The Unpredictable Joys of Analog Recording

Below are frequency response curves I've made myself by testing various analog recorders I've worked with over the years. What I wanted to know was, after a standard alignment procedure was performed (or, seemingly, not performed) by the studio techs (or sometimes by myself, to be sure), **what was coming out of the machine versus what went in?** Analog machines all sounded different to me, and I wanted to know why. The procedure was to do a repro circuit alignment using a reference tape with a series of tones recorded on it at standard levels, adjusting the repro circuits on the machine to play back all the frequencies at equal levels as much as possible. Then adjust bias and whatever else can be adjusted on the record circuit side of things (usually there are fewer adjustment options for the record circuitry), then fine-tune the repro alignment one more time. Whatever inaccuracies remain, are intrinsic to that particular machine/tape combination. You may think it's "flat", but surprise, it never is... *never!*

Here's a recent quote (Electronic Musician, Jan 2002) from world-famous engineer/producer/mixer **Bob Clearmountain**, making one of the few printed references (outside of AES journals) I ever see to the phenomenon I'm about to show you: "To me, analog is unpredictable; it does that funny thing to the bottom end. You work really hard on the bottom to get it exactly right, and then you play it back on your analog tape, and it's like, 'Oh, what happened there?' The storage medium is making decisions about what the bottom end should sound like." Indeed. Nonetheless, I'll note that I still mix to half-inch when requested (and I prefer 15 IPS for rock and roll) despite the stuff you're about to see below; forearmed is forewarned in this case.

My tools for getting these curves were either my Loftech TS-1 frequency generator, or a reference CD with a series of tones on it. After repro alignment, I would put a reel of blank tape on the machine and start recording various tones on it, always making sure that the meters I was looking at as my reference (whether on the board or the recorder) were reading 0VU (reference level for that machine) when the signal was going to the tape. (Some would say to use -10 VU but I've found it makes no difference to these results. And I sure don't record guitar, bass or kick drum at -10 VU...) Then I would play the tape back and compare the meter levels. For multitrack machines, I would eyeball all the meters/tracks and pick a couple which seemed "typical" or "average" in behavior, and read off of those, generally tracks closer to the center of the tape like 11 or 12. Low frequency fringing effects, if adjacent tracks were recorded on, made the lows come back a tiny bit hotter than they should have; I got around this by recording on alternate tracks.

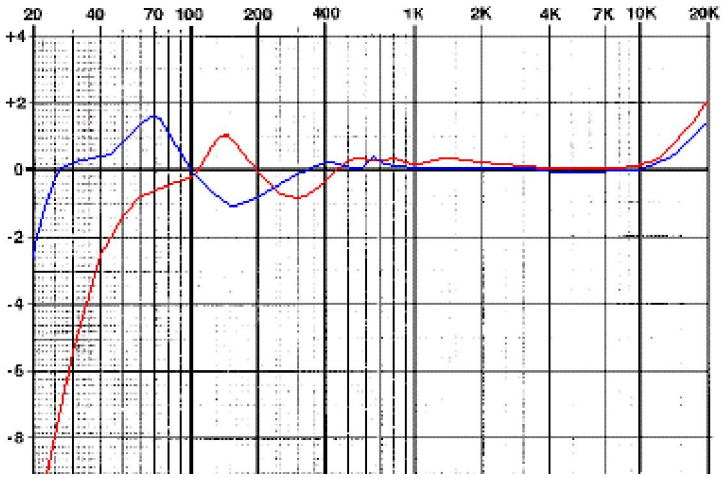
It has been standard in the studio biz to use three test tones for alignment purposes for analog tape machines: 100 Hz, 1kHz, and 10 kHz. Imagine my surprise to discover that a recorder can be aligned perfectly at these frequencies, and yet be totally *whacked.* I have since used two additional tones at all times: 40 Hz (since low E on a bass is 41.2) and 16 kHz. As it turns out many mastering engineers prefer this but no one listens to them!

A final, often overlooked thing I sometimes had to correct for was meter frequency response. Old-fashioned VU meters (the kind with a moving needle) appear to be uneven in their displays of frequencies at either extreme end of the spectrum, often dropping 1 or 2 dB at 20 kHz for instance. (Is it the meter, or the circuitry controlling the meter? It makes no difference here.) This sometimes makes people overtweak (or underbias) their machines because they think a signal on the tape is coming back too low at those extreme frequencies. My Loftech has a rock-solid digital level meter.

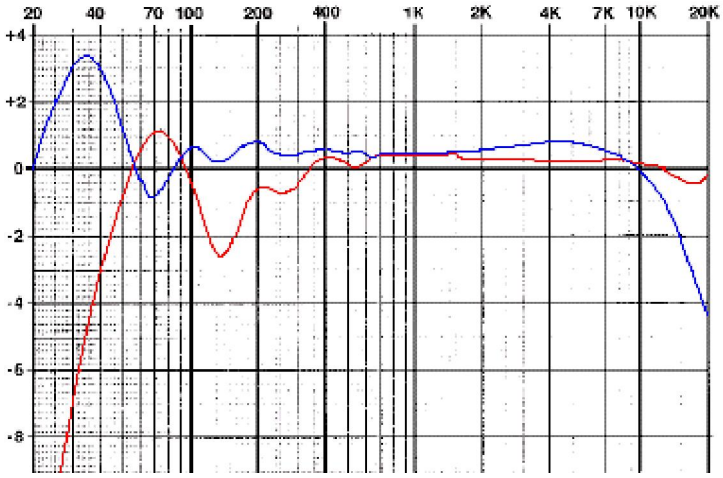
Most of these tests were done using Ampex/Quantegy 499 tape, a few with 456 tape. I found that the basic shapes of the characteristic curves (after each machine was aligned for the particular tape being used) did not seem to vary drastically with the different tape stocks (or with different reference levels, which varied from "plus 3" to "plus 9"). For 15 IPS, these are all NAB-aligned machines, without noise reduction. (Never had a chance to get 15 IPS CCIR curves while in Europe.)

Put simply, for what went into these recorders, imagine a solid, flat line across the graph, right at "zero". The blue line represents what came back at 15 IPS, the red line at 30 IPS. The big hump at the left in each graph is called a "low-end head bump" and is typical of analog machines. Often +2 dB or more, it can exaggerate the low end coming back from the tape, especially with kick drums, and is probably the reason why the adjective "punchy" came into existence. Enjoy.

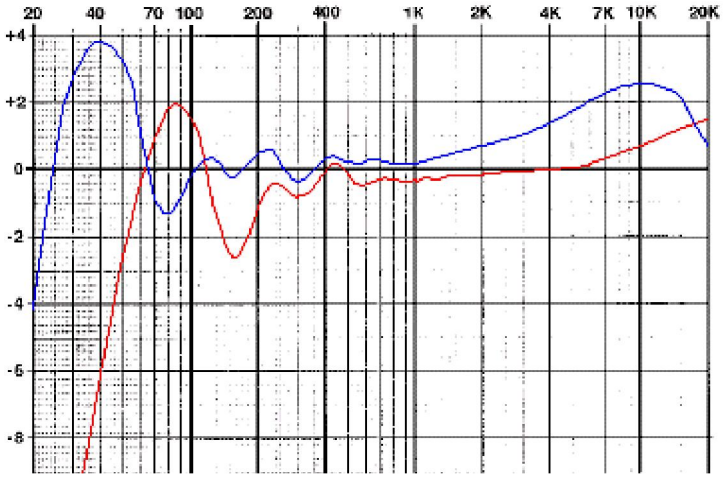
(If you want to pursue this in more depth, an excellent source of info is the website of Magnetic Research Laboratories, who make some of the alignment tapes we all use.)



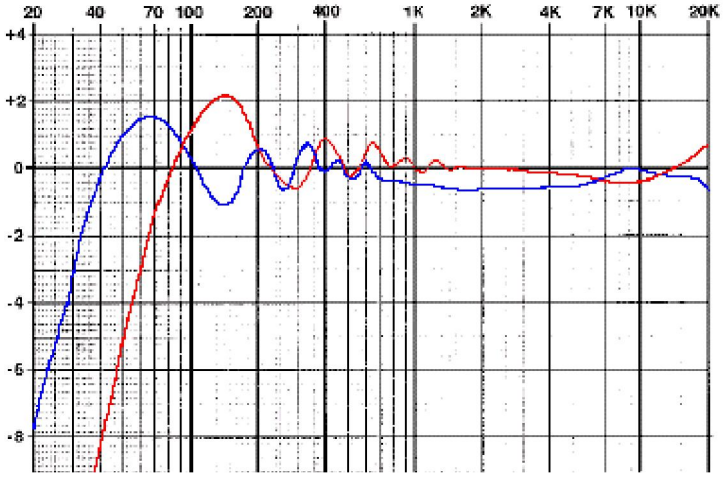
Otari MX-80 2-inch 24-track.Notice how this machine has been aligned according to "standard procedure" to return "zero" (flat) at 100 Hz, 1kHz and 10kHz... but the rest of the frequency spectrum is anything but "flat!" This funny curve with the low-frequency "extension" sticking off to the left is characteristic of the MX-80. You wouldn't know it from looking at these but this machine sounds pretty good at either speed, if you keep an eye on your low-end EQs during recording/mixing. (I still prefer it at 15 IPS.) This machine seems to have been a bit underbiased, judging from the +2 at 20K (or see comment immediately above). Note also that here, as with all of these graphs, the low end head bumps for the two speeds are **one octave apart.** Halving the tape speed = one extra octave on the left.



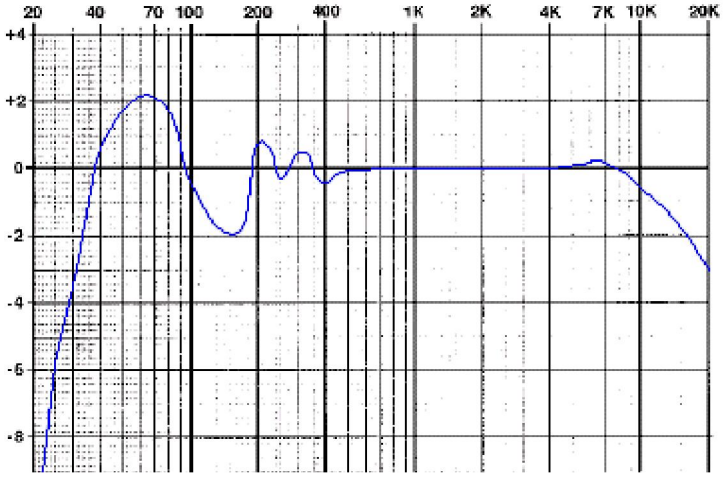
Ampex MM1200 2-inch 16-track. At 30 IPS, everything below 70 Hz is rolled off pretty steeply, not to mention the big trough at 140 Hz.On the other hand, at 15 IPS, the head bump (at a wall-shaking 35 Hz!) is pretty enormous, having a huge (too huge!) effect on the sound of a recorded kick drum or bass. As above, note how the machine is not far from "spec" at the three customary alignment data points of 100 Hz, 1kHz and 10kHz... yet it is far, far from "flat" at either speed.



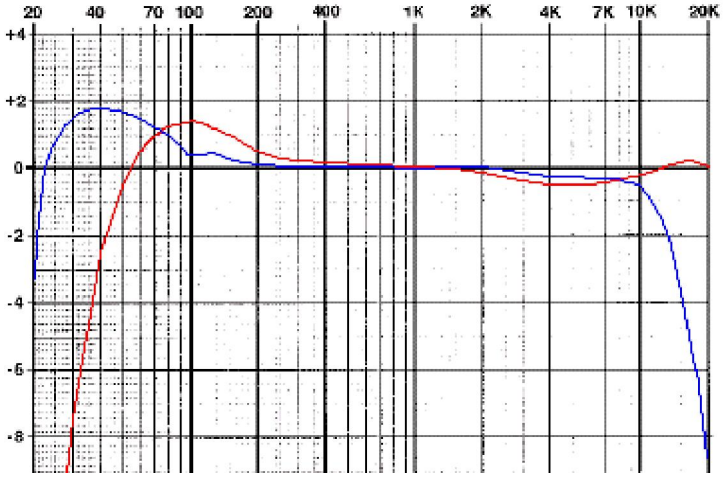
Ampex MM1200 2-inch 24-track. This machine was pretty far out of alignment, but even proper alignment would move the ends of these curves up and down but not change their shapes. In this case, the 30 IPS alignment at 100 Hz is plus 1.5 dB, yet it still rolls off everything below 85 Hz, and more steeply than the 16-track above. Had it been aligned at "zero" at 100 Hz, there would practically be NO bottom end coming back from this machine. At 15 IPS, the head bump (at 40 Hz) is even more outrageous. If I remember correctly, this machine was aligned for 30 IPS use at the time, and no one had aligned it for 15 IPS in a while, hence the right side of the blue line. Notice how the curves are similar to the same model machine above with the 16-track heads, but the 30% smaller track width shifts the curves to the right somewhat.



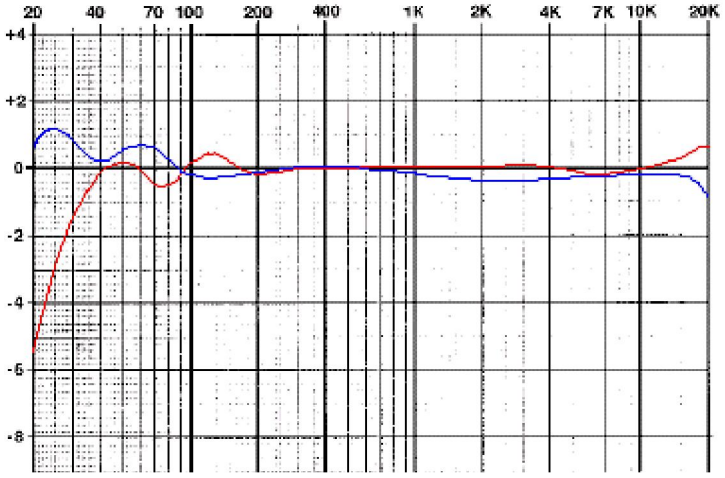
Tascam ATR60-16 1-inch 16-track. Utterly useless at 30 IPS... everything below 140 Hz goes bye-bye.Kick drums? Bass? Forget it. It's drastic; I don't know what Tascam was thinking. But having made about 100 records on this model machine, I learned that it is noisy but quite useable at 15 IPS. (Half the "tape hiss" is present even when the tape is not moving.) Note how the location of the main low-end head bumps are **one octave apart** as usual, but also **exactly one octave** above where they are in the graph for the 2-inch 16-track above; track width is **exactly half**, of course. This machine came with DBX noise reduction built-in. God help you if you used it... it kills the noise, but exaggerates these curves dramatically. (Signal is compressed by the DBX before going to tape... then played back off tape with these curves superimposed on it... then expanded by the DBX.)



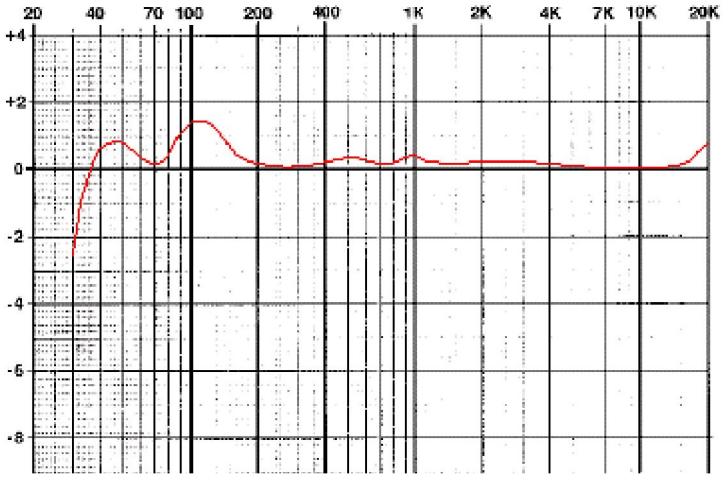
Tascam MS-16 1-inch 16-track. Older model of the machine shown above. There are still a lot of these babies out there; they're like old trucks, they keep going. These came from the factory set to run at EITHER 15 IPS or 30 IPS, but not both; I've never met anyone who knows how to internally change the speed on their machine. Again, I made a ton of records on this model (at both speeds) and found that it sounds terrible at 30 IPS though not quite as bad as the ATR60-16 . Sounds pretty good at 15 IPS, especially with a modern "loud" tape like 499 or GP9.



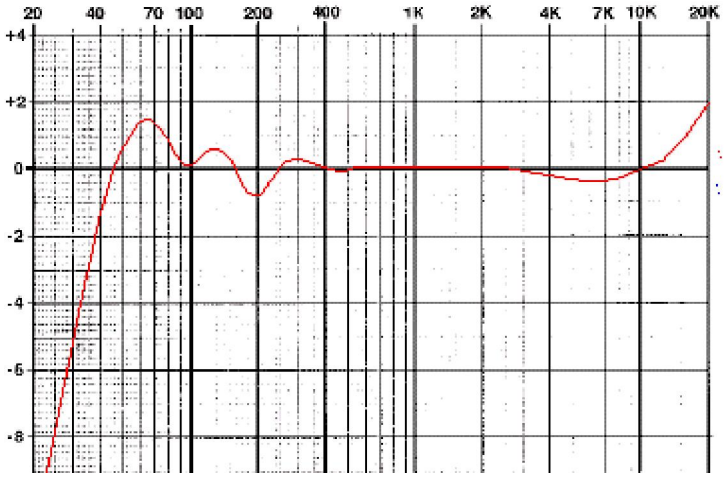
Studer A80 Mk II 2-inch 24-track. Plenty of these old dinosaurs around. Fairly un-lumpy curves but I prefer using at 15 IPS, even though this particular machine was suffering from either misalignment or extreme head wear, hence the steep slope above 10kHz at 15 IPS. This machine has been aligned plus 1.5 dB at 100 Hz for 30 IPS because otherwise the whole left side of the red curve would drop much too steeply - instead of minus 2.5 at 40 Hz, it would be minus 5 or 6.



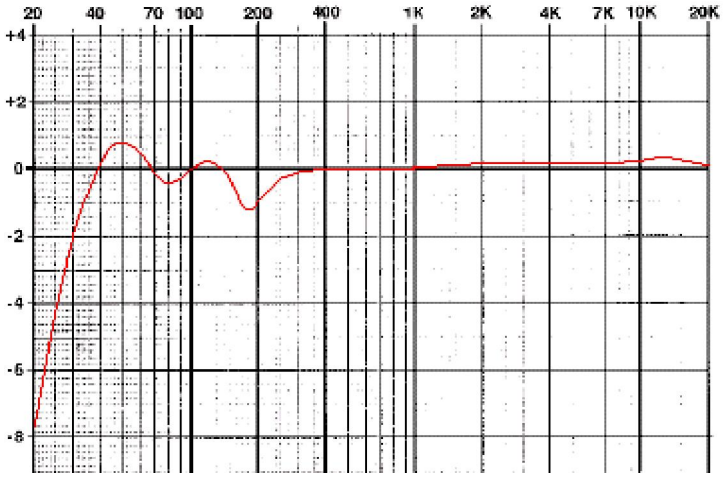
Studer A827 2-inch 24-track.This is about as good as it gets for a 24-track analog machine, at either speed.



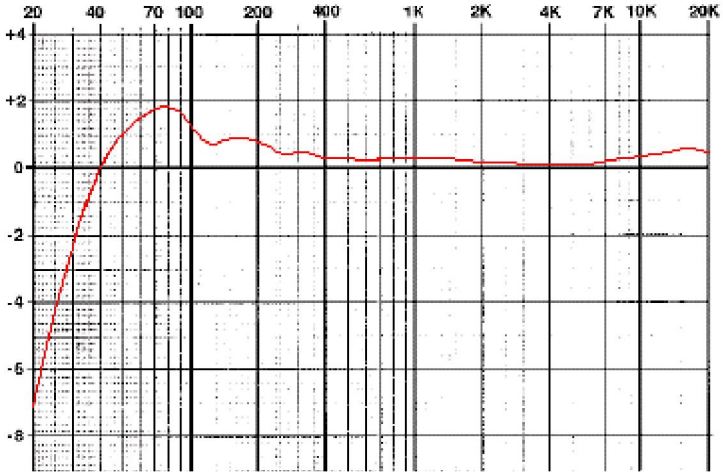
Studer A820 2-inch 24-track, 30 IPS. Slightly earlier generation than the 827 above; similar curve, but the bass roll-off is steeper. The peaks are a tiny bit further to the left though. Also a very good analog machine.



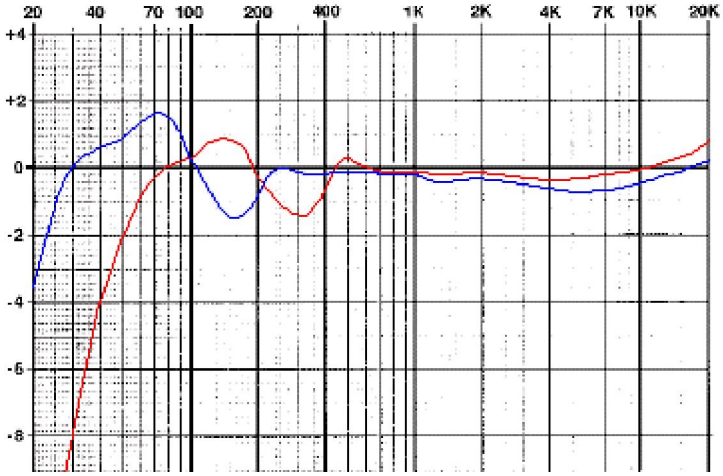
Otari MTR-90 2-inch 24-track, 30 IPS. Decent machine, only down 1 dB at 40 Hz when aligned in customary manner.Slope up to the right due to slight underbiasing.



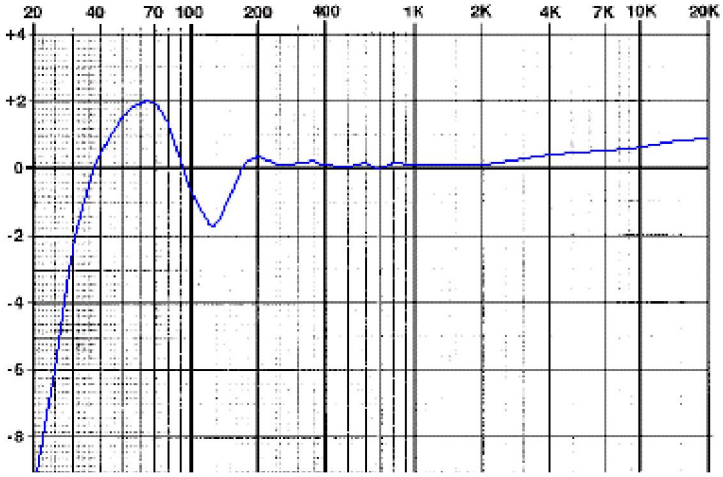
Otari MTR-100 2-inch 24-track, 30 IPS. This was Otari's top-of-the-line machine. Flat at 100, flat at 40 (!), not exactly flat in between, but pretty damn good. Only down 2 dB at 30 Hz. Note similar curve to MTR90 but shifted slightly to the left.



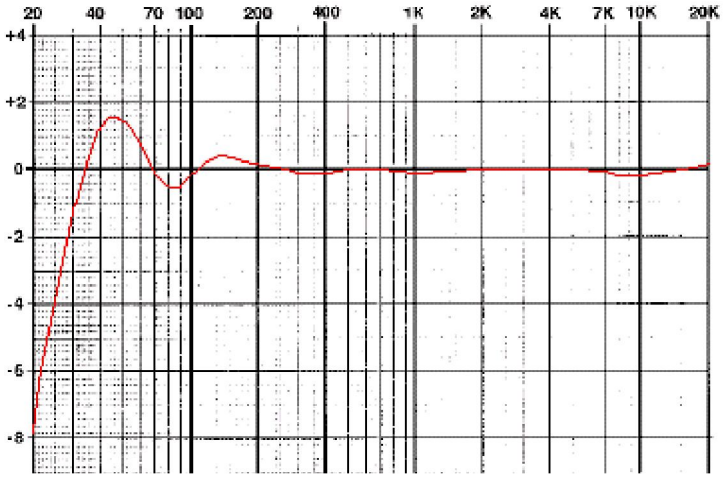
MCI 2-inch 24-track, 30 IPS. This is typical of MCI machines; nice smooth curve, useful but not exceptional low end (imagine if this machine's low end was aligned to be flat at 100 Hz, the whole left side of the curve would tilt down much more steeply as with the Studer A80) which doesn't fully explain why these machines sound so crappy. (My strong personal opinion based on multiple albums recorded on them.) With 16-track heads, one of these would probably be OK at 30 IPS, with a low end hump at a decent 60 Hz, but it would still sound like an MCI machine.



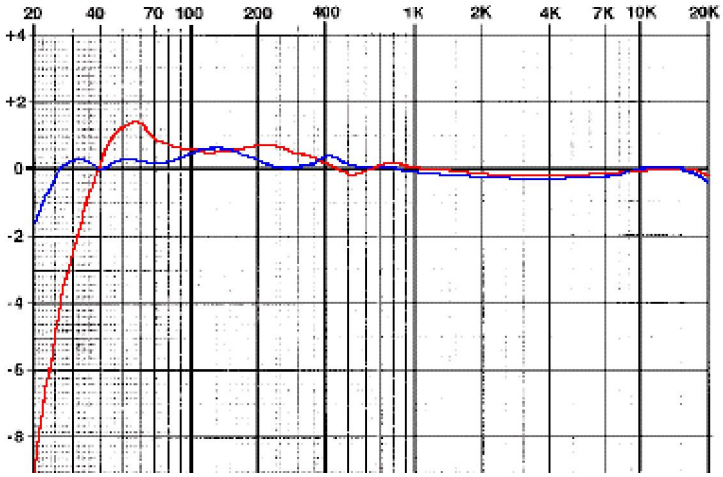
Another Otari MX-80 2-inch 24-track. Heads more worn on this one than the one at top of the page, but note the similarity in the curves. I really enjoy this machine at 15 IPS though.



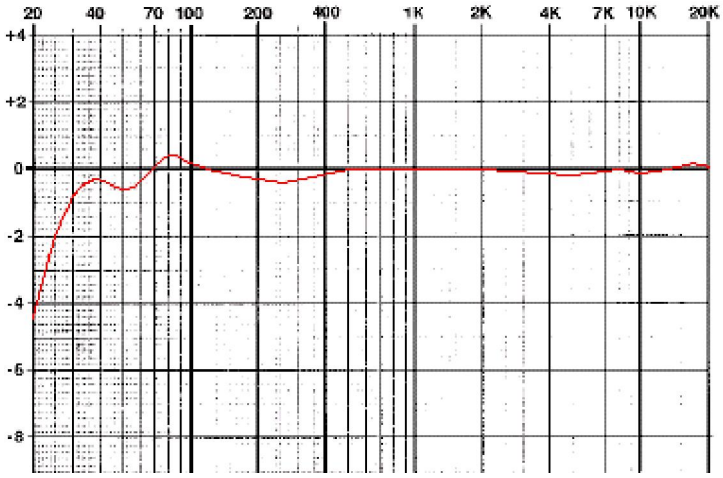
Otari MX-5050 Mk III half-inch 8-track, 15 IPS. My old workhorse (Bleach, etc, etc, *ad infinitum*) which is now behind a glass case in the EMP museum.



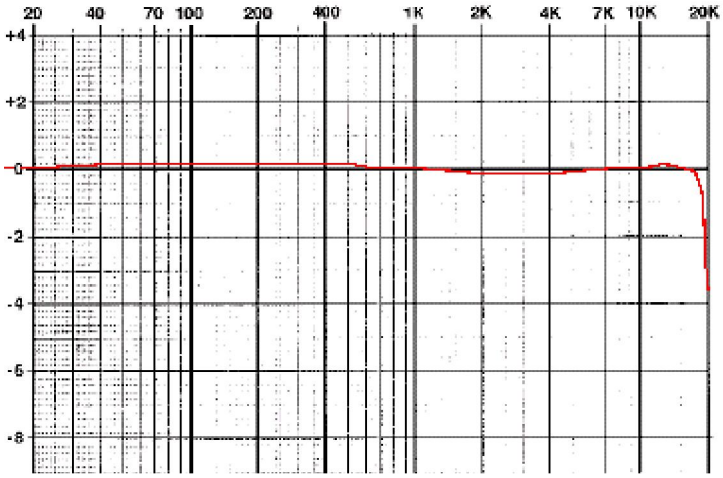
Studer A820 half-inch 2-track, 30 IPS. Very nice machine to mix onto if you don't mind the slight low end bump, which I don't. Also good at 15 IPS but I forgot to get a curve.



The Sony APR-5000 half-inch 2-track. I love mixing to this thing at 15 IPS. Can you see why?



Ampex ATR-102 half-inch two-track, with extended low frequency heads, 30 IPS. This is at Studio X in Seattle, and is about as good as it gets for a 30 IPS two track analog mixdown machine.



Input frequency response of my Starmax MT3200 computer's onboard A/D converter, data obtained by recording tones from a frequency test set through this converter directly into ProTools, and then measuring the amplitude of the resulting files.
(Obviously has nothing to do with any of the above graphs...)

Hey, anyone out there have a working Stephens, Lyrec, Saturn, Soundcraft, 3M, or other less common tape machine? Run some tests at any tape speed (preferably with at least 1/3 octave interval tones, so there's enough data points) and send me the data; I'll be glad to graph it and post it on here.

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