Last updated: 12/20/01

After collecting and enjoying quad albums for many years now, it's funny to look back and remember how thrilled I was to find those first quad tapes or that first quad reciever. I guess I evolved from having a setup that was "experimental", only hooked up when I wanted to use it, to a seperate quad system and 2 ch. stereo system, and finally now, one 4 channel system for everything. For many, though, quadraphonic sound is a strange new concept like it was for me a few years ago, at least where music playback is concerned. I guess I grew up in that "gap" between the time when quad had already faded away, and home theater was still yet to take shape. Back in grade school, I grabbed a book on audio (to try to make some use of our weekly library time:), and I ended up with a book which gave a really good overview of quadrophonic sound. Of course I had never heard of such a thing..., and I asked myself, "wait, why haven't I seen this stuff before?" Looking back, the book must have been writen around the earily '70s when quad stuff was just starting to hit the market. It just struck me as odd that this book talked about this technology which in my mind at the time didn't exist! Of course from that point on I knew that quad was out there, somewhere, and I kept my eyes open....but I didn't know exactly what I was looking for at that point. Well, now that I have a better understanding of this stuff, I'm hoping to provide some quad information to help people avoid some of the confusion that I ran into. In order to not make things too confusing for everyone, including myself, I'm dividing this page into the following secions:

Overview: What exactly is Quad

Quadraphonic sound consists of 4 channels, right front, left front, right rear, and left rear. Quad albums and equipment starting to show up in the earily '70s, and as you can probably imagine, quad albums came in primarily 3 different formats, 8 track, record, and open reel, the first 2 being the most common. The stereo 8 track, like the name says, has 8 tracks, making 4 programs (4 programs * 2 channels = 8 tracks). The quad 8 track used the same number of tracks (again, like the name says), and has only 2 programs (2 programs * 4 channels = 8 tracks). One more diffrence to keep in mind (one of the many reasons quad didn't stay around) is that when the number of programs is cut in half, so is the time, meaning quad 8 tracks had to have more tape to get the same play time as their stereo counterparts.

The stereo record (like all records) has a 2 sided "V" shaped grove, in which the needle rides. The stereo (and quad) records have that groove cut at a 90 degree angle, so each side is 45 degrees to the surface of the record, and each of the 2 channels in recorded it's own side of the groove. Since it isn't possible to have a groove with more than two sides that will play back right or be compable with existing equipment, quad records use incoding and decoding to take the 4 channels of sound and make them into 2 channels to store on the record, and to then seperate the 4 channels back out when it's played. Either matrixing or modulation of rear channels onto high frequencies is used to make the origional 4 channels fit onto 2 (There is more about this below).

Quad reel is like 8 track in that there are half as many "programs" (or in this case sides) to get twice as many channels. Quad open reel tape has one side with 4 channels instead of 2 side with 2.

As far as cassette and radio go, at least for me, thing are a little more vauge. Philips, who had the pattent on the cassette, proposed dividing the tape, which normally has 4 tracks (if it's stereo) into 8 tracks, so the tape would be compatable with all existing equipment. Another proposal was to make the tape one sided and use what would have been the second side for the rear channels, as was done with open reel. Philips didn't seem to like this idea since it would mean the quad tapes wouldn't play correctly in a stereo/mono machine, and pushed their plan for an 8 tracked two sided quad tape, which I believe would have ment poor quality due to the very narrow track width. I believe this was yet another reason for the "failure" of quad; no good cassette format. As of recently, after the Philips patent ran out, some 4 channel cassette

decks were made, though a little late for quad, they are primarily for home/semi-pro multi-channel recordings which would later be mixed down to 2 channels. I believe many of these decks also have a 3 3/4 ips "double speed" option, which from what I've read, improves the quality more so than noise reduction and metal tape, and which is a big step up in fidelity anyway. I also read something about 4 channel cassette decks being made in the quad era, but I don't know if that ever made it to production or not. If anyone's interested, I found some cassette players at a surplus store for $3 ea. They are auto reverce and therefore have 4 channel heads, and they look to be the insides out of a car player. If someone's interested in getting dubs without buying an open reel recorder, this might be a possibility (let me know and I'll tell you what's involved in making these work and how far I've gotten).

Likewise, radio had a few quad standards proposed, but as far as I know, again, it never went any further than that. Quite a few stations did use incoders or they played incoded records allowing people to listen in quad at home using a decoder. The Surround Sound Discography Home Page has some info about a quad radio standard finally agreed on in the earily '80s (a little late??)

So what about digital media? Good question :) Of course, with digital, you just have bits, what you do with them is up to you. The only limitations are the overall number of bits you can store (more bits means better audio quality, more playing time, or more channels....or some combination) and the speed at which you can read those bits. There are some compression schemes out there to help squeeze more info on a given media too. As this can easily be a confusing subject, I'll cover it in it's own section.

What to look for

If you're like me, you're probably wondering how you can tell quad tapes & records from every other record and tape out there (this is something I would have liked to have known when I first started looking for quad stuff). 8 tracks are probably the easiest to identify. I already mentioned that quad 8 tracks have only 2 programs, so anything with 4 programs is definetly not quad. The tapes also have a notch, about 1/4 inch wide and 3/4 inch long at the top left, if you're looking at the tape's label. This tells the player to go to 4 channel mode instead of 2. I've also found that most tapes have "quadraphonic" or "Q8" on the label someplace. The records don't have anything which physically makes them diffrent, again, I've found that most of the covers say "quadraphonic" someplace, and most have the incoding method in big letters on the record someplace too. My assumption is that quad was never around long enough to become an industry standard like stereo has, so the record companies made it a point to let you know when a record is quad, the same way all the earily stereo records say "stereophonic" or something to that effect in big letters at the top. I'm also told that some Bluesway (sp?) records either weren't marked as being quad, or had stickers on the shrink wrap telling the encoding method, so on these you have to pull the record out of the cover to see if it's quad or not. As far as open reel tapes, there's nothing special about the tape or reels, it's the exact same thing used for mono and stereo recording. As far as equipment goes, for me, one of the big clues in identifying a quad amp or reciever is that they have 2 headphone jacks (usually, not always), instead of re-inventing a quad headphone jack, a pair of stereo jacks are used for quad headphones (yes, there are quad headphones). There were a lot of 4 speaker stereo look-alikes made at a lower price that aren't quad at all, some even say "quad" or "4 channel" on them, so don't be fooled. Of course, anything that has front and rear inputs or outputs on it is likely quad, but there were a few lower end recievers and reciever/8 track combos that didn't have 4 channel inputs or outputs, they were just quad internally. Many have just a phono input and a (poor) built in decoder, so there would have been no reason for more than the two phono connectors.

Incoding / Decoding Methods (Quad Records)

Instead of me trying to write this info from scratch, I'm taking a good atricle from Gramaphone that someone gave me, not only will this save me from having to paraphrase it all, but it will probably end up better than I could do anyway. Note that I took everything out of the article word for word, and there are some references to figures which aren't on this page, I'd like to scan those and add them, but for now just ignore the references.

CD-4

Discrete discs - CD-4

The family of quadraphonic disc recording systems calling themselves 'discrete' employ a carrier technique, similar to that used to transmit multiplex stereo on a single radio broadcast wavelength. As was explained on page 4, this uses the audible frequecy spectrum - say 50 to 15,000 Hz - to take care of one set of programme information. Mixed with this is a 'carrier' tone at some supersonic (i.e. inaudible) frequency, say 30,000 Hz, on which is modulated another set of programme information. Stereo radio in fact applies the sum signal (L + R) to the main carrier and the difference (L - R)

to the supersonic sub-carrier and decodes the results at the reciever to derive the desired Left and Right signals. The only discrete carrier for gramophone records which has had widespread commercial exposure to date is the CD-4 system invented by the Victor Company of Japan (JVC-Nivico), first demonstrated by them in 1970, with CD-4 discs and demodulators appearing in June 1971. "CD-4" stands for "compatable descrete four-channel" and, using the stereo radio idea, it manages to modulate the four quadraphonic signals on to the conventional 45 degree/45 degree stereo disc grove. The channel numbering is

1 Left Front

2 Left Back

3 Right Front

4 Right Back

As Fig. 15 shows, the sum signal (1 + 2) and (3 + 4) form the audio frequency signals to the Left and Right cutter inputs respectively. This ensures a high degree of compatability with any ordinary stereo record player, which will simply reproduce (LF + LR) as its Left Channel output and (RF + RR) as its Right. In the same way, a mono player would simply add all four origional signals and so reproduce an acceptable mono signal. The difference signals (1 - 2) and (3 - 4) are first modulated onto a 30kHz carrier an ten added to the cutter Left and Right inputs respectively. This upper modulation is tailored to fit into a frequency bandwith from about 20 to 45 kHz. Ordinary stereo pickups will barely respond to these signals and will therefore simply reproduce the left and right sum signals. For quadraphonic reproduction, a new generation of pickup cartridges is being developed with reasonably consistent response up to about 50 kHz. When this full range is passed from the cartridge to a CD-4 demodulator, the four seperate 1, 2, 3, 4 signals are derived for sending to the inputs of a four-channel amplifier (or two two-channel stereo amplifiers).

CD-4 manufacturing problems

A number of special features have had to be introduced to enable the extended frequency responce of CD-4 to be recorded and reproduced effectively and to keep noise, distortion and inter-channel crosstalk to a minimum. While the normal RIAA equalisation cahracteristics and standard level of 22.3mm/sec are used for frequencies up to 20kHz, a constant velocity characteristic is used at higher frequencies and the level of the modulated difference signals is reduced by 19dB. The latter restriction is mainly to take account of the tracking requirements of pickups at these unprecedentedly high frequencies.

Frequency modulation is employed over most of the band, but this is changed to phase modulation in the range 800-6,000 Hz to maintain a crosstalk figure of about -20dB. High frequency pre-emphasis helps to preserve signal-to-noise ratio, assisted by a JVC developed automatic noise reduction system (ANRS). Tracing distortion has also to be tackled using a pre-distortion technique known as Neutrex. It should also be mentioned that the problems of cutting at very high frequencies have made it necessary to employ slow-speed running of the cutting lathe. For example, running the lathe at half speed, allows a halving of the frequencies in the signal; thus the range 30Hz to 45kHz can be reduced to 15 Hz to 22.5 kHz. Note, however, that even this exceeds the normal cutting frequency range of 30 Hz to 20 kHz and so elaborate refinements in the cutting electronics have been necessary. Even so, the playing time per isde of a CD-4 disc has usually tended to be restriced to about 20 minutes rather than the 30 minutes upper limit offered by many stereo records. Changes in the plastics mix for CD-4 also seem desirable, to give the required resistance to wear with the very tiny waveforms now employed (see Fig. 16). For the above reasons, only a few disc cutting centres and manufacturing plants have so far been establised.

CD-4 record player requirements

The first obvious requirement of a pickup designed to reproduce CD-4 records is a wide frequency resprone. JVC suggest that the best class of pickup should have a frequency responce within +-6dB from 20-40 kHz, while +-15dB will still give a reasonable signal to the demodulator. Crosstalk is important too and a figure of -15dB at the carrier frequency of 30 kHz is felt to be desirable, with even -6dB being just about acceptable. This kind of performance is barely achievable with a conventional elliptical stylus (still less with a spherical tipped one) and cartridges so far manufactured for CD-4 discs have all adopted a new stylus (after its inventor) and has two main features. First, it is shaped by chamfering a cone at two angles and rounding the point of contact of the two chamfered faces to a radius about 7 microns. This gives a wedge shape more closely resembling that of the cutting stylus, with a greater ability to trace the small waveforms, even at inner groves.

Second, an increased radius of curvature is employed in the vertical plane (see Fig. 17), which gives the stylus a four times greater area of contact with the walls of the groove. This by itself extends the frequency responce because it reduces the effective stylus/surface compliance and thereby raises the resonance frequency. It also brings benefits in respect of reduced crosstalk, distortion and wear of both stylus and record.

These advantages carry over to the playing of ordinary stereo records, not to mention matrix quadraphony records. The Shibata stylus can therefore be used in high fidelity system for LP records of all types.

Also, this came from a CD-4 record sleeve, I haven't tried it, but if anyone does, let me know:

The technically curious and sophisticated music listener who desires more information can write to us for a detailed brochure entitled "Everything You Always Wanted to Know About the CD-4 Discrete Disc". Send your request to "Discrete Disc", 13th floor, 15 Columbus Circle, New York City 10023.

Matrixed Formats

It is possible to avoid some of the complications in the manufacture and reproduction of quadraphonic records by employing a mixing (matrixing) technique instead of the 'descrete' carrier system just described. Since discrete quadraphony involves fout seperate recorded signals followed by four seperate amplifier chains, each chain independently connected to a seperate loudspeaker, we could refer to it in shorthand as 4-4-4. Using this coding, a mono system would be 1-1-1, a stereo system 2-2-2, a stereo record palyed on a mono machine would be 2-1-1 and so on.

A matrix system could similary be coded 4-2-4 to indicate that the programme material started life as a discrete four-channel master tape recording, was then combined in some manner on to only two channels and finally re-processed to get back the four signals of quadraphony. The 4-2-4 matrixing systems do not give such effective channel seperation as quadraphonic tapes or 'descrete' discs. However there is evidence that the ear can tolerate much higher amounts of interchannel crosstalk when identifying directions via more than two loudspeakers.

Matrix discs can claim the advantages of being playable with ordinary pickups and are easily broadcast. They also claim compatability with stereo and mono systems but this is somewhat variable.

The basic block diagram of matrix quadraphony is shown in Fig. 18. The four input signals are encoded on to the required two-channel transmission system, which might be a disc or a FM radio broadcast. These two composite signals can subsequently be decoded to restore the origional four channels of information. The encoding and decoding process can be one of selective attenuation and subsequent boosting of signals, with or without phase shifting. This can be compaired with panning of signals between any two loudspeakers, as explained earlier, or the partial cancellation of signals produced by the adding of out-of-phase components. Two basic matrix methods have dominated the market to date, namely the CBS/SQ (sometimes called the 'phase' matrix) and the Sansui/QS (a species of 'regular' matrix). They represent different philosophies in regard to the importance attached to such criteria as a clear front centre image and stereo compatibility. The differences can be best explained by referring to the matrix equations employed by the two systems.

The general equations which define the action of any matrix encoder in mixing four signals down to two are as follows:

Lt = ALf + BRf + CLb - DRb

Rt = BLf + ARf - DLb + CRb

where Lt and Rt are the total Left and Right signals to be recorded; A, B, C, D are numerical values plus phase angle values.

The SQ Matrix

Well out in the lead in terms of both hardware and software is the SQ matrix system devoped by the CBS Laboratories in association with the Sony Corporation. Several dozen equipment manufactures have been licened to produce SQ equipment and the recoed manufacturers issuing SQ coded records including EMI as well as CDS Records themselves.

The encoding equations used in the SQ matrix encoder take the form:

Lt = Lf + 0Rf - j0.707Lb + 0.707Rb

Rt = 0Lf + Rf - 0.707Lb + j0.707 Rb

where the operator j implies that the rear channel components are shifted in phase by +90 degrees in one channel and -90 degrees in the other.

The first thing to nitice is that the level of Right Front signal in the Left Total equation is zero and vice versa. This means that front speaker crosstalk is at a minimum and the front stereo image is fully preserved. The Lf and Rf signals are in fact applied to the +/- 45 degree planes of the groove as for ordinary stereo. The significance of the phase shifting of the rear channel signals is that, while Lb and Rb appear at both the Lf and Rf feeds to the cutter stylus, they effectively lead or lag on each other. This causes the stylus to describe a circular motion which, combined with the lengthwise motion of the groove, produce a clockwise helix for Lb and an anti-clockwise helix for Rb (see Fig.20). On relay, the decoder preforms sum and difference operations on Lt and Rt to extract four signals for feeding to the four loudspeakers.

As we have said, Lf and Rf emerge intact. However the signals sent to the rear speakers contain substantial amounts of all the other components, giving seperation between front and back and diagonally of only 3dB (see Fig. 19b). This is a severe limitation of the SQ matrix system and means that some blurring of images is inevitable with the basic decoder circuitry.

More recent designs, employing logic-controlled variable gain amplifiers have sought to improve seperation. At any instant, the circuit can detect the channel which has the highest level of signal and permit it to 'take command' and so increase the apparent seperation. This is claimed to produce crosstalk figures of as much as -30dB from side to side and -10dB from centre front to centre back.

The QS Matrix

The QS matrix developed by Sansui and employed by Pye Records in this Country has certain technically interesting features, though so far making less commercial impact outside of Japan than SQ.

The encoding equations used for QS take the form:

Lt = 0.92Lf + 0.38Rf + j0.92Lb + j0.38Rb

Rt = 0.38Lf + 0.92Rf - j0.38Lb - j0.92Rb

where j again implies some phase shift.

It will be seen that Lf to Rf seperation is no longer complete, each appearing in both the total Lf an Rf equations. However, on decoding, the QS matrix is found to offer the advantage of excellent diagonal seperation and, though the adjacent speaker seperation is only 3dB, this symmetrical distribution produces more stable quadraphonic images. For example, as shown in Fig. 19c, if the Lf signal is equally present in speakers Rf and Lb at some lesser level, the listener will still locate the Lf signal in the Lf speaker.

(***not yet finished, more soon***)

New Quad Technology

As you can imagine, "new quad technology" is really none other than than home theater merging back with music and the hi-fi world. So, I won't fight it, I'll give a quick rundown of home theater.

Somehow it seems like the only logical place to start is with Dolby Surround and Pro-Logic. While the difference is probably hardly worth mentioning anymore, Pro-Logic is nothing more than a type of decoder that does a better job decoding Dolby Surround. They use a steering logic, just like the SQ and QS decoders before them. Just to be lazy, I'll use the term "Pro-Logic" to cover the whole works from here on. Pro-Logic is a sort-of 4 channel system, there are the L and R of course, plus one rear channel derived from out-of-phase signals, and a center which is little more than the audio common to both the front and right. While I feal that calling the center a seperate channel is a stretch, because you can't send something to the L and R at the same time as it will always get sucked out and routed to the center...none the less many movies are recorded with that in mind. Note also that the single rear channel is of reduced frequency range, which is just fine for movies but is less than desirable for music.

"But what's the deal with this Pro-Logic II that I see on some of these new recievers?" you ask. No, it's not just the same old system repackaged, in fact, it's much closer to quad than it is to the old system, the rear speakers are full range, and

there are two rear channels. In fact, the decoders are supposed to be exelent for playback of QS incoded albums.

Compressed digital format

Okay, it's not 1976 any more and CDs seem to be outselling records, so why am I still trying to use some sort of matrixing scheme to fit 4 channels into two when a CD could just as easily have 4 channels in the first place? Good question, and one with a good answer: With compression, it's possible to get 4 descrete channels on a standard CD, without even giving up any of the playing time. Of course this technology is more commonly found in the movie/home theater side of things in the form of Dolby Digital and DTS. But what's the catch? Well, aside from needing the hardware to make things work, you're using lossy compression, so you actually end up with sound quality a little lower than that of a CD. Both systems can use a different amount of compression, meaning that the quality is decided by the person making the recording, but as a general rule of thumb, DTS uses less compression than DD. Also, DTS is a 20 bit system, unlike CDs and DD which are 16, so there is added sound quality there. For that reason, many find DTS to be an acceptable system for music/audio-only recording, where DD is typically used for movies only. In addition, DTS has made some music CD available, check their web page http://www.dtstech.com/consumer for more info. Likewise, DTS incoding software is now available, so many people have been making DTS incoded copies of quad albums for trading.

High definition audio formats

So what does multi-channel audio hold for the future? Another format war. Namely, SACD (Super Audio Compact Disk) vs. DVD-A (DVD Audio). SACD was origionally going to be the ideal upgrade path from CD, with compatibility and mutli-channel sound. This was going to be done with a two layer disk, one layer is basicly a CD, the other having the high definition data. Unfortunatly, SACDs don't all have that CD layer, and some of the eariler players were two channel only. DVD-A was in the works for a long time, a standard DVD was modified with some of the video data removed, making room for high quality uncompressed audio. Of course there could still be low bandwidth video as well, still frame images and credits, etc. Being DVD, there would be some level of compatibility with other disks, 2+ channel DD that could be played in any player. One interesting idea is to use software and a common DVD ROM drive on a computer for playback. As it turns out, both formats look to be close enough in format to be read my a computer. So which format looks to be winning the war? Hard to say at this point. It looks like DVD-A has some advantages in compatibility, but SACD looks to be slightly ahead in available titals. I highly suspect that the cost of a player that can handle both formats will be all but the same as the cost of playing just one or the other in the near future, so I think the real battle will be record companies trying to sell one format or the other.

Finding new hardware

My goal is to put as much information as I can on this site before trying to make things flashy. Unfortnatly, I'm having a hard enough time just keeping the info here up to date! So, with that said, I'm going to include some info on products that may be interesting to people looking to buy new hardware/media for quad use. Initally this will be unorganized and may move later, but for now, here it is:

CD-4 hardware:

-Audio Technica Trackmaster 8 can be used for CD-4 and is about $45

DVD Audio players that should play DTS CD-Rs:

-JVC XVSA70BK

-JVC XVSA75GD

-Panasonic DVDRP91K

-JVC XV-FA95GD

-JVC XV-FA95BK

One final note, for those of you wishing you could find a good QS decoder, look into getting a Dolby ProLogic II decoder, from what I hear it does a wonderful job,

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Misc.

This is that section for all that stuff that didn't fit in anywhere else, which I'll try to lump under some sub-headings.

My Glossary: (note that this is all to the best of my knowledge, so there's a good chance that some of this stuff is wrong, correct me if it is)

- Mono: short for Monophonic, mono is a prefix meaning one (as in monorail), which would lead me to believe that a mono recording is one with one and only one channel of sound.
- Stereo: short for stereophonic which means more life-like or 3 demintional (than mono I assume) or something to that affect, which indicates to me a recording with 2 or more channels (including but not limited to quad).
- Quad: again, short for quadrophonic, and again, quad is a prifix meaning 4 (as in quadralateral maybe?) which to me indicates 4 and only 4 channels.
- Surround Sound: (not just dolby) I've got to assume from the name that this includes anything which surrounds you, which to me means 3 channels or more. I'm don't know of any real clear definition of what surround really means, any ideas?

"Quad died in the '70s": I don't think "died" is the right term to use (though I don't know what is), yet everyone seems to think quad died. There were a lot of factors which lead to the end of quad, instead of me trying to repeat all the reasons for quad's demise, I suggest you take a look at the FAQ on 8-Track Heaven, section 14. Though it's primarily about the quad 8-tracks, I think it does a good job explaining the end of quad in general. Modern Quadraphonic talks about the record companies not wanting to take the time to mix the quad albums, they prefered to make a 2 channel tape/record, and didn't really care otherwise as long as they were able to sell it (They explain it better than this, you'll have to take a look for yourself).

My observations: I'm not sure why it is, but most of the quad tapes that I've come across have been in much better condition than my stereo tapes, most of which are the same age, and I'm not too sure why. Many of my stereo tapes have some fading in the plastic, and a lot have wrinkles and bubbles in the labels, which many of the quad tapes don't have. One guess is that these were intended to be marketed to people wanting high-end audio, so they were made better then their stereo counterparts. Another possibility is that sence quad portables and car decks are more scarce that stereo ones, these tapes might have been stored under better conditions than most. Either way, it's looks like yet another advantage of quad :)

Now that I waited until the end of the page, here's my favorite part, all my quad albums and equipment. Don't think that once you've seen this once that that's all to see, this list changes all the time (I'm sure I won't be able to update it all the time though :).

Links

(Note I saved many of the best links for my main page).

I guess I could have done a better job and stuck these links in different places in the page, but for now they're going to lumped together at the botton:

Pro Logic Surround Decoder Principles of Operation
Columbia SQ System (Can't say I agree with what this page says :) (start at the beginning)
Barbra Streisand Quad CDs (SQ incoded, made from LPs)

Back