juicedLink

Field Guide to Audio Production

“SA/NA - SE/NE - CYA” Methodology

Three Steps to Quality Audio on a Budget

1 Contents

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2 READ THIS FIRST– Fundamental Principles

2.1 Introduction

Get ready. You were about to learn a ton of information, in a short period of time. To make it digestible for you, we've developed the "*SA/NA - SE/NE - CYA*" Methodology, so you will be able to retain what you've learned, and quickly be able to put it into practice. It only takes adherence to these three steps to achieve quality audio on a budget ...

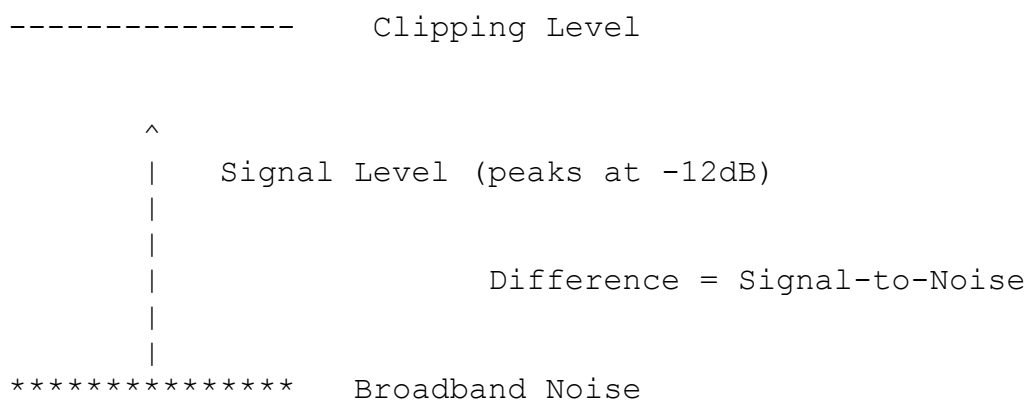
This document is still a work in progress. We will also be adding more content later. Make sure the subscribe to the juicedLink blog, to get notified when updates are available.

When you're out on Facebook/Twitter/Forums helping your colleagues, I want to see you spreading the word on "*SA/SA – SE/NE – CYA*". That way, I will know that I've done my job with this field guide ...

- Robert from juicedLink

2.2 Signal-to-Noise Ratio (SNR)

The main objective for recording quality audio, is you want to optimize the signal-to-noise ratio (SNR) in your recording. The figure below represents what a spectrum plot would look like for a tone that signal. The vertical axis is the amplitude, and the horizontal axis is the frequency. The vertical arrow represents the magnitude of the tone signal level. The horizontal line at the bottom represents the level of some broadband noise. The difference between the arrow and horizontal line represents the signal-to-noise ratio (SNR).



2.2.1 Optimize Signal

We want to make the signal is high as practically possible. But, there's one constraint, which is electronic recording equipment has a maximum signal that it can handle before it starts clipping. So, you want to leave some headroom below the clipping level (top line in the figure above), to allow for fluctuations in the signal level.

So, what is typically done is to adjust the signal level so the meters in your recording device (recorder or camera) peak at about -12dB Full Scale.

2.2.2 Minimize Noise

Electronic noise (hiss) cannot be eliminated from recording equipment (like cameras or recorders). The objective is to make the noise (whenever the source) be as small as possible relative to the signal. Noise can come from a variety of sources, such as:

- Background noise
- Echo
- Wind noise
- Handling noise
- Electromagnetic interference
- Electronic noise

2.3 "SA/NA - SE/NE - CYA" Methodology Introduction

SAAHH … NAAHH … SEE … NEE … CYA … it rolls right off the tongue. Say it out loud a few times. Remember it. When you are in the field, this will be your check to be sure that you are not neglecting anything in your audio production flow.

We have already mentioned how it is all about signal-to-noise ratio (SNR). But, there's a lot of components that go into it, and how do you remember it all: selecting the right microphone, microphone placement, microphone orientation, what settings to use on the camera, what settings to use on the preamplifier, making your recording resilient to unexpected events ...

So, let's break things down into smaller chunks ...

Let's first consider SNR on the acoustic side of things. So, "***SA/NA***" refers to the "Signal-Acoustic / Noise Acoustic" ratio. Considerations that you will learn as we go through this methodology include:

- Selecting the right mic (omni, cardioid, hypercardioid, shotgun, lav) for the job (*SA/NA*)
- Getting your sources within the mic acceptance angle (*SA*)
- Tucking noise sources (air conditioner vents, the crew) into mic nulls (*NA*)
- How to get the juiciest signal into your mic front end (*SA*)
- Minimizing wind and handling noise (*NA*)

Then consider SNR on the electronics side of things. So, "***SE/NE***" refers to "Signal-Electronics / Noise-Electronic" ratio. Considerations that you will learn as we go through this methodology include:

- When do you need a really now noise mic (*NE*)
- Selecting a mic to minimize electromagnetic interference (*NE*)
- What settings to use on the camera/recorder (*SE/NE*)
- How to use a low-noise preamp to improve SNR of noisy cameras and recorders (*SE/NE*)

Then, of course, we need to put it all together into a process to make sure that there's no screw-ups, and we Cover You Arse, or "***CYA***". Considerations that you will learn as we go through this methodology include:

- Using Audio Bracketing for camera overload protection (*CYA*)
- Why only a fool neglects to wear headphones (*CYA*)
- What steps to add to my production flow if my camera does not have headphones or meters visible while recording (*CYA*)

3 SA/NA – SE/NE – CYA Methodology

The end of last section explained what "*SA/NA – SE/NE – CYA*" represents. Now, let's dive into the details …

3.1 GET THE MIC CLOSE

3.1.1 Inverse-Square Law (*SA*)

The acoustic signal decreases rapidly as you move away from the source. It falls off by the inverse-square law, where you loose 6dB of your signal every time you double the distance from the source. So, consider this example:

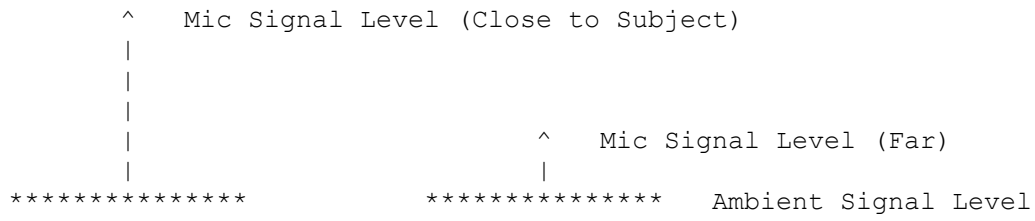
- Mic placed 1 ft from person speaking
- Move the mic to 2ft, you've lost 6dB of the original signal
- Move the mic to 4ft, you've lost 12dB of the original signal
- and so on …

So, the distance the mic is from the source has a HUGE effect on the amount of signal that makes it into the front end of the microphone. Let's make note that the inverse square law has a profound impact on the "Signal-Acoustic" (*SA*) in the "*SA/NA – SE/NE – CYA*" Methodology.

3.1.2 Mic Placement Example: Background Noise (*SA/NA*)

Let's apply the inverse-square law and it's impact on "Signal-Acoustic" (*SA*), to see how it has just as a profound impact on the signal-to-noise (SNR) that can be achieved from a microphone "Signal-Acoustic/Noise-Acoustic" (*SA/NA*).

Assume that we are on location in a convention center, which has a high ambient signal level from all of the people chatting at the various booths on the floor. It doesn't really matter which direction the microphone is pointed, the high ambient signal level of the chatter is pretty constant in all directions. Now, consider a mic placed close to a person speaking, and compare that to when the mic is placed further away from the subject. Below is a spectrum plot comparing the two scenarios:



From the two plots, you can see the mic signal level when far away from the subject speaking is much lower because of the inverse-square law attenuating the sound pressure level at a greater distance, while the background noise of the ambient signal level remains the same. Correspondingly, the difference between the signal level and noise level for the mic placed further away is much lower than when the mic is placed close to the subject who is speaking. So, to optimize the Signal-Acoustic/Noise-Acoustic SNR, or "*SA/NA*", going into the front end of the microphone, GET THE MIC CLOSE !!!

3.1.3 Mic Placement Example: Mic Noise (*SA/NE*)

This time, instead of background noise, consider the case of a microphone's electronic self noise. So, instead of Noise-Acoustic, we are considering the Noise-Electronic of the mic. But again, no matter where you point the mic, the mic self-noise is always constant. So, we have the identical situation as described above, but the horizontal line of the ambient signal level is replaced by the horizontal line of the microphone's noise. Again, to

optimize SNR, the rule is to GET THE MIC CLOSE !!!

3.1.4 Fundamental Rule: GET THE MIC CLOSE (*SA/NA*)

THIS IS THE MOST IMPORTANT RULE FOR CAPTURING QUALITY DIALOGUE … GET THE MIC CLOSE !!!

- This is especially important for low level signals like dialogue.
- The reason getting good SNR coming out of your mic is so important is because it will set the maximum achievable SNR for the entire system, and there is no way of "fixing" it with other production techniques, production equipment, or non-lossy post production tools.
  - Although a juicedLink low-noise preamp is effective at improving the signal-to-noise performance of poor performing downstream components like a noisy camera or recorder, it can NOT improve poor performing noisy upstream components, such as a poor SNR captured by a mic. The preamp will accurately reproduce whatever is presented to it. This is to say "garbage-in, garbage-out".
  - Sometimes there are software tools that can help in post. They work best with a noise source that is constant (like the constant hiss from electronic noise). But, it is extremely difficult to effectively remove other noise sources, such as echo, background noise, wind noise, and handling noise. Even when it can be done, it is very time consuming, and the techniques are lossy so it will degrade your desired signal.

3.1.4.1 Ways to get the Mic Close

Mounting a mic on top of your camera is fine for run-n-gun paparazzi style shooting. But, when you want quality dialogue, you NEED TO GET THE MIC OFF THE CAMERA AND CLOSER TO YOUR SUBJECT.

- Use a boom pole and boom operator
- Set up the mic on a C-stand
- Use a hand held mic
- Use a lavaliere
- Plant a mic in your scene (behind a plant, computer monitor, coffee cup)

3.2 Microphone Basics

3.2.1 Balanced vs Unbalanced Signaling (*NE*)

Below is a photo of 2 typical microphone connectors, balanced XLR an unbalanced miniplug. Notice how both have 3 contacts.

- UNBALANCED SIGNAL
  - Comprises 2 connections: Signal + Ground
    - Note: a 3 contact miniplug may carry 2 unbalanced signals (right and left) plus ground
    - The 3 contacts are referred to TRS, or Tip, Ring, Sleeve. For a stereo miniplug, the left channel is on the Tip, right channel on the ring, and ground is on the sleeve.
- BALANCED SIGNAL
  - Comprises 3 connections: Signal + Inverted Signal + Ground
    - Signal is referred to as "+" or "HOT" and will reside on XLR pin-2
    - Inverted Signal referred to as "-" or "COLD" and will reside on XLR pin-3
    - Ground will reside on XLR pin-1

What's the point? The advantage of a balanced signal is that a receiver can be designed in the preamp which will cancel undesired signals that get onto the Signal + Inverted Signal conductors of a balanced line. This is known as Common Mode Rejection. So, balanced signaling is much less susceptible to picking up electromagnetic interference that can get onto mic cables ... MINIMIZING NOISE. This helps lower the Noise-Electronic (*NE*) component for optimizing SNR.

What does this mean in practice? You want to have long cable runs use balanced signaling. So, something like the Rode VideoMic (unbalanced shotgun mic) is fine for use on camera (short cable run). But you will want to use something like the Rode NTG2 (balanced XLR shotgun mic) when you are booming to get the mic close for quality dialogue. So, a balanced XLR mic like the NTG2 is more versatile, as it can be used both on camera, or with a cable boomed off camera (for best dialogue SNR).

3.2.2 Dynamic vs Condenser Mics

- RUGGED:
  - Dynamic microphones are more rugged. So, they will typically be used for hand held microphones.
- SENSITIVITY
  - Condenser mics are more sensitive, and will be used in things like shotgun mics.
- POWER
  - Dynamic microphones do not require power to operate.
  - Condenser microphones require power. Some condenser microphones have a battery compartment (NTG2). Other condenser microphones (like the NTG1 or NTG2) can receive power from the device that they get plugged into, called Phantom Power.

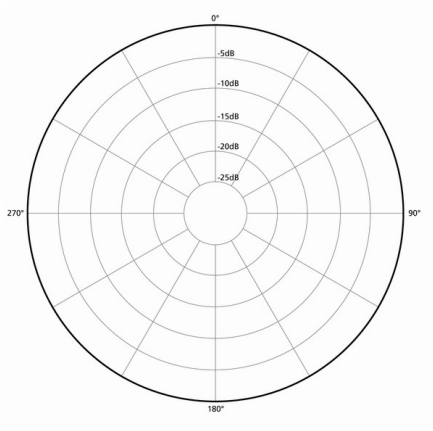
3.2.3 Phantom Power

- PHANTOM-ONLY MICS
  - ADVANTAGE: The advantage of mics that only use phantom power (like NTG1) is that they can be smaller/lighter, so easier to boom or mount to your camera (no battery compartment).
  - DISADVANTAGE: The disadvantage is that phantom power will drain the battery from your mixer faster.
- PHANTOM VS BATTERY – Does the mic sound better running from phantom instead of battery?
  - For all practical purposes, no.
  - There can be a small difference in the maximum sound pressure level the mic can handle, but you'll never come close to that in practice anyhow (or, your ears would be bleeding because it's so loud).
  - There can be a small difference in the mic impedance, but a low noise preamp that you may use with your mic makes the mic impedance spec very forgiving. So ... no …
- PHANTOM SPECS
  - Mics spec'd typically at 48V, or 11-48V.
    - Running 12V from your mixer will conserve mixer battery life. So, it's nice when you can find a mic that will work down to 11V.
- WARNING
  - ONLY apply phantom power to condenser mics which require it. For example, never apply phantom power to an unbalanced mic or wireless receiver. You will basically be shorting 48V to ground, and risk damaging your equipment.
    - Never apply phantom power to wireless mic receivers, unbalanced microphones or adapters, ribbon microphones, dynamic microphones.
  - TIP: Newbie? Take different color tape and color-code your mics and adapters based on their phantom power requirements.
- TROUBLESHOOTING
  - For a mic to operate from phantom power, it requires the phantom voltage as well as a ground reference. In audio for video production, audio equipment is often mounted to the camera rigs, and sometimes hum/buzz can occur because of ground loops. So, people will take steps to eliminate ground loops, like using ground lift switches and the like. So, if you find that your phantom mic does not seem as it is getting power, check to make sure the mic is actually getting a ground reference, especially if a ground switch has been set to the LIFT position.
- PLUG-IN POWER ≠ PHANTOM POWER
  - Some cameras (mostly Sony camcorders) provide a low voltage (~5V) from the 3.5mm minijack mic input to power unbalanced electret element based mics. This is not the same as phantom power for balanced XLR microphones.

3.3 Selection of Mic Polar Pattern

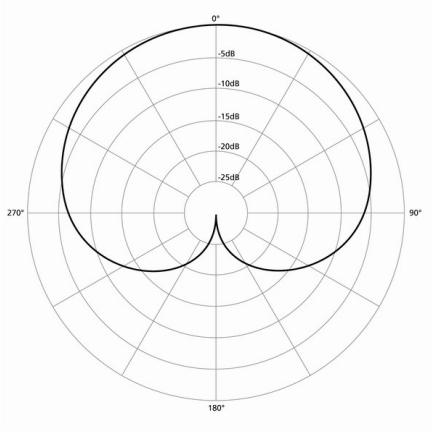
3.3.1 Mic Polar Patterns

Polar pattern plots show the attenuation of sound waves incident from different angles upon the microphone. For the pots below, the microphone orientation is pointing upward.



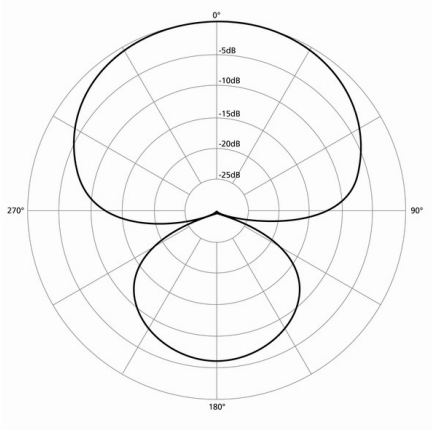
3.3.1.1 Omni

- PATTERN
  - Accepts signals from all directions.
- APPLICATION
  - Does not suffer from “Proximity Effect” like directional mics (below)
    - Proximity Effect is where mics placed close to the source (mouth) will distort and become very bassy
    - Providing the best Signal-Acoustic/Noise-Acoustic (*SA/NA*) in high background noise environments, because you can get it closer than other mic types
  - Situations where signal could be coming from anywhere



3.3.1.2 Cardioid

- PATTERN
  - Upside down “heart” … “cardio” … get it …
  - Wide front end acceptance angle
  - Attenuates signals from the back (null directly behind mic)
  - A small amount of attenuation from the sides
- APPLICATION
  - When you need a wide front end acceptance angle and attenuation from the rear

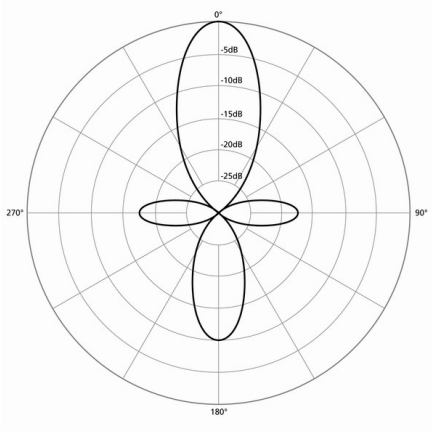


3.3.1.3 Hypercardioid

- PATTERN
  - Attenuates from the sides a little more than a cardioid
  - 2 nulls at offset angles in the back
  - Starts accepting more signal through a rear lobe
- APPLICATIONS
  - Directional front end and decent side rejection
  - Clever use of nulls for attenuating noise sources
  - Hypercardioid capsule is often selected for use in conjunction with an interference tube to create a shotgun microphone

3.3.1.4 Shotgun

- SHOTGUN:



- Constructed of directional capsule (such as hypercardioid) plus an interference tube
- Narrow front acceptance angle
- Significant attenuation from the sides. This is the main feature of a shotgun mic. There are typically a number of lobes on the sides at a low level (this plot shows a single lobe on both sides).
- Starts accepting more signal through a rear lobe
- Longer interference tube = more side rejection

- APPLICATIONS
  - Situations calling for the most directivity and side rejection
  - Create a "circle of silence" around your subject by having the shotgun point nearly straight down or nearly straight up, rejecting the signals entering into its sides.

3.3.2 Examples of Polar Patterns and SNR (SA/NA)

- SIGNAL: Need to make sure your acceptance angle is wide enough to cover what you want to capture.
- NOISE: Take advantage of attenuation and nulls and place noise sources (air conditioner vents, crew) at those angles.

3.3.2.1 Selection Example – Choir on Stage, Fidgety Audience

- SCENARIO
  - Choir on stage
    - Signal-Acoustic (*SA*) source emanating from large geometric area
  - Fidgety Audience
    - Noise-Acoustic (*NA*) behind the microphone
- ANALYSIS OF OPTIONS
  - OMNI: Not very good choice, as it will accept the noise (*NA*) from the audience behind the microphone
  - HYPERCARDIOID: Not a good choice, as it will accept the noise (*NA*) from the audience behind the microphone via its rear lobe
  - SHOTGUN: Not a good choice as it has too narrow of an acceptance angle to accept the signal (*SA*) from the full width of the choir, and it will accept the noise (*NA*) from the audience behind the microphone via its rear lobe
  - CARDIOID: Great choice as it has a very wide acceptance angle to accept the signal (*SA*) from the full width of the choir, and it will reject the noise (*NA*) from the audience behind the microphone with its rear null

3.3.2.2 Selection Example – Boom Actors on Couch in Living Room, Fidgety Crew Behind Camera

- SCENARIO
  - Boom Actors on Couch in Living Room, Fidgety Crew Behind Camera
    - Signal-Acoustic (*SA*) source emanating from localized geometric area
  - Fidgety Crew
    - Noise-Acoustic (*NA*) behind the camera
- ANALYSIS OF OPTIONS
  - OMNI: Not very good choice, as it has no directivity to isolate the localized actors
  - CARDIOID: Not a very good choice because if you were to boom with an orientation to tuck the fidgety crew into the rear null of the mic, the mic would be in the view of the camera
  - HYPERCARDIOID: A good choice to boom from above with the mic orientation angle such that the fidgety crew will be aligned with one of the rear nulls
  - SHOTGUN: A good choice to boom from above with the microphone angle such that the fidgety crew will be attenuated by the mic side rejection. However, you must be careful about echo. See

more details in the *Misuse of Shotgun Mics* section.

3.3.3 So, What's an Omni For?

- Handheld mics are frequently omni
  - Because they can be used close to the source (mouth) without Proximity Effect
  - Providing the best Signal-Acoustic/Noise-Acoustic (*SA/NA*) in high background noise environments
- Lav mics that are worn are often omni
  - If the lav on somebody's shirt becomes mis-directed, you won't have undesired attenuation

3.3.4 Misuse of Shotgun Mics

- ORIENTATION
  - The WORST orientation for a shotgun mic is pointing straight out (like, mounted on top of your camera).
    - Will pick up all of the background noise behind your subject with its very sensitive front end.
    - Will pick up a lot of the noise behind the mic (YOU AS THE CAMERA OPERATOR) from its rear lobe
    - But, when you're run-and-gun paparazzi style, sometimes that's the best you can do.
  - Objective: Create a "circle of silence" around your subject by having the shotgun point nearly straight down or nearly straight up, rejecting the signals entering into its sides.
- ECHO
  - Shotgun mics don't like echo. The interference tube of a shotgun mic gets confused at time delayed signals (echo) which can create a "coloration" of your audio.
  - So, a pro will typically not use a shotgun indoors, and choose a hypercardioid for indoor use instead.
  - But, you can still use a shotgun indoors. Take care with minimizing the echo. Get the MIC CLOSE so the echo is small relative to the desired signal. The "coloration" is more like a 2nd or 3rd order effect.

3.4 Other Noise-Acoustic Sources

3.4.1 Echo (*NA*)

- Toss around blankets to cover hard surfaces.
- Break up the "resonant cavity" of an empty room with large plush furniture.
- Make the Signal-Acoustic (*SA*) level high relative to the echo Noise-Acoustic (*NA*) by GETTING THE MIC CLOSE

3.4.2 Wind Noise (*NA*)

- The open-cell foam wind screen that came with your mic is not sufficient for outdoor use.
  - Use zeppelin (covers entire mic), or something like Rycote Softie (covers mic front end)
    - Products like the Rycote Softie which only cover the front end leave elements like the mic filter switch and interface to the XLR connector and release pin exposed
      - Surprisingly, wind going over these elements create turbulence which creates mic handling noise
      - Use electrical tape to cover these elements
- Engage the low-cut filter on your mic
- Wear headphones
  - The meter doesn't delineate between displaying Signal-Acoustic (*SA*) vs Noise-Acoustic (*NA*)
- In constant wind outdoors, have subjects with back to wind, and use a lav or boom from below, using subjects body to block wind.

3.4.3 Handling Noise (*NA*)

- Use shockmount for mounting mic to boom or camera
- Engage the low-cut filter on your mic
- Wear headphones
  - The meter doesn't delineate between displaying Signal-Acoustic (*SA*) vs Noise-Acoustic (*NA*)
- Boom op
  - Wear headphones
  - PRACTICE booming technique to minimize handling noise

3.5 Minimizing Noise-Electronic (NE)

All recording devices (cameras, recorders) will have noise associated with it. It will vary. Cameras are typically not very good. Recorders can vary greatly from excellent to pretty poor.

3.5.1 Noise Figure of Cascaded Amplifiers

The first amplifier in the signal chain sets the noise characteristics for the entire system. This is known as the "Noise Figure of Cascaded Amplifiers". So, if you have a noisy camera or recorder, you can fix that by using a juicedLink low-noise preamplifier.

3.5.1.1 Example – Canon DSLR

When DSLRs first came out, they got a bad reputation because you could not turn off the AGC. Now, even budget DSLRs have manual control of their audio. This allows you to manually throttle back the noisy gain in the camera, and replace the noisy gain with clean gain from the juicedLink low-noise preamp, optimizing Signal-Electronic/Noise-Electronic (*SE/NE*).

SETTINGS: In the camera, manually throttle back the noisy gain to 1 click above off, and replace the noisy gain with clean gain from the juicedLink low-noise preamplifier.

ADVANTAGES:

- Now you can record directly to your camera with excellent signal-to-noise performance, with no need to sync your audio in post with an external recorder.
- You will never forget to record your audio, by neglecting to hit record on the external recorder (not just once, but TWICE)
- Quickly dial in the signal level to the optimum setting with the front panel potentiometers (instead of hitting gain rocker buttons found on many recorders, or having to go into the firmware of the camera to set the level)
- Small, lightweight, and power efficient.
- Instant boot time for eventing
- Can be used with noisy external recorders (like the H4n), to improve their signal performance using the same principle similar to cameras

3.5.2 Use Balanced XLR Microphones

Balanced signaling is less susceptible to picking up electromagnetic interference. So, for long cable runs such as from the camera to the boom operator, you want to use balanced XLR microphones with balanced signaling.

3.6 Optimizing Signal-Electronic (SE)

We want to make the signal is high as practically possible. But, there's one constraint, which is electronic recording equipment has a maximum signal that it can handle before it starts clipping. So, you want to leave some headroom below the clipping level (top line in the figure above), to allow for fluctuations in the signal level.

So, what is typically done is to adjust the signal level so the meters in your recording device (recorder or camera) peak at about -12dB Full Scale.

- TOOLS
  - Meter
  - Potentiometer on Preamplifier
    - Some recorders have rocker buttons for adjusting the signal level. When you need to quickly fine tune an adjustment, hitting a rocker button takes too long.
    - Similarly, it will take too long to go into the camera firmware and fumble with the menu system for quickly making signal level adjustments.
    - The juicedLink low-noise preamps have front panel potentiometers for this purpose.

3.7 CYA

Here are some CYA tips, some of them less intuitive than others.

- Wear Headphones
  - The meter won't tell you if your mic is poorly oriented, or if you have too much wind/handling/background noise, etc
- Use colored electrical tape to color-code your mics and connectors with their phantom power requirements, to ensure you don't improperly use phantom power and potentially damage your equipment. See *Phantom Power* section for more details.
- Coach your talent/actors regarding how the audio is being captured
  - If you are using directional mics, let them know where to project their voice, and where they can not look away and speak
  - If you are using lav mics, let them know they need to minimize the rustle of clothing
- Using Audio Bracketing for camera overload protection when possible
  - The juicedLink Riggy-Micro and Riggy-Assist preamps have a unique feature called Audio Bracketing
  - Consider, for example, one of the 3XLR input preamps, like the Riggy-Assist RA333 or Riggy-Micro RM333
    - It has 3 XLR inputs:
      - XLR-L1
      - XLR-L2
      - XLR-R
    - And, the camera has 2 recording tracks (right/left).
    - There is a MONO/STEREO switch. In the STEREO setting, XLR-L1 and XLR-L2 are routed to the left channel of the camera, and XLR-R is routed to the right channel. In MONO, all mics are mixed together, and presented to both the right and left output.
    - When the Audio Bracketing switch is turned on (Rpad), then the right channel is attenuated by about 16dB. You would use this in the MONO setting, so you have the same signal going to both the right and left outputs. So, if you blow out your main recording on the left, you have a backup that you can pull from in post on the right at a safe lower level.
- If your camera doesn't have meters and headphones
  - Then you will be using the meters and headphones in the juicedLink Riggy-Assist preamps. But, this means that you are not actually metering/monitoring in the recording device.
  - So, you need to take an extra step in your production flow to ensure that there is continuity to the camera. You don't want something as silly as neglecting to plug the cable into the camera all of the way to ruin your day.
  - If you camera has meters in the setup menu (which most do), then before your shoot, verify you have continuity to the camera and the right/left meters in the camera are registering.

4 Specialized Topics

4.1 Production Flow Options

4.1.1 Camera Mounted Unbalanced Mic (such as VideoMic)

- ADVANTAGES
  - Lightweight and portable
  - Great for the run-n-gun paparazzi style shooter
  - Record directly to camera, no sync in post
- DISADVANTAGES
  - No potentiometer to dial in optimal signal level
  - Mic position is not optimal SNR for dialogue. For quality dialogue, camera mounted mic too far away. Need to GET THE MIC CLOSE.

4.1.2 Low Noise Preamp (juicedLink)

- ADVANTAGES
  - Mount a balanced XLR mic (such as the NTG2, AT875R, etc) to the camera for run-n-gun paparazzi style
    - Use juicedLink low-noise preamp to get better SNR from camera by the *Noise Figure of Cascaded Amplifiers* principle
  - Use balanced XLR mic (such as the NTG2, AT875R, etc) and boom operator (or c-stand) to get mic close to your subjects
    - GETS THE MIC CLOSE to get best SNR for dialogue
    - Uses balanced signaling for the cable run from the mic to the juicedLink, to minimize electromagnetic interference
  - Use with wireless mics for tether-free operation
  - Use multiple mics, and individually control mic level for mix
  - Use Audio Bracketing for camera overload protection
  - juicedLink front panel potentiometers enable quick and accurate setting of signal level, so you don't need to go into the camera menu system and fumble around to set levels
  - Great production flow for one-man-bands or small crews

4.1.3 External Recorder

- ADVANTAGES
  - record remotely from the camera. So, it can be placed on stage (like for a piano recital) while you record from the back of the auditorium
- DISADVANTAGE
  - You will need to sync your audio and video in post
    - There is software to help you do this.
    - But, it becomes more of a pain with large numbers of short clips (DSLRs can only record for short periods at a time)
- NOTES
  - Although many recorders can record with a higher bit rate compared to most cameras, there is no advantage to this in terms of signal-to-noise. See *16bit 48KHz versus 24bit 96KHz Audio Recording*.
  - Some people have the misconception that they must use an external recorder because you can not record directly to the camera with excellent signal-to-noise performance. This is not true, so long as you use a juicedLink low-noise preamp before your camera and take advantage of the *Noise Figure of Cascaded Amplifiers* principle for getting better signal-to-noise from downstream electronics. You

may very well have a good reason to use an external recorder for the particular shot you are capturing from a production flow point of view. But, if you think that you need to do this to capture quality audio, that is incorrect.

4.1.4 Dual System

- This flow is best suited for larger crews with dedicated audio team.
- After shoot, video and audio team can go off and work on sweetening their material independently, then swap out the audio scratch track with the scrubbed track when they start to integrate.
- Back when DSLRs didn't have manual control (and recorded with poor SNR), it provided a quality recording in the recorder and a scratch track to the camera for PluralEyes to sync on.
- Today, with cameras that have manual control, headphones, and meters, it is not necessary for quality SNR recording (with use of a juicedLink low-noise preamp).
- This flow is best suited for larger crews with dedicated audio team.
- Again, although many recorders can record with a higher bit rate compared to most cameras, there is no advantage to this in terms of signal-to-noise. See *16bit 48KHz versus 24bit 96KHz Audio Recording*.
- Again, some people have the misconception that they must use an external recorder because you can not record directly to the camera with excellent signal-to-noise performance. This is not true, so long as you use a juicedLink low-noise preamp before your camera and take advantage of the *Noise Figure of Cascaded Amplifiers* principle for getting better signal-to-noise from downstream electronics. You may very well have a good reason to use an external recorder for the particular shot you are capturing from a production flow point of view. But, if you think that you need to do this to capture quality audio, that is incorrect.

4.2 16bit 48KHz versus 24bit 96KHz Audio Recording

4.2.1 Does 24bit 96KHz Sound Better? No …

There is a great paper by Meyer and Morgan of the Audio Engineering Society showing that people can not discern the difference between 16b/48KHz versus 24b/96KHz. Although you need to be a member of AES to access the paper, there is a nice summary from Mix Magazine's article called *The Emperor's New Sampling Rate*.

4.2.2 Does 24/96 Record Better SNR for Dialogue with a Mic? No ...

Here, we're going to walk you through an analysis of the numbers.

- THEORETICAL SNR FROM AN IDEAL ANALOG-TO-DIGITAL CONVERTER (A/D)
  - 16 BITS: 16 bits has 2^16 steps resulting in a full scale range of 20log(2^16) = 96dB. But, you only meter to -12dB for sufficient headroom during recording. So, the effective theoretical dynamic range from an ideal (A/D) is 96 – 12 = 84dB.
  - 24 BITS: 24 bits has 2^24 steps resulting in a full scale range of 20log(2^24) = 144dB. But, you only meter to -12dB for sufficient headroom during recording. So, the effective theoretical dynamic range from an ideal (A/D) is 144 – 12 = 132dB.
  - So, for an ideal ADC, 24 bits is indeed capable of recording with higher SNR than 16bits. But, will you ever see this in practice?
- PRACTICAL SNR FROM THE OUTPUT OF A MIC RECORDING DIALOGUE
  - Consider a Rode NTG3, considered by the industry to be an very low-noise microphone.
  - The NTG3 has a noise specification of 13dBA
  - SNR for microphones are referenced to 1Pa = 94dB
    - So, for a sound pressure level of 1 Pa, the NTG3 provides a SNR of 94 – 13 = 81dB
      - This is less than both the theoretical SNR for both an ideal 16bit or 24bit A/D
  - In practice, the SNR output of the NTG3 is actually much worse
    - Remember, the mic SNR was referenced to a sound pressure level of 1Pa. Let's put that into perspective:

        - 2 Pa is the sound pressure level of a jackhammer at 1m
        - 0.36 Pa is the sound pressure level of long term hearing damage
        - 0.03 Pa is the sound pressure level of a conversation at 1m
    - So, the real SNR coming out of the mic of a conversation is more like 0.03 Pa = 64dBA.
        - So, the SNR out of the NTG3 is 64 – 13 = 51dB
            - So, the SNR out the mic is the limiting factor for SNR performance in either case of a 16bit or 24bit ideal A/D

So, the output from even a very low noise microphone for dialogue will be about 51dB. So, an ideal A/D at 24bit is of no additional value over 16bit, since the signal to noise out of the mic is the limiting factor in both cases.

Now, this is not to say that there isn't a difference in the performance of recorder models. But, it doesn't have anything to do with bit depth. The biggest differentiator between recorders/cameras is the analog front end. But as we have seen in the *Noise Figure of Cascaded Amplifiers* section, using a juicedLink low-noise preamp before noisy analog front ends can fix that.

4.3 Microphone Recommendations

In this section, I am going to provide you with my personal comments and recommendations for microphones, with the understanding that you have a budget to work with.

4.3.1 Shotgun Microphones

I always prefer to use XLR microphones, instead of the camera mounted minijack microphones. If all you're going to do is strictly run-n-gun work, then the camera mounted minijack microphones are fine. But, as soon as you want to get excellent signal to noise performance for dialogue, you want to get the microphone off the camera, and boom it so it's much closer to your subjects. Then, you want that microphone to be an XLR microphone instead of the minijack microphone, because balanced XLR signaling is much less susceptible to picking up noise and interference then unbalanced microphones.

For a shotgun microphone that is in the sweet spot of price/performance, check out either the Rode NTG2 or Audio-Technica AT875R. More expensive microphones are better, but only incrementally. For example, mics similar to the NTG3 have even lower noise properties, but this better noise performance really only comes into play when shooting a wide shot (mic relatively far away) in a very quiet environment (like a sound stage). Using the NTG2/AT875R and following the principle of GETTING THE MIC CLOSE and using a juicedLink low-noise preamplifier, you will record with excellent signal-to-noise. The quality with less expensive microphones rolls off a really fast. Although the NTG2 has slightly better specs, I find myself using the AT875R as my go-to microphone, because it's so short and light, making it easy to mount to the camera and easy to boom. But, what makes it so small and light is that runs from phantom power only, so your preamp will need to provide phantom power. The NTG2 can run from its own battery, so the preamplifier does not need to have phantom power.

4.3.2 Wired Lavaliere

For a wired lavalier that's in the sweet spot of price/performance, check out the AT803B.

4.3.3 Wireless System

I've not found inexpensive Wireless Systems that I like. The inexpensive ones have been quite noisy and have dropouts. I use the Sennheiser G3, and I like it a lot.

4.4 Understanding Mic Specifications

Under Construction