Dealing with INTONATOR Processing Delay Time

by Jay Graydon

Digital Processing Time

When using any digital processing tool, whether using an analog or digital Input source, whether the Output signal is analog or digital routing, keep in mind a digital processing device needs time to compute - this leads to audio delay compared to the original Input source.

Further, a device such as the INTONATOR requires extra processing time as to constantly analyze waveforms and then correct the pitch. (The process is much deeper than the simple explanation just described). All in all, such is life in digital processing land.

The good news is there are ways around the problem using recorder track time shifting techniques.

After performing a test as to discover the minimal INTONATOR delay processing time (see "The Delay Test Using A Digital Tape Recorder "), I discovered the following:

• **If using the INTONATOR'S analog Input and Output with the Sample Rate set to a 48 kHz, the delay time is rounded off to 8.6 milliseconds. The exact delay equals 414 samples.**

• **If using the INTONATOR'S digital light pipe Input and Output (connected to an ADAT recorder) with the Sample Rate of 48 kHz, the delay time is rounded off to 7.2 milliseconds. The exact delay equals 347 samples.**

Note: even though the INTONATOR delay time may be longer than noted above (when dealing with complex pitch correction), after the INTONATOR recovers (pauses between vocal phrases), the minimal delay time returns to the noted numbers above.

Such delay times can be offset which will be explained shortly, but before we do, the following will explain the reason why we want to eliminate the processing delay.

Keeping The " Performance Feel" In Tact

In most cases, when recording a vocal(s), instrument(s), etc., the performer will be listening to other instruments (either a live recording or an overdub situation). Performers pride themselves as to lock in to a "feel" meaning the band and or singer(s) are typically relating to a rhythm pulse. If the INTONATOR is used for the vocal or any instrument (patched in as to record to tape in real time) during this process, the processing delay time would cause the performance to sound "late" compared to the rhythm pulse which would hurt the "feel" of the performance.

Even though it is difficult for the best musical "ears" to notice a few milliseconds of delay, a quality performer would notice such a delay when listening to the recorder playback. Not so much as a delay problem, but as a "feel" problem.

In a situation where the performers are using headphones, lets say that the vocal is patched into the INTONATOR (its Output would rout to the headphones). The processing delay will surely be noticed by the vocalist.

Further, lets say that the vocalist sings a note flat. As the INTONATOR corrects the pitch, the vocalist would automatically try to tune up with the corrected pitch which would push up the pitch farther than the correction - this would cause the vocal performance to swim around in pitch land. In either case, such events would cause musical confusion.

Also, since the audio processed signal would be "late" compared to real time, the pitch would not follow the music in a logic fashion - the pitch correction is occurring later than where needed. Further, no way to realize if the pitch correction is set to the idea setting.

Moreover, even if the INTONATOR signal was not monitored back to the performer (the performer just hears the "dry" non-effected signal as the original signal was split off to the INTONATOR for one recorder track and the non-effected signal to another recorder track), best to not use the INTONATOR during the real time recording process as pitch correction flexibility is "fixed" as you had set the parameters to one setting only. The next paragraph will clear up the last sentence.

The bottom line: we recommend using the INTONATOR after recording the performance for two reasons - you can make up the delay time as well as pitch parameter settings. All experienced recording engineers and producers know "performance feel" is

most important - after the source is recorded, adding/working with processing allows total flexibility!

The manual does mention you might record the non-effected vocal to one track and the INTONATOR processed signal to another for comparison. No harm recording in this fashion but the odds you will have better pitch correction results working with the original non-effect signal after recording the vocal.

Time Shifting A Recorder Track As To Make Up For The Delay

Important: In the following sections, whenever we mention doing any patches (digital or analog), always make sure to mute the monitor speakers until the patch is complete!

Working With A Hard Disk (Non- Linear) Recorder
This is the best method as you have total control over the minimum and random delay!

1. The vocal is recorded without the INTONATOR in the signal path. For example, lets say the vocal was recorded on recorder track #1.
2. After recording the vocal, copy this track to a blank (non-used) recorder track using the track copy edit page. For our example, lets use track #2 for the copy.
3. Patch the Output of track #2 into the INTONATOR either digitally (preferred) or using analog routing.
4. If digital or analog routing, patch the respective INTONATOR Output into a blank (non-used) recorder track Input. For our example, lets use recorder track #8.
5. Set the INTONATOR settings to the basic pitch correction settings mentioned in this manual. At this point, do not worry about setting the pitch correction for optimum settings.
6. If digital routing, in the set-up page, set the INTONATOR Sample Rate as to correspond to the recorder Sample Rate used for recording the original vocal and set any other parameters needed for the digital routing mode. If using analog routing, for our example, set the INTONATOR Sample Rate to 48 kHz (used for this test).
7. Put track #8 into record ready and record the vocal INTONATOR track for about 10 seconds.
8. Playback the recorder and solo track #8 as to make sure your recorded properly.

At this point, you want to move track #2 backwards in time by the same distance track #8 is late in comparison to track #1.

1. As to move track #2 backwards in time, open up the edit page that allows track waveform viewing.
2. You want to view tracks #1, #2 and track #8.
3. Zoom in and magnify using the maximum settings - this will allow you to see the waveforms in full for each cycle.
4. Looking at the waveforms, at the beginning of the first wave form attack, you will notice that track #1 and #2 are lined up (the same starting point) and track #8 is late in comparison to both tracks #1 and #2.
5. Using the edit mode that allows you to shift track time, note the time difference between track #1 and #8. Now move track #2 backwards in front of track #1 by the same distance. Track #2 is now positioned before track #1 by the amount that track #8 was late in comparison to track #1.

If not clear, we will map out. Using the INTONATOR'S digital routing set to at 48 kHz, we know the minimal delay time is approximately 7.2 milliseconds. Since you are using a hard disk recorder, no need to worry about the delay time numbers but we use for this example as a reference point. The * shows the time position of each track. Zero milliseconds is used for track #1's reference.

Before shifting track #2	Milliseconds		
	7.2	0	+7.2
Track #1 (original vocal		*	
Track #2 (before performing the above time shift)		*	
Track #8 (INTONATOR time test track)			*

After shifting track #2	Milliseconds		
	-7.2	0	+7.2
Track #1 (original vocal)		*	
Track #2 (after performing the above time shift)	*		
Track #8 (INTONATOR time test track)			*

Dealing with INTONATOR Processing Delay Time

At this point, you now have track #2 shifted backwards in time by the same amount of time as track #8 was late. When recording the INTONATOR pitch correction (which is what happens next), the basic INTONATOR processor delay is eliminated since track #2 has been shifted earlier than the original vocal performance thus eliminating the minimal delay.

1. From now on, make sure to mute recorder tracks #1 and #2 on the mixer as you will monitor track #8 for the vocal (the INTONATOR track).
2. Erase track #8.
3. Play the recorder and monitor track #8 in auto Input mode (see the sidebar "About the Track Mode Switch" regarding Input modes) - this will allow you to listen through the INTONATOR and recorder track #8's signal Input path through the mixer.
4. Experiment with the INTONATOR'S window/attack/amount settings until you are satisfied with the results. You may also want to use other features such as the De Esser. If so, set to taste.
5. Remember that you are set up to record on track #8 so time to record the pitch correction.
6. After recording, set the track monitor mode to auto Input and check to make sure the signal was recorded properly.
7. If you need to change pitch settings for specific vocal passages, set the track monitor mode to Input , change the INTONATOR settings and "punch in and out" where needed.
8. Note: whenever wanting to experiment with pitch settings, use Input mode as to hear the INTONATOR path without recording. Before "punching in", switch the mode to auto Input as to hear the track playback before the "punch".

Almost finished but just one more thing to do as to really nail the delay fix. As mentioned, the INTONATOR creates random delay when dealing with complex pitch correction. Since you have the ability to view waveforms, go back to the edit page that allows such viewing.

From now on, track #2 is not needed regarding viewing. You want to compare track #1 (the original vocal) with track #8 (the INTONATOR vocal track). This following process will take some time but is worth the hassle as to keep the "performance feel" in tact.

Starting from the first vocal note, look at the beginning of each individual waveform cycle start and shift track #8 as to match the same starting spot as track #1. After each waveform time shift, always save to the hard disk in case you make a mistake, and in case of a hard disk system crash. Best to save as a different save number each time in case you need to go back to an earlier save. If you take the time to perform this method, the vocal "feel" remains in tact while ending up with an "in tune" vocal!

Note: after you are happy with the results, you could erase tracks #1 and #2. Only do this if absolutely necessary (needing open tracks). If so, erase track #2 first as you can duplicate this track from track #1 anytime you wish. Keep in mind you may want to do further pitch corrections somewhere down the line. If so, track #1 (the original vocal) would be available!

Working With Computer Based Software

This is basically the same as the above section. The difference is you need to transfer the original recorder vocal track from the recorder to the computer editing software. If using this technique, transferring the vocal from a digital recorder, best to use a program that allows sample accurate transfers.

After digitally transferring the vocal, follow the instructions in the above section. After completing the process, digitally transfer the vocal back to a blank (non-used) recorder track.

> ### *About the Track Mode Switch*
> *Most recorders allow two basic options for track monitoring:*
> * *Input. The track will always monitor the Input signal, as long as the track is record-enabled (it doesn't matter whether the recorder is playing back, recording, or stopped). This mode is most often used while setting levels.*
> * *Auto. The record-enabled track monitors the Input signal while recording or stopped, and monitors the tape while playing back. This mode is used after the levels are properly set.*

Overview Regarding Tape Recorder Formats

In the beginning of this chapter, we have mentioned that even though the INTONATOR delay time may be longer than the minimal time discovered in the test (dealing with complex pitch correction), after the INTONATOR recovers (pauses between vocal phrases), the minimal delay time number will be accurate regarding the starting point of the following vocal phrase.

If not using a hard disk recorder or computer based software that allows the user to offset random delay, in the following tape recorder section, best to use the delay setting we mention as to insure the vocal will never be "early".

After saying that, there are no rules in recording land. If you

want to take the time, when hearing pitch corrected vocal phrases that become late within the phrase (caused by random delay), you could experiment with offsets and "punch in and out" where needed.

Working With Digital Tape Recorders
Important: In the following section, we will be using an extra recorder track as to record the INTONATOR pitch correction. If you do not have an extra (blank) track available, see section, "Using The INTONATOR Without Re-Recording The Original Vocal To Another Recorder Track".

Keep in mind we know that the INTONATOR set to 48 kHz Sample Rate has a minimal analog routing delay time of 8.6 milliseconds (the exact delay equals 414 samples) and digital routing equals 7.2 milliseconds (the exact delay equals 347 samples). We will use these delay numbers for track offsets.

Since the ALESIS ADAT system is the most common digital tape recording system used in this era, we will use for the example. If using another format such as the Tascam series, or any digital tape recorder format, the following information should easily adapt (check the manual for specifics). In any case, the digital tape recorder must include delay track time offsets.

The current ADAT recorders (other than the original black panel model) allows "local" track delay time shifting. Also, the BRC remote includes this feature. If using the BRC remote with original black panel model, since the BRC allows track delay time shifting, no problem.

Note: The ADAT M20 series remote is called "CADI". If using this series, when we mention BRC, replace with CADI.

Using One ADAT Recorder
The concept is to rout the previously recorded vocal track through the INTONATOR which will be recorded onto a blank (non-used) recorder track. For our example, we will use recorder track #1 for the original vocal and recorder track #8 for the INTONATOR pitch correction recorder track.

For the following, refer to the recorder manual for specific settings regarding digital or analog routings as well as this manual regarding compatibility.

1. The vocal is recorded on track #1 without the INTONATOR in the signal path.
2. For digital routing (preferred), patch the ADAT's light pipe port Output into the INTONATOR'S light pipe port Input and then patch the INTONATOR'S light pipe port Output into the ADAT's light pipe port Input.
3. Note: If using another digital routing format, the concept is basically the same. Using the digital bus available on the re corder, patch the digital recorder Output into INTONATOR corresponding digital Input. Patch the INTONATOR'S digital Output into the recorders digital Input. If using a format needing word clock (sync), check the recorder manual for patching and set up details.
4. If using analog routing, patch recorder track #1's analog Output into one of the INTONATOR'S analog Inputs. Patch the INTONATOR'S corresponding analog Output into recorder track #8's analog Input.
5. If digital routing, set the INTONATOR Sample Rate as to correspond to the recorder Sample Rate used for recording the original vocal (typically 48 kHz for the ADAT format) and set any other parameters needed for the digital mode. If using analog routing, for our example, set the INTONATOR Sample Rate to 48 kHz.
6. Set the INTONATOR settings to the basic pitch correction settings mentioned in this manual.

The routing is set up and now time to set track delays on the ADAT.

The ADAT format allows for delaying tracks so you want to delay all other previously recorded tracks except for tracks #1 and #8 - this will make up for the INTONATOR minimum processing delay time meaning when monitoring or after recording, track #8 will line up in time with the delayed tracks.

1. If using digital routing, using the ADAT track delay mode, delay all previously recorded tracks (except for tracks #1 and #8) by 347 samples (roughly 7.2 milliseconds).
2. If using analog routing, using the ADAT track delay mode, delay all previously recorded tracks (except for tracks #1 and #8) by 414 samples (roughly 8.6 milliseconds).

At this point, the minimal INTONATOR processing delay will not be a problem when recording the pitch correction onto track #8.

Dealing with INTONATOR Processing Delay Time

1. On the mixer, mute recorder track #1 track return as you will monitor track #8 for the vocal (the INTONATOR track).
2. Put track #8 into record ready and monitor in Input mode (see the above sidebar "About the Track Mode Switch" for more information) - this will allow you to listen through the INTONATOR and recorder track #8's signal Input path through the mixer before recording.
3. Play the recorder but no need to record as of yet. Experiment with the INTONATOR'S window/attack/amount settings until you are satisfied with the results. You may also want to use other features such as the De Esser. If so, set to taste.
4. Set the track monitor mode to auto Input mode and record the INTONATOR pitch correction onto track #8 in full.
5. If you need to change INTONATOR settings for specific vocal passages, change the INTONATOR settings and "punch in and out" where needed.
6. Note: whenever wanting to experiment with pitch settings, on the recorder, use Input mode as to hear the INTONATOR path without recording. Before "punching in", switch the mode to auto Input as to hear the track playback before the "punch".
7. After recording, check to make sure the signal was recorded properly.
8. On the song "track sheet", note which tracks you delayed noting the delay time settings (except tracks #1 and #8 as there is no delay setting). From now on, you will need to set the delay settings or save these settings using the "Save Setup To Tape" feature. This way, when working on the song in the future, just load the set up using the "Load Setup" feature. Note: the save to tape and load from tape may use another name depending upon the recorder format.
9. For tracks not yet recorded upon (open tracks), no reason to delay after recording as they will be lined up in time with the others.
10. At this point, if you are happy with the pitch correction, mute the monitor speakers, undo the INTONATOR routing and take track #8 out of record ready.
11. Remember that from now on track #1 will not be used unless you wanted to use the original vocal in certain sections of the song. In this case, you would track delay track #1 by the same delay settings used in this section as to line up in time with the other tracks.
12. If not wanting to use the original vocal, at this point you could erase track #1 but only do this if absolutely necessary (needing an open track). Keep in mind you may want to do further pitch corrections somewhere down the line. If so, track #1 (the original vocal) would be available!

Since you have eliminated the basic processing delay, you have eliminated the major delay problem. If you are happy with the results, great! If you feel that some of the vocal phrases are slightly "late" from time to time, the only accurate fix is to use computer based software for time shifting as mentioned in the hard disk recorder section.

In that case, you would bounce track #1 and track #8 to the hard disk recorder or computer based editing format and shift track #8's waveform to match track #1's waveform - this takes time but will keep the performance "feel" in tact!

Using Two ADAT Recorders

The concept is to digitally bounce the previously recorded vocal track from ADAT recorder #1 to ADAT recorder #2. After completing that task, the digitally copied vocal track on recorder #2 will rout through the INTONATOR which will be recorded back to recorder #1 using an open track.

Again, we will assume the vocal has been recorded on track #1 on the first ADAT recorder. We will digitally copy that track to the 2nd ADAT recorder using track #8 (for our example). After completing the bounce, we will then digitally rout track #8 into the INTONATOR and then rout its Output into a blank track on the 1st ADAT recorder (using track #5 for our example).

1. The first thing to do is to digitally bounce the previously recorded vocal from track #1 on ADAT recorder #1 to track #8 on the 2nd ADAT recorder. Patch ADAT recorder #1's light pipe port Output into ADAT #2's light pipe port Input and then patch ADAT #2's light pipe port Output into ADAT #1's light pipe port Input.
2. Make sure that the sync cable is connected to both ADAT's as to allow for sample accurate tracking among the two recorders.
3. Check the ADAT manual regarding setting to digital (optical) mode as to make a timing correct copy. Note: if set to analog mode when making the digital copy, some ADAT formats may allow the digital copy but the copy would be 24 samples ahead.
4. Make sure the 2nd recorder is set to the same Sample Rate as was used for recording the original vocal.
5. Record the transfer and after making the copy, playback as to make sure the copy on track #8 (2nd ADAT) was recorded properly.

Dealing with INTONATOR Processing Delay Time

Time to rout track #8's Output on the 2nd ADAT to the INTONATOR and its Output to track #5 on ADAT recorder #1.

For the following, refer to the recorder manual for specific settings regarding digital routings as well as this manual regarding compatibility.

1. Undo the light pipe port patch used for the above track copy but keep the sync cable patch between the two ADATS in place.
2. Now patch the ADAT #2's light pipe port Output into the INTONATOR'S light pipe port Input and then patch the INTONATOR'S light pipe port Output into ADAT #1's light pipe port Input. This allows you to digitally pick up the signal from ADAT #2 (from track #8), send to the INTONATOR, and rout its Output to ADAT recorder #1 (track #5).
3. Note: If using another digital routing format, the concept is basically the same. Using the digital bus available on the recorder, patch the 2nd digital recorder Output into the corresponding INTONATOR digital Input. Patch the INTONATOR'S digital Output into recorder #1's digital Input. If using a format needing word clock (sync), check the recorder manual for patching and set up details.
4. Set the INTONATOR Sample Rate as to correspond to the recorder Sample Rate used for recording the original vocal (typically 48 kHz for the ADAT format) and set any other parameters needed for the digital mode.
5. Set the INTONATOR settings to the basic pitch correction settings mentioned in this manual.

The routing is complete for sending the track copy to the INTONATOR and then back to the first ADAT recorder. As to deal with the INTONATOR minimal processing delay, we will use the recorder machine time offset mode as to shift the 2nd ADAT early in time- this will make up for the INTONATOR minimum processing delay time meaning track #8 on the 2nd ADAT will line up in time with the tracks on ADAT #1.

Note: if using ADAT black panel recorders, you need the BRC remote as to time offset the 2nd recorder as this feature is not available on the recorder.

Using the recorder time offset edit mode, since we are using digital routing, set recorder #2 as to be 347 samples ahead of recorder #1 (roughly 7.2 milliseconds).

At this point, the minimal INTONATOR processing delay will not be a problem when recording the pitch correction onto track #5 (ADAT recorder #1) so here we go.

1. On the mixer, mute recorder track #1 (ADAT #1) and track #8 (ADAT #2) track returns as you will monitor track #5 for the vocal (the INTONATOR track).
2. Put track #5 into record ready and monitor in Input mode (see the above sidebar "About the Track Mode Switch" for more information) - this will allow you to listen through the INTONATOR and recorder track #5's signal Input path through the mixer before recording.
3. Play the recorder but no need to record as of yet. Experiment with the INTONATOR'S window/attack/amount settings until you are satisfied with the results. You may also want to use other features such as the De Esser. If so, set to taste.
4. Set the track monitor to auto Input mode and record the INTONATOR pitch correction onto track #5.
5. If you need to change INTONATOR settings for specific vocal passages, set the track monitor mode back to Input mode, change the INTONATOR settings, and "punch in and out" where needed.
6. Note: whenever wanting to experiment with pitch settings, use Input mode as to hear the INTONATOR path without recording. Before "punching in", switch the mode to auto Input as to hear the track playback before the "punch".
7. After recording, check to make sure the signal was recorded properly onto track #5.
8. On the song "track sheet", note the 2nd recorder track offset time. The reason to do this is in case you want to perform the same process in the future.
9. At this point, if you are happy with the pitch correction, mute the monitor speakers, undo the recorder track offset, pull the tape out of recorder #2, and undo the INTONATOR routing. Also, take track #5 out of record ready.
10. Remember that track #1 will not be used unless you wanted to use the original non- pitch corrected vocal in certain sections of the song. If so, there is no time offset needed if wanting to use since the INTONATOR delay was made up for when recording the pitch correction.
11. If not wanting to use the original vocal, at this point you could erase track #1 but only do this if absolutely necessary (needing an open track). Keep in mind you may want to do further pitch corrections somewhere down the line. If so, track #1 (the original vocal) would be available!

Dealing with INTONATOR Processing Delay Time

Since you have eliminated the basic processing delay, you have eliminated the major delay problem. If you are happy with the results, great! If you feel that some of the vocal phrases are slightly "late" from time to time, the only accurate fix is to use computer based software such as mentioned in the hard disk recorder section.

In this case, you would bounce track #1 and track #5 to the hard disk recorder or computer based editing format and shift track #5's waveform to match track #1's waveform - this takes time but will keep the performance feel in tact!

Using The INTONATOR Without Re-Recording The Original Vocal To Another Recorder Track

If no blank recorder track, this method is surely an option. As soon as you record the vocal, best to set up this routing and use during all future overdubs and mixing. This is because all future overdubs (especially other vocals such as background vocals) should hear the INTONATOR vocal pitch correction as to tune up with.

Using The ADAT Recorder Format

For the following, refer to the recorder manual for specific settings regarding digital or analog routings as well as this manual regarding compatibility.

The concept is to delay all tracks (other than the vocal track) as to eliminate the INTONATOR minimal processor delay time.

As with our other examples, we will assume the vocal is recorded on track #1 without the INTONATOR in the signal path.

Using A Digital Mixer

Lets assume you are using just one ADAT recorder that is patched into the mixer using digital routing.

1. Patch the ADAT's light pipe port Output into the INTONATOR'S light pipe port Input and then patch the INTONATOR'S light pipe port into the mixer's light pipe port Input.
2. Note: If the mixer uses another digital routing format, the concept is basically the same but check the mixer manual for details.
3. Set the INTONATOR Sample Rate as to correspond to the recorder Sample Rate used for recording the original vocal (typically 48 kHz for the ADAT format) and set any other parameters needed for the digital mode. Also set the mixer to the same Sample Rate.

4. Set the INTONATOR settings to the basic pitch correction settings mentioned in this manual.

The routing is set up and now time to set track delays on the ADAT.

The ADAT format allows for delaying tracks so you want to delay all other previously recorded tracks except for track #1 - this will make up for the INTONATOR minimum processing delay time meaning when monitoring, the INTONATOR signal will line up in time with the delayed tracks.

Using the ADAT track delay mode, delay all previously recorded tracks (except for track #1) by 350 samples (roughly 7.3 milliseconds). In other digital routing examples, we mentioned to delay by 347 samples. In this case, we add 3 samples since we are not recording but just monitoring - this is because the ADAT format needs 3 samples of time to process digital data.

When playing the recorder, the INTONATOR minimal processing delay is eliminated!

1. Play the recorder and experiment with the INTONATOR'S window/attack/amount settings until you are satisfied with the results. You may also want to use other features such as the De Esser. If so, set to taste.
2. When mixing the song, if you need to change INTONATOR settings for specific vocal passages, before changing the settings used for most of the song, using artist tape (tape used to write upon such as for mixer fader level settings) put a little piece of artist tape next to the knob(s) which will be moved. Note the knob(s) positions by making a little mark next to the knob(s) pointer. When making changes, use another colored marker for those positions. This will allow you to return to any settings marked when needed. When mixing, keep in mind that setting changes will happen in real time but no big deal as engineers have been using this method for many years.
3. On the song "track sheet", note which tracks you delayed noting the delay time settings (except tracks #1 as there is no delay setting). From now on, as long as you have the INTONATOR in the sonic path, you will need to set the delay settings or save these settings using the "Save Setup To Tape" feature. This way, when working on the song in the future, just load the set up using the "Load Setup" feature. Note: the save to tape and load from tape may use another name depending upon the recorder format.
4. Before mixing, for tracks not yet recorded upon (open

tracks), no reason to delay after recording as they will be lined up in time with the others.

Using An Analog Mixer

Again, the concept is to delay all tracks (other than the vocal track) as to eliminate the INTONATOR minimal processor delay time. Since the mixer is analog, we obviously will use analog routing.

1. As with our other examples, we will assume the vocal is recorded on track #1 without the INTONATOR in the signal path.
2. Patch recorder track #1's analog Output into one of the INTONATOR'S analog Inputs. Patch the INTONATOR'S corresponding analog Output into mixer Input #1.
3. Set the INTONATOR Sample Rate to 48 kHz for our example.
4. Set the INTONATOR settings to the basic pitch correction settings mentioned in this manual.

The routing is set up and now time to set track delays on the ADAT.
The ADAT format allows for delaying tracks so you want to delay all other previously recorded tracks except for track #1 - this will make up for the INTONATOR minimum processing delay time meaning when monitoring, the INTONATOR will line up in time with the delayed tracks.

Using the ADAT track delay mode, delay all previously recorded tracks (except for track #1) by 414 samples (roughly 8.6 milliseconds).

When playing the recorder, the INTONATOR minimal processing delay is eliminated!
1. Play the recorder and experiment with the INTONATOR'S window/attack/amount settings until you are satisfied with the results. You may also want to use other features such as the De Esser. If so, set to taste.
2. When mixing the song, if you need to change INTONATOR settings for specific vocal passages, before changing the settings used for most of the song, using artist tape (tape used to write upon such as for mixer level settings) put a little piece of artist tape next to the knob(s) which will be moved. Note the knob(s) positions by making a little mark next to the knob(s) pointer. When making changes, use another colored marker for those positions. This will allow you to return to any settings marked when needed. When mixing, keep in

mind that changing changes will happen in real time but no big deal as engineers have been using this method for many years.
3. On the song "track sheet", note which tracks you delayed noting the delay time settings (except tracks #1 as there is no delay setting). From now on, as long as you have the INTONATOR in the sonic path, you will need to set the delay settings or save these settings using the "Save Setup To Tape" feature. This way, when working on the song in the future, just load the set up using the "Load Setup" feature. Note: the save to tape and load from tape may use another name depending upon the recorder format.
4. Before mixing, for tracks not yet recorded upon (open tracks), no reason to delay after recording as they will be lined up in time with the others.

Working With Analog Tape Recorders

Important: use this concept only when mixing as it will not work for overdubbing.

If using a multi track analog recorder, believe it or not, there is a way to get tracks to be heard in the future meaning you can advance tracks to be heard before others.

Analog recorders have three heads lined up in the following fashion.

ERASE HEAD   RECORD HEAD   PLAYBACK HEAD

Keep in mind that the tape recorder transport moves tape from left to right when recording or playing back.

The record head is also used for a playback head for previously recorded tracks when overdubbing - this is called sync mode. If analog recorders were not designed in this fashion, while listening to the playback when overdubbing, when playing back the newly recorded material, it would be early in comparison since the record head is positioned before the playback head.

When mixing the song, you monitor the recorded information from the playback head. Since the record head (sync head) can also be used for a playback head, you could use the record head (sync head) for any track as the playback head with a simple modification (see sidebar: wiring sync Output cards) while using the normal playback head for all other tracks. Keep in mind that

a quality analog recorder's record head (sync head) basically sounds as good as its playback head.

Wiring Sync Output Cards

Note: If using a Studer analog multi track recorder, the odds are good that the model will have separate XLR connectors for sync out. In that case, no need to perform the following.

If not a qualified tech, hire a tech to perform the following.

In the recorder manual, find the drawing for the sync card. Look for the Output points. For our set up, we are using track #1 so the sync card to be wired would be track #1.
· If balanced, wire up a cable (long enough to reach the INTONATOR)with a male XLR connector on one end and use pin #2 for hot. Use pin #3 for neutral and pin #1 for ground. Now wire up the other end to their corresponding pins on the sync card.
· If unbalanced, wire up a cable (long enough to reach the INTONATOR) with a 1/4 male phone connector on one end using the hot pin for the tip and the ground for the sleeve. Now wire up the other end to their corresponding pins on the sync card.

When mixing the song, the concept is to use the sync head for the vocal track. Since the sync head is before the playback head, you need to discover the distance between the two heads before setting up the INTONATOR - a delay/phase test is required so here we go.

Analog Recorder Delay Phase Test
Between The Sync And Playback Head
The concept is to record a constant source on a blank recorder track. After recording, the signal is then routed to a delay line (from the sync card cable mentioned above) and patched into a mixer module. The original signal is monitored from the playback head and the delay line signal is monitored from the sync head. Both mixer module return levels will be set to the same level and one of these signals will be set to inverted (reverse) phase.

While experimenting with delay times, at the point when you hear full signal cancellation, you have discovered the amount of delay (in milliseconds) between the two heads. At that point, you will note the delay number then subtract the INTONATOR minimum delay time.
For the following, you will need a delay line and a any CD

(cassette tape, radio, whatever) for the sound source. We will use a recorded CD for the example.

Note: Only use a CD that does not have reoccurring "loops" as with most dance records. Best to use a CD that uses a real band with a vocal as we want a source without loop repetition.

Keep in mind when doing a test with a tape recorder, always best to use blank tape as to not accidentally record over your previously musical material! We will use track #1 for our example.

Recording The CD Onto An Open Recorder Track

Patching The CD Into The Recorder
1. Mute the mixer monitor speakers.
2. Patch either the left or right Output from the CD player into recorder track #1's Input.
3. The level is not important meaning any level below zero dB down to -15 dB will do. If no volume control on the CD player, If needing more or less level, you could rout the CD player through a non-used mixer module and send to track #1 via a tracking bus or aux send.

Setting Up The Recorder
Set recorder track #1 to record ready .and set the recorder monitor mode to Input. mode. (see sidebar, "About The Track Mode Switch").

Setting Up The Mixer
1. On mixer module #1, bring up the fader level to -10 dB on its fader throw.
2. Set mixer module #1's line trim control to 0 dB.
3. Set mixer module #1's pan pot to center.
4. Set the mixer stereo bus level to unity gain.
5. Monitor mixer module #1 through the stereo mixer monitor bus.
6. Unmute the monitor speakers and set to a fairly low monitor level.

Recording The CD Onto Track #1
1. Play the CD and check that the level on recorder meter track #1 is in the area we mentioned above. If not, set the level withing the area we mentioned.
2. Put the recorder in record mode, play the CD, and record about 1 minute.
3. Take the track monitor mode out of auto Input and lock the

recorder playback mode to "tape". This will allow the playback signal to be monitored off the playback head.

4. Playback the recorder as to make sure the signal was recorded properly.
5. Take track #1 out of record ready.

Setting Up The Delay Line
1. Mute the mixer monitor speakers.
2. Time to use the sync head cable (the one you wired from track #1's sync card). Remember that if using a Studer recorder, the sync head connector may be available.
3. Patch this cable into the delay line Input.
4. Patch the delay line Output cable into mixer module #2's line Input.
5. Set the delay line Input volume control to unity gain (zero dB mark). If the delay line also has an Output volume control, set to unity gain as well.
6. Make sure to set the delay line blend control to 100% wet - this will allow the delay signal to pass through the delay line without any of the non-delayed signal (which is what we want).
7. For now, set the delay time setting to minimum.

The next step in the process is to reverse the phase on mixer module #1 or #2. Lets reverse the phase on mixer module #1 for the example.

On mixer module #1, if the mixer Input modules include phase reversal switches (also called "out of phase"), switch to reverse phase. If your mixer does not offer this mode, you need to wire up a patch cord that reverses the phase (see sidebar below). Patch this phase reverse patch cord from recorder #1's Output into mixer #1's Input.

Mixer Settings For The Delay Line Return
1. On mixer module #2, bring up the fader level to -10 dB on its fader throw.
2. Set mixer module #2's line trim control to 0 dB.
3. Set mixer module #2's pan pot to center.
4. Monitor mixer module #2 through the stereo mixer monitor bus.
5. Unmute the monitor speakers and set to a fairly low monitor level.

Checking Levels
At this point, both recorder track #1's Output on mixer module #1, and the delay line return on mixer module #2, should be at least close to same level unless there is a gain mismatch between the mixer and delay line. This is easy to discover.

1. Temporarily, pan mixer module #1 to full left and mixer module #2 to full right.
2. Play the recorder and look at the mixer stereo meters - module #1's signal will be shown on the left meter and module #2's signal will be shown on the right meter.
3. If the levels look the same, skip the next step.
4. If not, move mixer module #2's fader as to match the level shown on the left stereo meter.
5. Now pan both modules back to "center".

Discovering The Delay Time Between The Heads
If you are using the tape speed of 30 IPS, the odds are good the delay time will be somewhere between 50 and 100 milliseconds (depending upon the recorder model). If using the tape speed of 15 IPS, the above numbers would be doubled.

1. Play the recorder - at this point, experiment with delay time settings until hearing partial or full signal cancellation.
2. When hearing at least partial cancellation, experiment with the delay settings by slowly changing the delay numbers up and down. Example: when hearing some cancellation, continue adding delay time until going past the point of cancellation. Now subtract delay until going past the point of cancellation. You now have a small window of delay settings as to work with so continue the process (going up and down with delay numbers) until finding the point of the most cancellation.
3. When hearing the most cancellation, you have discovered the delay time between the heads!

Considerations
If using an analog delay line, the unit may only allow for single millisecond steps instead of 10th's of milliseconds (or more). Not a serious problem meaning the setting should be close enough for this application.

If using a digital delay line, keep in mind that all digital gear has processing delay time. The odds are good that the analog to digital and back to analog processing time will be in the neighborhood of .6 milliseconds. We will make up for that delay when adding the INTONATOR in the path.

Dealing with INTONATOR Processing Delay Time

In any case, the test is complete so note the delay time number somewhere which will can always find when needed. Lets say that the delay time between the heads is 75 milliseconds.

Before moving on, break down the delay line patch set up. Mute the monitor speakers, unpatch the delay line Input and Output and get the phase back to normal on mixer module #1.

Using An Analog Recorder/INTONATOR For The Vocal Track When Mixing

Now that you know the delay time between the sync and playback head, since the vocal track can be heard in the future by 75 milliseconds (our example) using the sync head, no problem elimination the INTONATOR minimal analog delay of 8.6 seconds.

If using an analog delay line, you would set the delay time to 66.4 milliseconds. The math is as follows; 75 (in the future sync head time span) - 8.6 (INTONATOR minimum delay processing delay time) = 66.4.

If the analog delay line that only allows single millisecond delay steps, you would set to 66 milliseconds as to round off.

If using a digital delay line using analog routing, keeping in mind that the analog to digital and back to analog processing time is in the neighborhood of .6 milliseconds, you would set the delay line to 65.8 milliseconds as to make up for the processing delay. The math is as follows; 75 (in the future sync head time span) - 8.6 (INTONATOR minimum processing delay time) - .6 (digital delay line processing time) = 65.8.

If the digital delay line only allows single millisecond steps, not 10th's of milliseconds or greater (typically older designs), set to 65 milliseconds as the digital processing time may be slower than current models.

When setting up the mix, set up the vocal track as to rout through the delay line and INTONATOR as follows.

1. Remember that the vocal was recorded on track #1 without the INTONATOR in the signal path.
2. Set the recorder to tape mode (as you would normally do when mixing). This allows all tracks to be played back via the playback head except for the vocal track (which will use the sync head as mentioned in the next step).
3. Using the cable wired from track #1's sync card, patch into the same delay line used for the test.
4. Patch the delay line Output into either analog Input on the INTONATOR.
5. Patch the INTONATOR'S corresponding analog Output into mixer module #1's line Input.
6. On the INTONATOR, set to analog routing as well as the analog Input and Output used (left or right).
7. Set the Sample Rate to 48 kHz for our example.
8. On both the delay line and the INTONATOR, set the Input level for unity gain (zero dB marking next to the pot pointer). If the delay line has an Output volume control, set to unity gain as well.
9. Note: there may be a gain mismatch causing too much or too little level (the mixer or delay line may be a -10 dB gain structure). If so, when playing the recorder, look at the meter level on the delay line at the loudest vocal passage. If the level is either too low or high, set to average zero dB. Now do the same using the INTONATOR'S meter and level control.

You are set up to mix so experiment with the INTONATORS pitch controls when playing the tape.

When mixing the song, if you need to change INTONATOR settings for specific vocal passages, before changing the settings used for most of the song, using artist tape (tape used to write upon such as for mixer level settings) put a little piece of tape next to the knob(s) which will be moved. Note the knob(s) positions by making a little mark next to the knob(s) pointer. When making changes, use another colored marker for those positions. This will allow you to return to any settings marked when needed. When mixing, keep in mind that changing changes

will happen in real time but no big deal as engineers have been using this method for many years.

The Delay Test Using A Digital Tape Recorder
Note: if using a hard disk recorder system or computer based software that allows visual track time shifting, no need to deal with this test since time shifting is visual using such formats.

As to discover the INTONATOR's minimal delay time, I performed an oscillator comparison test using phase reversal on one of the two recorded signals as to discover the cancellation point while experimenting with delay times on the original source track. This may sound confusing but will be explained as you read on. Keep in mind that this test can be used for any outboard digital processing tool.

For this test, you need either a synthesizer or a test oscillator that allows frequency sweeping (not fixed frequency settings only).

This test was performed using the M20 ADAT recorder format. Keep in mind when doing a test with a tape recorder, always best to use blank tape as to not accidentally record over your previously musical material!

This test will be in 3 stages:
* Test Stage #1 deals with recording an oscillator tone onto a recorder track.
* Test Stage #2 deals with routing the recorded oscillator track through the INTONATOR and recording this signal to another recorder track.
* Test Stage #3 deals with INTONATOR delay time discovery.

Test Stage #1 - Recording The Oscillator Tone
Patching The Synth Into The Recorder
1. Mute the mixer monitor speakers.
2. Patch the synth Output into recorder track #1's Input. Note: If using an analog synth, if the synth has more than one Output, use the one labeled "mono" if available. Otherwise, use the left or right Output. If the synth has high and low gain Outputs, use the high gain Output.
3. If using a digital synth, patch in digitally if you like. Keep in mind audio quality is not an issue here so patch in using either routing.

If using a test oscillator with sweepable frequency pot (not fixed frequency settings only), patch it's Output into recorder track #1's Input. If this is the case, when reading the following, eliminate synth descriptions.

Setting Up The Synth Patch
We want a single oscillator, pure synth tone - no modulation, envelopes, or effects. With digital synths, you may be able to create a default (sometimes called "initialized") patch containing a pure, sustained tone. If not, you'll need to take an existing patch and edit it. With analog synths, the needed adjustments will be made with front panel knobs. Following are the edits you need to make.

1. Select a sine or triangle waveform (sawtooth, square, or pulse waveform will also work).
2. Set the oscillator level control to maximum.
3. Turn the levels of all other oscillators to minimum or switch off if they have bypass switches.
4. Set the oscillator to the "8 foot" setting. If the synth does not indicate foot settings, it may show octaves as "-1," "+1", etc. In this case, set to a setting that does not have a plus or minus sign. When we get around to playing the synth note, we want a note in the neighborhood of middle "C" in relation to a piano middle "C".
5. The oscillator and filter should not receive any type of modulation (vibrato, pitch bend, or aftertouch) - we just want a pure, steady, annoying tone to start.
6. Check that the oscillator, filter, and VCA (voltage controlled amplifier) or DCA (digital controlled amplifier) are not affected by keyboard velocity or pressure (aftertouch).
7. Set the filter cutoff parameter to the highest possible frequency so that the sound is as bright as possible.
8. Set the filter and VCA/DCA envelope generator to fast attack and maximum sustain so that the sound remains at a constant level and does not fade away.
9. If using an analog synth with analog routing, set the synth master Output volume control all the way up. This level will not overload most recorder track Inputs. If it does (a level mismatch. i.e., +4 level synth into a -10 recorder Input), bring down the synth master volume as to show zero dB on recorder track #1's meter.
10. If using an digital synth with digital routing to the recorder, set the synth master Output volume about 3/4th's up as to prevent possible digital "clipping". Maximum level is not important for the test.

Setting Up The Recorder
1. For either digital or analog routing, set the recorder to receive the signal.
2. Set recorder track #1 to record ready and set the recorder monitor mode as to allow monitoring through the recorder electronics before recording - typically called auto Input mode.

Setting Up The Mixer
1. On mixer module #1, bring up the fader level to -10 dB.
2. Set mixer module #1's line trim control to 0 dB.
3. Set mixer module #1's pan pot to center.
4. Set the mixer stereo bus level to unity gain.

5. Monitor mixer module #1 through the stereo mixer monitor bus.
6. Unmute the monitor speakers and set to a fairly low monitor level as this oscillator sound will be most annoying.

Recording The Oscillator Tone
1. Put the recorder in record mode and record about 1 minute while doing the following:
2. Hold down middle "C" on the synth keyboard and while doing so, turn the synth master tune pot up and down (at a medium speed) using its full throw - this will create a siren type sound. If using a test oscillator instead of a synth, turn the frequency pot up and down in the area of 500 cycles up to 3 kHz cycles. In any case, keep repeating the up and down frequency sweep while recording the oscillator.
Note: the reason to keep moving the master tuning pot is as follows: if the oscillator pitch were stable, since a stable oscillator pitch is a periodical (repeating) waveform, when we get into the phase test, this would fake out the actual point of phase cancellation. This will make sense as you read on.
3. At this point, you have the oscillator siren sound recorded and playback as to make sure it is on tape. If not, go back to step #1 in the beginning of this section.
4. Now take recorder track #1 out of record ready and unpatch the synth (or test oscillator) from recorder track #1's Input.

Test Stage #2 - Routing The Recorded Oscillator Track Through The INTONATOR And Recording This Signal To Another Recorder Track.

Patching Recorder Track #1's Output Into The INTONATOR Input And The INTONATOR'S Output Into Another Recorder Track Input

Now that we have the oscillator recorded on track #1, we will patch its Output into the INTONATOR Input as to record its Output onto another recorder track (we will use recorder track #3 for the example). This will allow the discovery of the delay time in comparison to the previously recorded oscillator signal recorded on recorder track #1.

Two ways to patch - analog or digital routing. If your set up allows both routing possibilities, if you may use one or the other at some point in time, best to perform this test twice. Choose either routing now and after completing the test, come back to this point and redo the test using the other routing.

Dealing with INTONATOR Processing Delay Time

Routing option #1: Analog routing
1. Mute the mixer monitor speakers.
2. Patch recorder track #1's analog Output into the INTONATOR'S left analog channel Input.
3. Patch the INTONATOR'S left analog channel Output into recorder track #3's Input.
4. Set the INTONATOR Input level pot to zero dB.
5. Now go to the manual section regarding the basic set up for INTONATOR settings and set to analog routing. Since we are using the left channel Input, set to left channel. In this test, the Sample Rate used was 48 kHz.
6. For this part of this test, no pitch correction was in play so the INTONATOR window and amount pots were set to full left - this shuts down the pitch correction functions just allowing the non-effected signal to rout through the INTONATORS electronics but induces the minimal processing delay time. After recording this routing, the idea is to check the delay time in comparison to the previously recorded oscillator track. If pitch correction was induced, no way to do the out of phase comparison test as pitch changes would not cancel out. This will make more sense as you read on.

Routing option #2: Digital routing
1. Mute the mixer monitor speakers.
2. If using the ADAT format, since the light pipe port is common to both the ADAT and INTONATOR, patch the ADAT's light pipe Output into the INTONATOR'S light pipe Input. Now patch the INTONATOR'S light pipe Output into the ADAT's light pipe Input. Note: if using another recorder format, since the INTONATOR offers all digital formats, patch in the same fashion meaning recorder digital Output to INTONATOR Input then INTONATOR Output into digital recorder Input. Check the recorder manual for details as you may need word clock, etc.
3. Now go to the manual section regarding the basic set up for INTONATOR settings and set to digital routing settings. If using an ADAT recorder, when going through the "set up pages", select ADAT when mentioned. Keep in mind that when setting ADAT routings, this example uses track #1 for the source and track #3 for the destination track. No matter what digital recorder format you are using, make sure to set the INTONATOR to the same Sample Rate as was set on the recorder when recording the oscillator siren tone. (In this test, the Sample Rate of 48 kHz was used which shows up as 44.1 kHz/48 kHz in the set up page).

4. Check your recorder manual as to discover how to perform the digital routing software process. If using an ADAT recorder, use the optical mode (not track copy mode) and make sure the ADAT Input routing is set to digital. As to make sure you are in this mode, on the ADAT meter display, a "D" will be visible at the bottom of each tracks bar meter display.
5. For this part of this test, keep in mind you do not want any pitch correction in play so set the INTONATOR window and amount pots to full left - this shuts down the pitch correction functions just allowing the non-effected signal to rout through the INTONATORS electronics which induces the minimal processing delay time. After recording this routing, the idea is to check the delay time in comparison to the previously recorded oscillator track. If pitch correction was induced, no way to do the out of phase comparison test as pitch changes would not cancel out with the non-pitch changed oscillator signal. This will make more sense as you read on.

Recorder Set Up
Set recorder track #3 to record ready and set the recorder monitor mode as to allow monitoring through the recorder electronics - typically called Input mode (see the above sidebar, "the track mode switch").

Mixer Set Up
On mixer module #3, bring up the fader level to -10 dB.
Set mixer module #3's line trim control to 0 dB.
Set mixer module #3's pan pot to center.
Set the mixer stereo bus level to unity gain (this was already set when recording the oscillator "siren" tone).
Monitor mixer module #3 through the stereo mixer monitor bus. Unmute the monitor speakers and set to a fairly low monitor level as this oscillator sound will be most annoying.

Recording The Oscillator Tone Through The Intonator Onto Recorder Track #3

Dealing with INTONATOR Processing Delay Time

1. Rewind the recorder about 5 seconds before the point where you recorded the oscillator siren sound.
2. Put the recorder in record mode and record until you no longer hear the oscillator siren sound.
3. Set the track monitor mode to auto Input and rewind the recorder as to make sure it was recorded. If not, go back to step #1 in this section.

Test Stage #3 - INTONATOR Delay Time Discovery.

Reversing the phase on mixer module #1
At this point, you have the original oscillator source recorded on track #1 and the INTONATOR non-pitch effected oscillator signal recorded on track #3. The next step in the process is to reverse the phase on either mixer module #1 (recorder track #1 return) or mixer module #3 (recorder track #3 return). Lets use mixer module #1 for the example.

On mixer module #1, if the mixer Input modules include phase reversal switches (also called "out of phase"), switch to reverse phase. If your mixer does not offer this mode, you need to wire up a patch cord that reverses the phase (see sidebar below). Patch this phase reverse patch cord from recorder #1's Output into mixer #1's Input.

__Wiring an "out of phase" patch cord__

Regarding the way to wire this patch cord, this is simple. If a two wire patch cord, on only one of the two patch cord connectors, reverse the ground and hot pin connector. If a 3 wire patch cord, reverse the neutral and hot wire. Example: if an XLR connector, swap pin #2 and pin #3 on one connector only.

Important: Always clearly identify any "out of phase" cable so you don't use it accidentally when recording when not wanting a reverse phase path! Do this by using a piece of artist tape wrapped around both connectors and note "reverse phase".

Discovering The Delay Time
As to review, the original oscillator "siren" signal was recorded on track #1 and this track signal was patched into the INTONATOR which was recorded on track #3. We know that the INTONATOR is causing the delay so we will delay track #1 as to find the delay time.

As mentioned, you have both mixer modules #1 and #3 set to -10 dB on their respective fader throws, both mixer modules are set to 0 dB line trim levels, and both are panned to "center". The odds are good that when playing the recorder, both levels should be the same (or very close) which is what you want. Here's why:

You also have mixer module #1 set to reversed phase. After discovering the delay time caused by the INTONATOR, since both signals are identical (except for the fixed (non drift) delay time created by the INTONATOR), since one of the two signals is phase reversed, when discovering the correct delay time, the signals will cancel out!

1. On the ADAT recorder (or the digital tape recorder you are using), go to the track delay edit page and for track #1 only, set to single sample delay steps instead of milliseconds/tenths of milliseconds. Note: if the recorder only allows milliseconds/tenths of milliseconds delay steps, this will work but not quite as accurate.
2. Play the recorder and while listening two both tracks #1 and #3, continually press the button that delays the signal.
3. When starting to hear signal cancellation, you are near the delay time setting. At that point, press the delay button slower. Keep pressing the delay time button until hearing the most cancellation - if you start hearing less cancellation, hit the button that subtracts the delay time numbers.
4. You are now very close to finding the exact delay time number so work within the area going forward and backwards regarding the delay setting until finding the delay time number that produces the most cancellation.

As mentioned, I discovered if using the INTONATOR analog Input and Output with the Sample Rate set to a 48 kHz (on both the INTONATOR AND ADAT recorder), the delay time is rounded off to 8.6 milliseconds. The exact delay equals 414 samples.

Dealing with INTONATOR Processing Delay Time

If using the INTONATOR digital light pipe Input and Output (connected to an ADAT recorder) with the Sample Rate of 48 kHz (on both the INTONATOR and ADAT recorder), the delay time is rounded off to 7.2 milliseconds. The exact delay equals 347 samples.

The Delay Test Using An Analog Tape Recorder
See "Working With Analog Tape Recorders" as to discover the distance between the sync and playback head. After performing that test, go to the above section. "The Delay Test Using A Digital Tape Recorder" and use the analog routing.

The only difference is when we mention track offset delays, instead insert the delay line as explained in "Working With Analog Tape Recorders". Use the delay line as to find the cancellation point.

bio:
Guitarist/songwriter/producer/recording artist/engineer Jay Graydon has been nominated for 12 Grammies and won two. For more info, surf to
http://www.umu.se/users/KEO/graytxt.htx

Jay Graydon and Craig Anderton are writing a book series dealing with recording technique which will soon be available. The vocal book (and others) will include further detailed "INTONATOR" information.

In closing, I would like to thank Craig for allowing me to borrow a few paragraphs of wording from our books included in this chapter.