the front panel!

- 7 Indicator LEDs

Note: all LEDs are visible through a removal plate on the front panel.

- 8 The optional Audio Delay Board mounts on this header
- 9 The optional Repeater Builder AP-50 Active Filter/Limiter board mounts on this header

10 DIPSWITCH

The dipswitch on each Radio Card allows easy selection of various features

Table 1

	ON	OFF
S1	Receiver audio is de-emphasized by the Radio Card	Receiver audio is not de-emphasized by the Radio Card
S2	No Delay Board Installed	Delay Board Installed
S3	Speech/DVR pre-emphasized	Speech/DVR not pre-emphasized
S4	Tone generator pre-emphasized	Tone generator not pre-emphasized
S5	DTMF decoder de-emphasized	DTMF decoder not de-emphasized
S6	External COS active low	External COS active high
S7	External CTCSS decode active low	External CTCSS decode active high
S8	Use Internal COS/CTCSS	Use external COS/CTCSS

Radio Card Jumpers, Switches and Adjustments(continued)

External Carrier Operated Switch

The signal from the receiver which indicates that a signal is present is called COS. The RC810 can accommodate an external COS signal that presents either a logic high (5 to 15 volts dc) or a logic low (< .8 vdc) when a signal is present. This is selected using the dipswitch S6 as shown in Table 1 above.

External Sub-Audible Tone Decoder

In addition to the COS signal, each Radio Card can use a signal derived from an external CTCSS (*continuous tone controlled squelch switch*) decoder. The RC810 accomodates either a logic high (5 to 15 vdc) or a logic low (< .8 v) when a valid tone is detected. This is selected using the dipswitch S7 as shown in Table 1 above.

On board COS and CTCSS/DCS Decoder

If you have supplied the RC810 with unfiltered and unprocessed discriminator audio from your receiver, you may select to use the on board squelch and CTCSS/DCS decoder. This is selected using the dipswitch S8 as shown in Table 1 above.

Note: this feature will not work if you do not use unprocessed discriminator audio from your receiver.

Receiver Audio and De-Emphasis

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 (although if you wish to use the on board squelch and CTCSS circuitry you must use audio that is not de-emphasized), as the Radio Card takes care of this for you. If you choose a point inside the receiver that is already de-emphasized, you can disable de-emphasis on the Radio Card with dipswitch S1.

Note: If you use ungated audio from your receiver and experience "feedthru" audio in the form of low level white noise during transmitter hang time, you may need to "knock down" the audio level by inserting series resistance with the audio lead. You will need to experiment with the correct value but it probably will need to be in the range of 10K to 100K.

Controlling Pre-emphasis for Speech and Tone Generation

In most repeater installations, receiver audio is de-emphasized before being sent to the transmitter, where it is pre-emphasized again. However, some installations utilize what is called "flat audio". In these installations, neither de-emphasis nor pre-emphasis is used and the entire repeater audio chain passes audio without shaping it in any form. It is then up to the radio being used to communicate through the repeater to provide the pre-emphasis and de-emphasis needed in FM communications.

If a flat audio system is used, there needs to be proper pre-emphasis added to those things that require a proper relationship between low and high frequency audio. In the RC810, pre-emphasis may be added for any speech that is generated by the RC810 as well as tones (such as Courtesy Tone and DTMF). This is selected using dipswitches S3 & S4 respectively as shown in Table 1 above.

Controlling De-emphasis for the DTMF Decoder

You may select individual de-emphasis for the DTMF decoder using dipswitch S5 as shown in Table 1 above.

Transmitter Audio

Audio is supplied from the Radio Card to the transmitter. This audio consists of receiver, speech and tone audio, switched and mixed under control of the CPU.

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. Each decoder may be configured to require CTCSS in order to function or not require CTCSS.

Indicator LEDs

LED's are provided for monitoring all the Radio Card'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 are not needed, they may be turned off via DTMF commands to conserve power. The LEDs are readily visible by removing the sub panel on the front panel of the RC810's rack mount enclosure.

Radio Connections

Each Radio Card contains 2 DB9 connectors. The female towards the bottom of the cabinet is where the connections to the radio to be connected is wired according to the following:

Description

- 1 CTCSS Encode Control. This output may be programmed to be active low or active high.
- 2 CTCSS Decoder In. May be selected to be active high or active low
- 3 Transmitter PTT. This active low output may sink up to 60 volts @ 500 ma.
- 4 Transmit audio. This low impedance output provides up to 4 volts of audio
- 5 Receiver audio. This high impedance input may be either discriminator or de-emphasized audio
- 6 CTCSS Tone Out. This audio output supplies CTCSS or DCS encoded tone for your direct FM transmitter
- 7 Receiver COS. This input may be selected to be active high or active low. If active high, a voltage > 5 volts should be used.
- 8 Fan Control. This active low output may sink up to 60 volts @ 500 ma.
- 9 Ground

The other DB9 (a male) is used for interfacing various signals particular to the radio used on that particular Radio Card.

Description

- 1 User definable. This pin is connected to a solder pad on the Radio Card pc board and may be used as the owner desires.
- 2 Serial Data IN. Serial data from the remote base radio.
- 3 Serial Data OUT. Serial data to the remote base radio.
- 4 Logic Output 1. This active low output may sink up to 60 volts @ 500 ma and may be used to control and external device.
- 5 Ground
- 6 Logic Output 2. This active low output may sink up to 60 volts @ 500 ma and may be used to control and external device.
- 7 Logic Input 1. This input may be used as needed
- 8 Logic Input 2. This input may be used as needed
- 9 A/D Input. Typically used with a temperature sensor to monitor heat sink temperature but may be used otherwise.

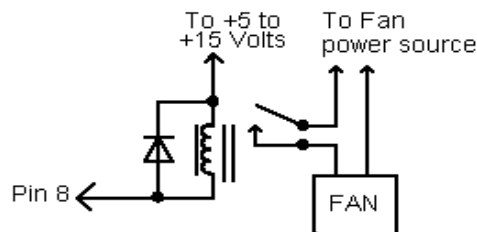
Note: Logic and A/D Inputs are protected against overvoltage. Up to 20 VDC may be safely applied.

Note: A/D Input is internally referenced to +5 with a 4.7 k resistor so no external reference is needed.

Fan Output

A cooling fan may be connected in order to cool the heatsink of the transmitter connected to that Radio Card. To avoid unnecessary wear and tear on the fan, the fan only comes on when that transmitter is keyed and remains on for 1 to 60 minutes after the 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. When active, the Fan Output is pulled to ground. This output is an open collector therefore it will not source any voltage.



Serial Data Input/Output

The RC810 supports a variety of radios for use as a frequency agile remote base. Control of these radios is accomplished by making the correct connection to the Radio Card's Radio I/O connector.

If your radio requires TTL level (it requires a level converter to connect to a computer), you can hook it directly to the RC810 without the need for an external converter. Typical radios would be those manufactured by Icom and Yaesu

Pin

2	Serial Data IN from Radio
3	Serial Data OUT to Radio
5	Ground

If you're using the Doug Hall RBI-1 Remote Base Interface, the connections are:

7	Data to RBI-1
8	Clock Data to RBI-1

Note: If using the RBI-1, you will lose the use of Logic Inputs 1 & 2 on the Radio Card as they are used for sending data to the RBI-1.

Using the Kenwood TM-V7 or TM-G707 as your remote base radio, a separate hardware interface is required.

The hardware interface takes care of automatically switching the radio(s) between programming and operational modes and takes care of all other connections (such as COS, PTT and audio signals) through the 6 pin DIN packet connector. There is no need to modify the radio(s) in any way.

The schematic for the V7a/G707 interface may be found at the end of this manual.

Note: If using the V7 Interface, you will lose the use of User Logic Output 2

The RC810 supports the Kenwood single-band mobiles TM-271A (2 meters) and TM-471A (70 cm). Interfacing the necessary serial connections is easy. Connection for controlling the radio is simplicity itself:

J1 (DB9 male on Radio Card)

Pin

3	Pin 2 of mic connector
5	Pin 4 of mic connector



You also need to provide the audio, PTT, etc. signals as well.

Unfortunately, the A suffix models (the ones sold in the USA) do not have a packet jack already installed and the necessary signals are not readily available from the mic jack. Fortunately however, Kenwood made these signals very easily accessible but it does require you open the radio in order to connect to them.

If you remove the cover of the radio, you will see gold plated pads near the power connections. These pads are normally used in the E model (European) to connect a pigtail, which then provides the necessary signal access for packet use. These will supply the needed connections (other than programming) to the RC810 for remote base use as well.

<u>PAD NAME</u>	<u>SIGNAL</u>
PKS	PTT (active low)
SQC	COS (active high of +5)
PR9	Receive audio *
PKD	Transmit audio *

* The characteristics of both receive and transmit audio is determined by menu selection 39, which is normally used for packet.

In the 1200 baud mode:

PR9 provides 500 mv p-to-p, deemphasized and squelch gated audio

PKD provides preemphasized transmit audio

In 9600 mode:

PR9 provides 500 mv p-to-p, non-deemphasized and non-gated discriminator audio

PKD provides non-emphasized transmit audio

Motherboard

Power Connection

Power is applied to the RC810 via a 2.5 mm coaxial power plug which is supplied with the RC810. No fusing is necessary in order to protect the RC810 as it has its own internal fuse.

Serial Connection

The RC810 provides both a USB and RS232 serial connection, although both may not be used at the same time.

Jumpers JP20 and JP21 allow you to select which one to use by setting jumpers according to the table below:

	JP20	JP 21
RS232	1 & 2	1 & 2
USB	2 & 3	2 & 3

I/O Connections

The RC810 supports connecting external devices (other than radios of course) by the use of the Motherboard's DB25 connector. The pinout is as follows:

<u>Pin</u>	<u>Name</u>	<u>Description</u>	<u>Pin</u>	<u>Name</u>	<u>Description</u>
1	AD1	Analog Channel 1	14	IN6	Logic/Alarm Input 6
2	AD2	Analog Channel 2	15	IN7	Logic/Alarm Input 7
3	AD3	Analog Channel 3	16	IN8	Logic/Alarm Input 8
4	AD4	Analog Channel 4	17	UF1	Logic Output 1
5	AD5	Analog Channel 5	18	UF2	Logic Output 2
6	AD6	Analog Channel 6	19	UF3	Logic Output 3
7	AD7	Analog Channel 7	20	UF4	Logic Output 4
8	AD8	Analog Channel 8	21	UF5	Logic Output 5
9	IN1	Logic/Alarm Input 1	22	UF6	Logic Output 6
10	IN2	Logic/Alarm Input 2	23	UF7	Logic Output 7
11	IN3	Logic/Alarm Input 3	24	UF8	Logic Output 8
12	IN4	Logic/Alarm Input 4	25	GND	Ground
13	IN5	Logic/Alarm Input 5			

Note: All signals on the Motherboard are independent of those on the Radio Cards. In other words, the above signals are in addition to those on the Radio Cards.

Analog Inputs

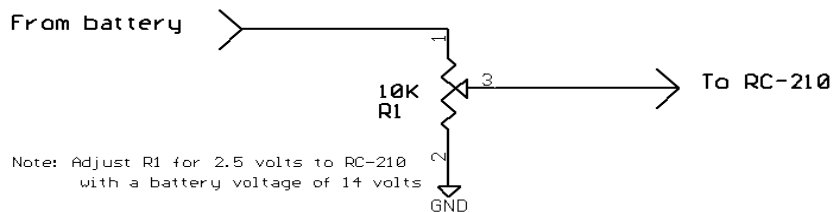
The RC810 allows you to connect external analog devices and readback their value on command. This is typically used for remote monitoring of such things as backup battery voltage, transmitter power, etc. There are 8 "meters" corresponding to the 8 Analog inputs. There are 6 meter faces you may define (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

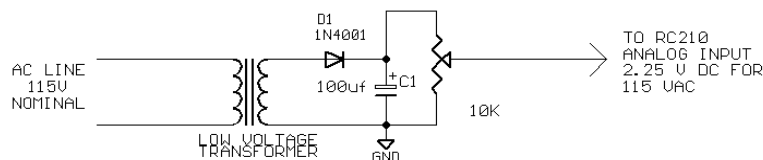
NOTE: The examples and descriptions in this section applies to the A/D Inputs on both the Radio Cards and the Motherboard.

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:



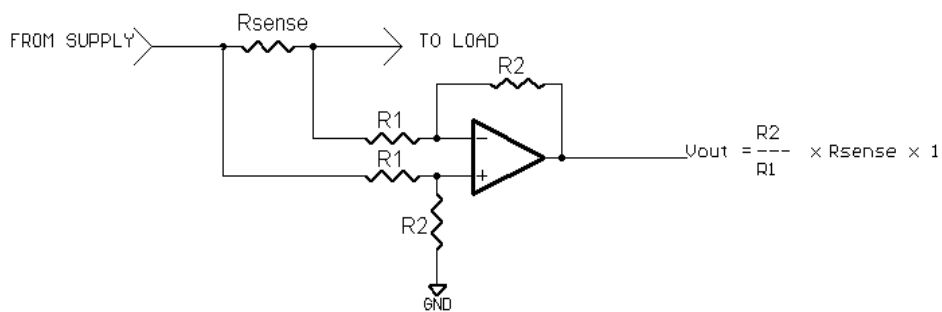
Current

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 the voltage drop across the resistor reduces the voltage to the load. BE sure to calculate the worst case 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.

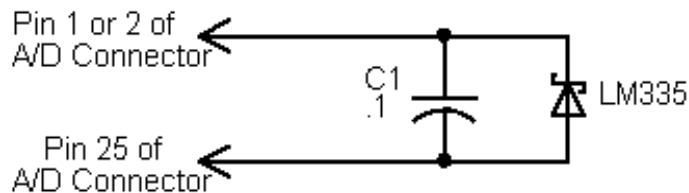
The following shows how to measure current



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.

While the Radio Cards already include the required 4.7K resistor to +5 volts on the Card itself, you will need to include such a resistor on the Motherboard for each A/D Input to be used with an LM335 .



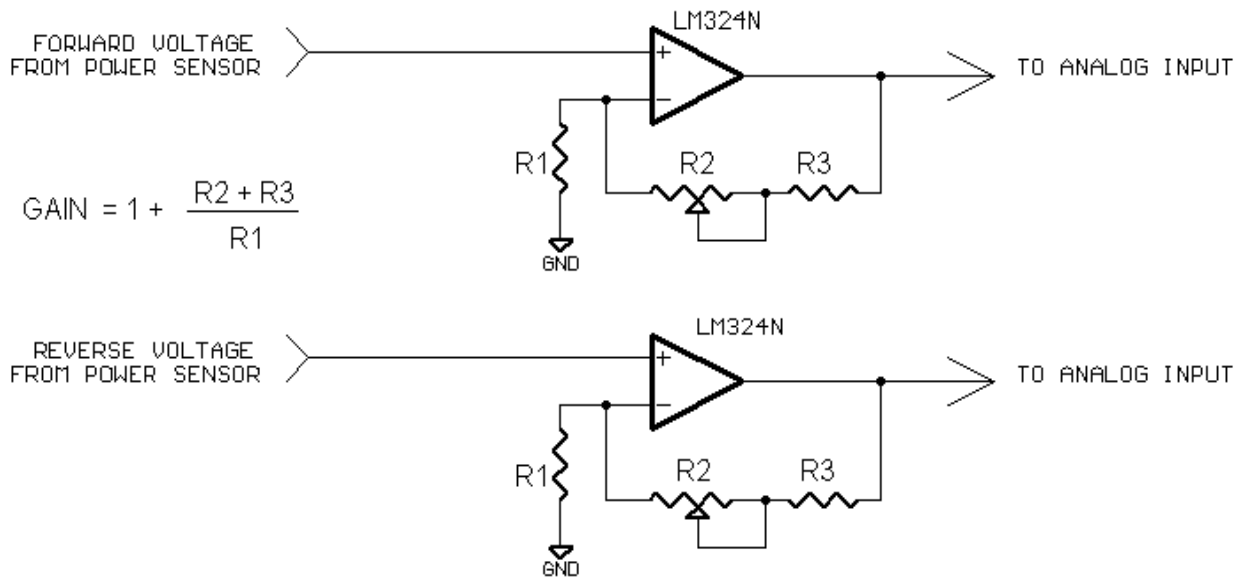
Note: The A/D inputs on the Motherboard do not contain a reference resistor. Therefore if you wish to connect an LM335 to a Motherboard A/D Input, you will need to add an external "pull up" reference resistor. This is not necessary on the Radio Card A/D Input.

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 RC810 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 RC810.

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 RC810 incorporates 8 alarm logic inputs on the Motherboard and 2 on each Radio Card. When used with the proper sensors, you 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 logic transitions. That is to say that an Input recognizes when it is pulled to ground and when a ground is removed. You can program what action should be taken when either of these transitions occur.

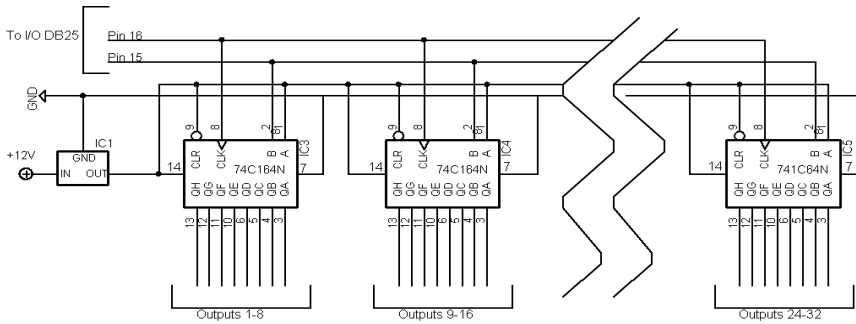
Note: Alarm Inputs on both the Motherboard and Radio Cards are protected against overvoltage.

Logic Outputs

The RC810 provides 8 general purpose outputs (expandable to 32) 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 32 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 32, you'll need a total of 4 shift registers (74164N).

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.



Note: When using Extended Logic Outputs you will lose the use of Logic Inputs 7 & 8

Audio Delay Expansion Headers

Audio from the receiver buffer is routed through pin header connectors on the PC board to allow connection of the Arcom Audio Delay Board (ADB). This board provides a programmable audio delay of approx. 2 to 2000 ms, which removes DTMF bursts and squelch tail crashes from the transmitted audio. If the board is not connected then dipswitch S2 must be ON to complete the audio path from receiver to the rest of the controller.

Setting Audio Levels

Refer to the PCB layout at the beginning of this Manual for the location of the adjustment trimpots and the ADB header JP1.

If the ADB audio delay board is installed, temporarily remove it and make sure dipswitch S2 is ON. Connect an oscilloscope to JP1, pin 1.

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. Adjust the receiver level trimpot R2 for a level of .800 volt peak-to-peak as shown on the oscilloscope.

Once the receiver levels are adjusted, it's time to adjust the transmitter audio level. While still generating a signal on the receiver frequency, adjust the transmit level trimpot R23 for +/- 3 Khz of the transmitter. Turn off the signal generator.

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 level trimpot to the midpoint and adjust the transmit level trimpot 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 R39 adjusts the level of courtesy tones and CW ID's. You should adjust it for +/- 3 Khz deviation.

The Speech/DVR trimpot R51 adjusts the level of the output of the speech and DVR chips. 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 are unable to obtain the proper levels above, you may need to change (or jumper out completely) R74, which is a 39K resistor located near the female DB9 Radio Connector

Setting On-Board Squelch Threshold

Setting the proper threshold for the on-board multi-level squelch circuit is important as it establishes the baseline point from which all squelch action is based. As a reminder, it is important to point out again that the on-board squelch will only operate correctly if you supply the Radio Card with raw, unfiltered, ungated and non de-emphasized audio from the receiver.

To set the threshold, dipswitch S8 should be set ON. Turn the Squelch Threshold trimpot R14 fully clockwise. The green COS LED should be out. Increase R14 until the LED starts flashing and continue turning R14 counter clockwise until the COS LED is steadily ON. The threshold is now correctly set. If you plan on using the on-board squelch, you are now done. If you plan on using an external COS signal, set dipswitch S8 back to OFF.

Note: If you are unable to obtain the proper operation above, you may need to change (or jumper out completely) R74, which is a 39K resistor located near the female DB9 Radio Connector

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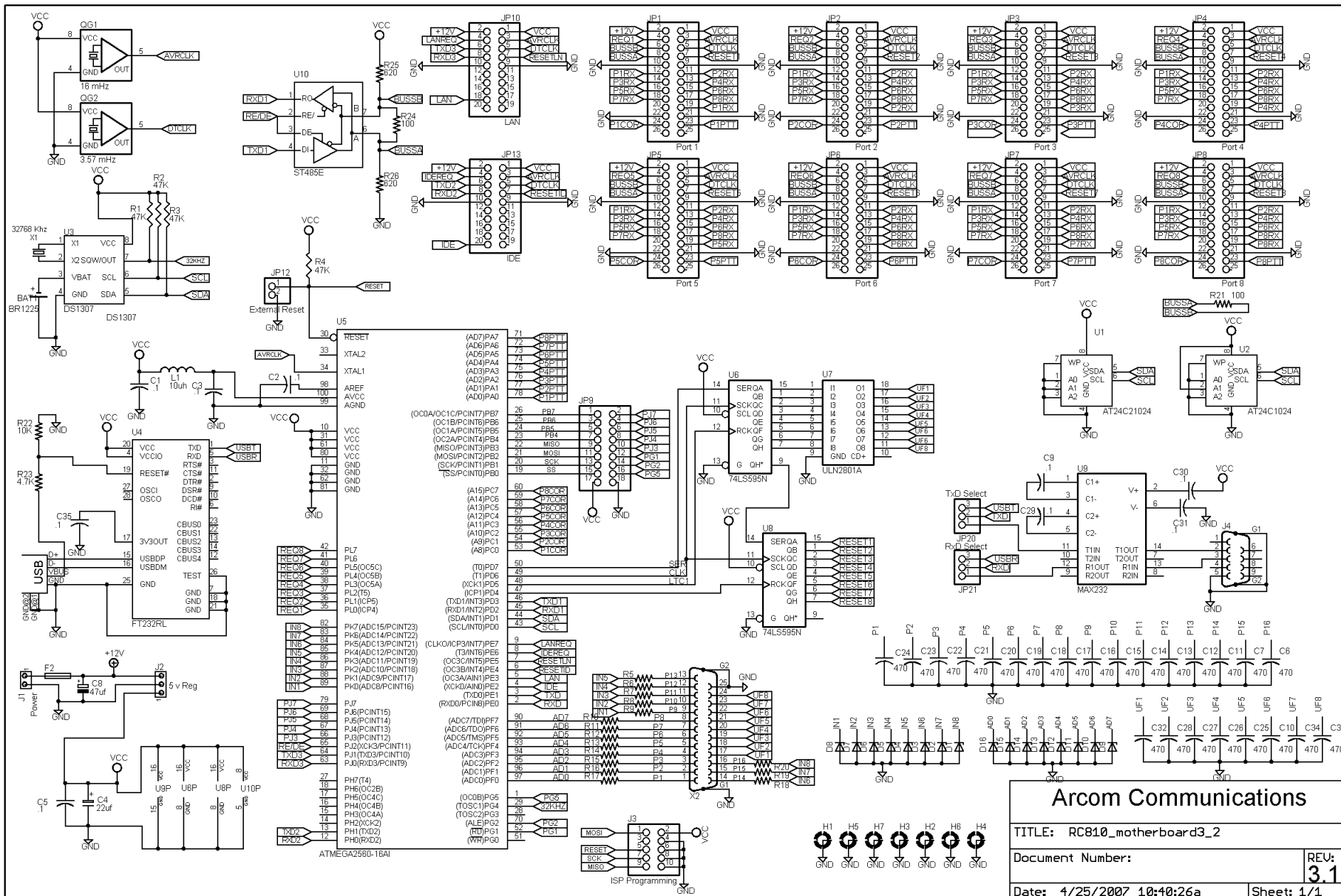
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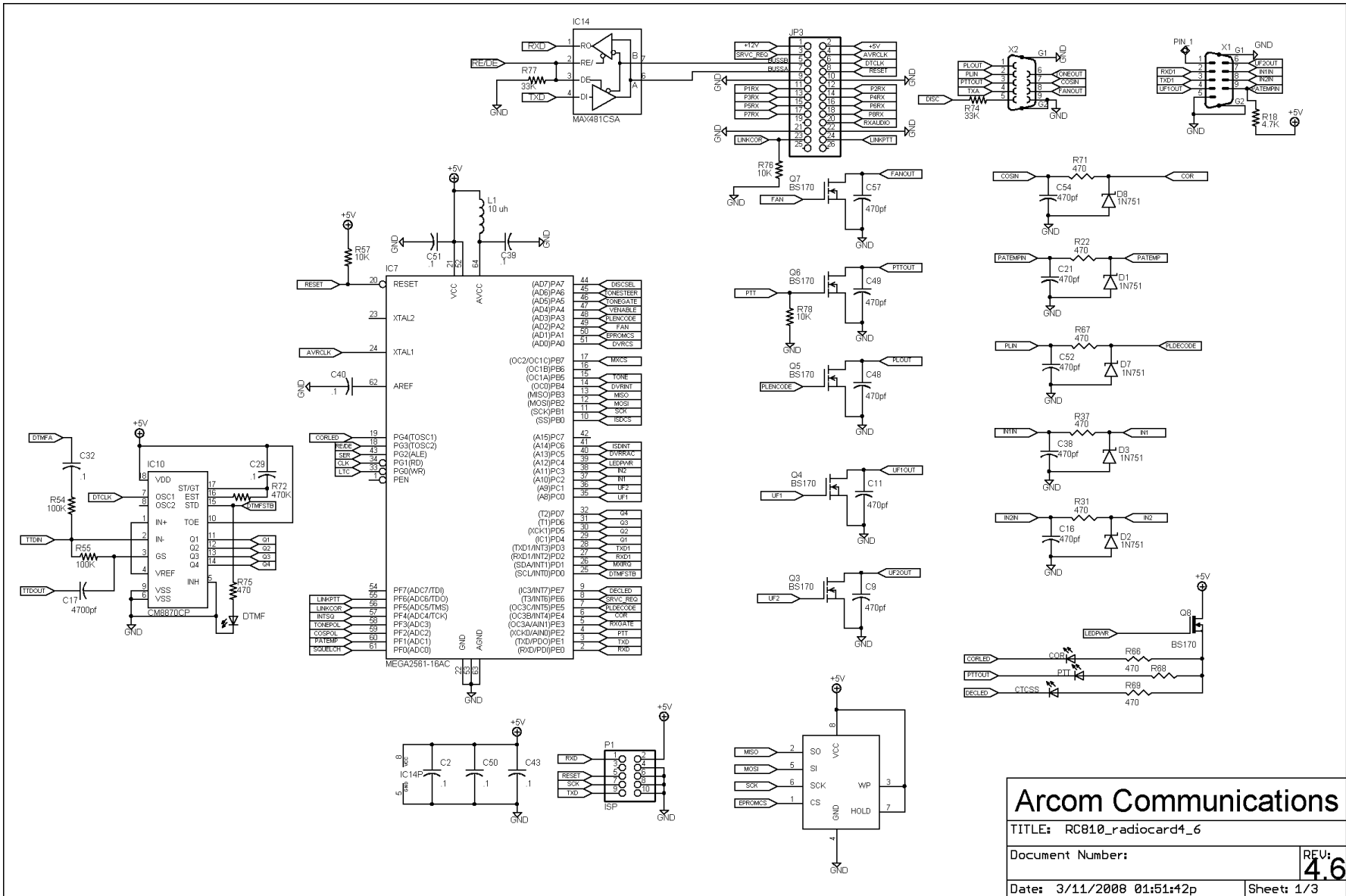
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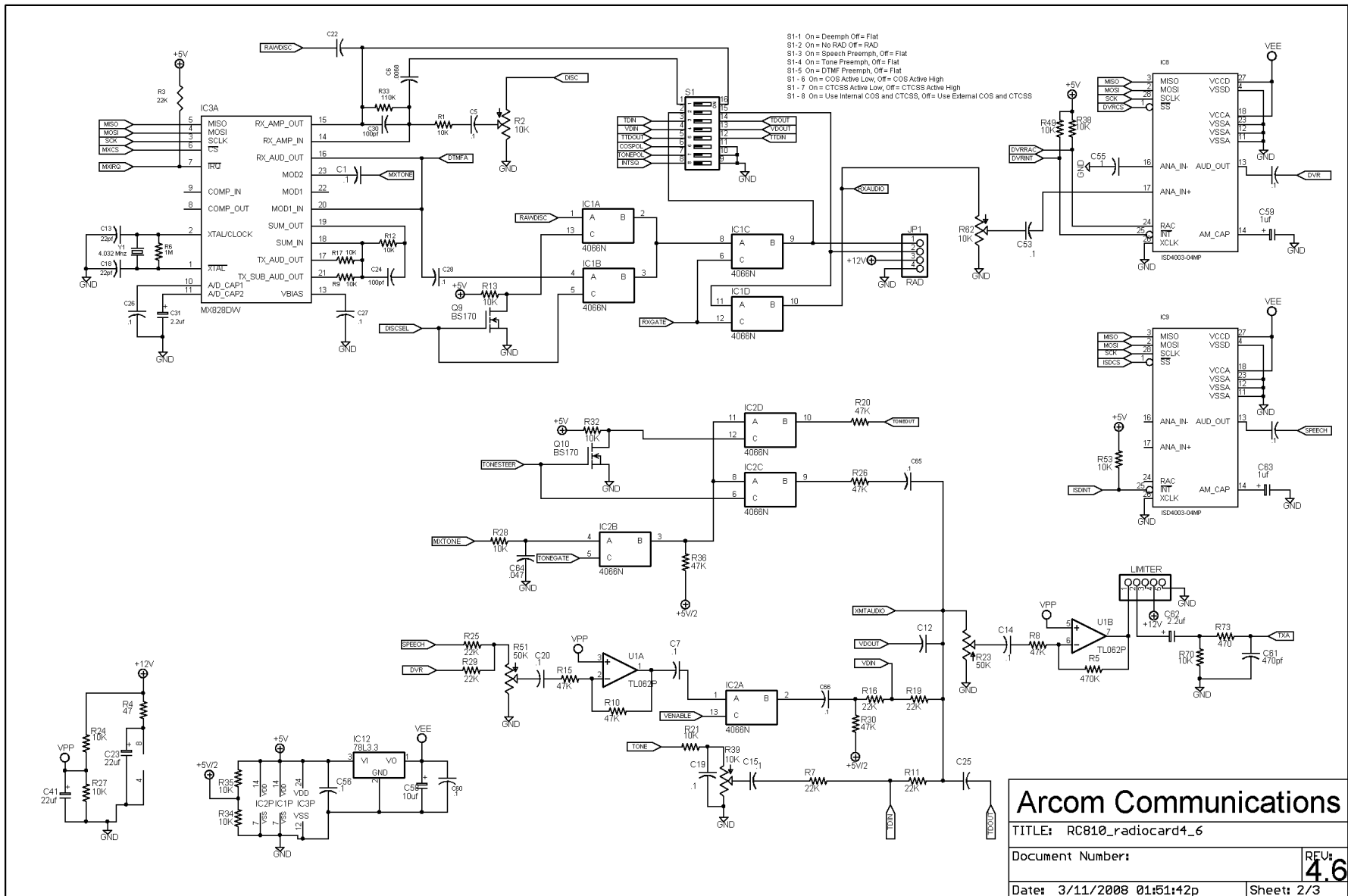
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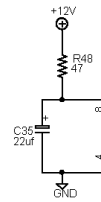
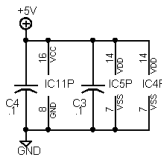
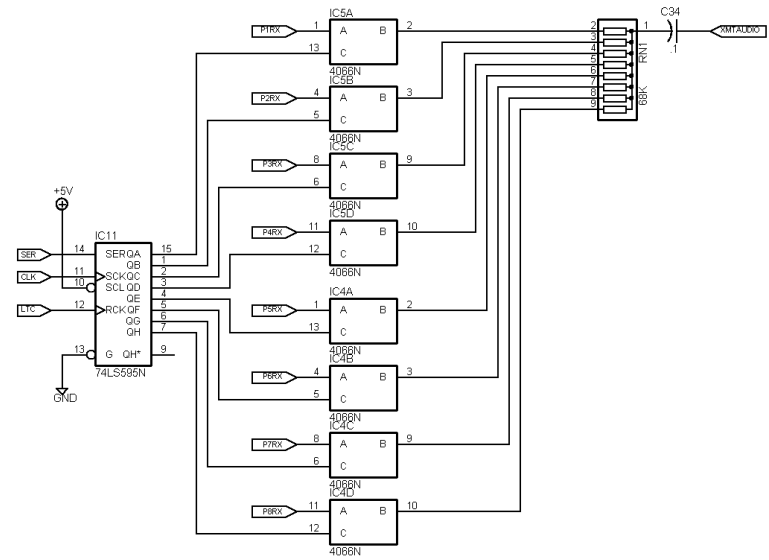
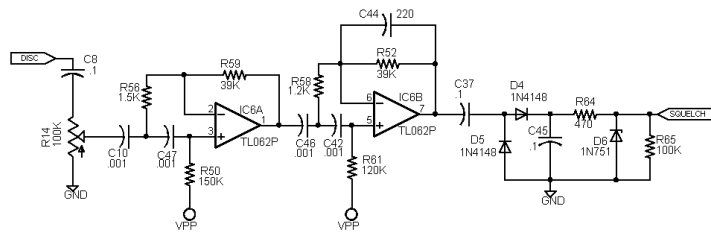
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