BLUE REPORT

Sept. 2006

Radial Engineering Ltd.
1638 Kebet Way
Port Coquitlam BC V3C 5W9

Tel: 604-942-1001
Fax: 604-942-1010

email: info@radialeng.com
web: www.radialeng.com

INTRODUCTION

The Radial Blue Report is a comparative study that presents the professional audio engineer and system designer with a complete review of the features, construction and specifications of four of the most popular active direct boxes used in professional touring today: the Radial J48, the Countryman Type 85, the BSS AR133 and the Klark-Teknik DN-100.

It is important to note at the outset that all of these direct boxes are produced by quality manufacturers and are well deserving of the success they have enjoyed in the market. The intent of the Blue Report is not to dishonor any of our esteemed competition, but to compare all of these units using the same test equipment under the same conditions so that the audio engineer can make a proper informed decision with respect to his or her direct box requirements.

As with any piece of audio gear, the user must balance his or her personal taste with factual measurements. For instance, some engineers may prefer the 'sound' of a given pre-amp or direct box over another, even though both pieces may measure the same. Subjective listening will always play a part in any purchase. This of course brings to bear one's philosophy behind a given product - do you want a direct box to sound like something? Or do you feel that a direct box should take the sound of the instrument and pass it along to the mixing console to allow the engineer to make the musical decision?

At Radial, we believe our task is to be 'true to the music'. In other words, it is our job to provide the very best interface possible given restraints such as features, convenience, size, available power, budget and so on. Therefore, we do not believe it is our task to change the tone of that pre-CBS Fender Jazz Bass or adding sizzle to that new $5,000 Martin D45. Our job is to provide the most invisible and natural sounding interface possible so that the distinctiveness of the instrument shines through.

To this end, the Radial engineering team works diligently to remove all types of distortion that may hamper the audio circuit. This includes ensuring an ultra-wide linear bandwidth, reducing harmonic distortion at all frequencies, attaining the very lowest phase distortion, reducing inter-modulation distortion, eliminating residual noise and providing the maximum dynamic signal handling for today's high output instruments.

By going to this extreme, a funny thing happens: Odd as this may sound, less distortion sounds better. Or maybe, we should say, it does not sound at all.

Enjoy!

Peter Janis

President

Radial Engineering Ltd.

HISTORY OF THE ACTIVE DIRECT BOX

The first direct boxes that appeared in the 1970s were for the most part, hand made boxes with isolation transformers. The transformer provided a means to isolate the stage musician and his personal amplifier from the PA system while simultaneously lowering the impedance and balancing the signal for long cable runs.

Back in the early days of concert touring, the 'only' bass guitar you would see on stage would be a passive Fender Precision or Jazz while the 'keyboard du jour' was the Rhodes piano. Acoustic guitars were plagued with terrible options which included primitive piezo pick-ups, magnetic pickups that went inside the sound hole and awful sounding preamps. And remember the feedback? How things have changed!

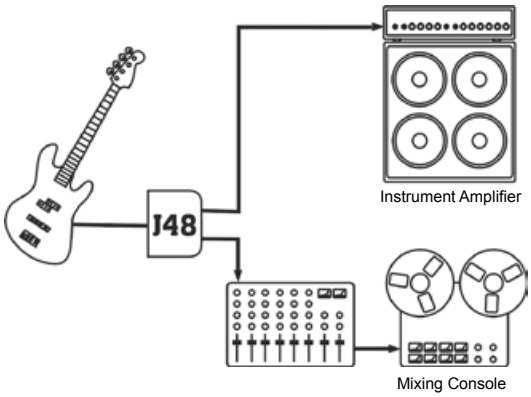
Back then, bass guitars like those old Fenders had low output pickups. What musicians noticed was that when they introduced a passive direct box into the circuit, the sound would change. It would lose punch and body. They quickly found out that the early transformer used in those passive DIs introduced an excessive load on the pickup. This caused the tone to change because the pickup not only had to drive the bass amplifier, but also had to drive the transformer, the mic-splitter transformer and 250 feet of cable.

In America, Countryman started the active DI box revolution in the 1980s with a buffering preamp in the form of a direct box that boosted the signal without loading the pickup. With an active direct box, the bass pickup no longer had a huge load added and the tone going to the amp retained its natural tone. The high input impedance worked well for piezo pickups such as employed on violins, acoustic guitars and worked just fine for most other instruments too. In the UK, Brook Siren Systems (BSS) and Klark-Teknik (KT) would follow this lead and become major producers of direct boxes in the European market.

In 1996, Radial Engineering launched their first direct box the Radial JDI which oddly enough was a passive DI. Today, the Radial JDI has become an industry standard. The Radial JDI addressed a new need that did not exist when typical active DI first appeared: it could handle the huge transients of digital pianos and synthesizers without distortion. (Most active DIs are unable to handle huge transients without distortion)

In 2002, Radial introduced a 'new generation' active direct box, the Radial J48. The intent behind the Radial J48 was to provide the musician with the benefits of a high 'input impedance' to reduce pickup loading while providing a superior internal rail voltage to handle the huge transients of today's active acoustic guitars and bases. It also had to work without batteries, while deriving its power from 48V phantom as the use of batteries is an unwelcome necessity in the world of pro-touring. The solution: following the path set by power amplifiers, the J48 employs a noise-free internal digital switching power supply that converts the phantom power to AC and back to DC for greater rail voltage and more than doubles the headroom. With greater headroom comes less distortion and less compromise. Instead of bandwidth limiting the signal as others do, the J48 extends to 160kHz - this is not a typo - 160,000 cycles per second.

Keep in mind that digital switch-mode technology did not exist back in the '80s, nor did the plethora of active acoustic guitars, high-output basses, digital pianos or electronic drums. The Radial J48 is a direct box made for today's world of musical instruments.



The basic DI setup is the same for passive or active direct boxes except active DIs receive 48v phantom power from the mixing console.

1996

2000

2002

BLUE REPORT EXECUTIVE SUMMARY

As you go through this report, you will note that the Radial J48 direct box outperforms all others in all tests. It is more linear throughout the audio range while exhibiting lower harmonic distortion at all frequencies and it introduces significantly less phase distortion to boot. But most impressive is the harmonic analysis of the Radial J48 and how it produces a 'text-book perfect' series of even order harmonics while the competition is fraught with harsh sounding, odd-order harmonics. Radial DIs have consistently rated higher in blind listening tests. We are pleased to say that the Blue Report provides clear, measurable and repeatable results that prove beyond a shadow of a doubt that all those subjective reviewers were in fact correct with their assessment: the Radial J48 sounds better!

But this is not all. When comparing the construction, quality of parts and ability to either rack-mount, podium mount or simply band these DIs around, the J48 once again outshines the competition. And the Radial J48 is supported with a 3-year transferable warranty that is unique in the industry.

Conditions	Radial J48	Brook Siren BSS-133	Klark-Teknik DN-100	Countryman Type-85
All tests were performed under these conditions: Audio Precision SYSTEM-2622 CASCADE+ DSP Level: 0dbU (774.6 mV RMS) Source impedance: 600 ohms Load: 1,200 ohms (300 ft. of twisted pair cable) Capacitance: 10,000 pfd (.01µF) of total capacity. Bandwidth: 22Hz - 22kHz - not weighted				
SPECIFICATION				
Output impedance	200 ohms	600 ohms	300 ohms	600 ohms
Freq. response (20Hz to 20kHz)	+0dB / -0.5dB	+4dB / -1.0dB	+3dB / -1.0dB	+0dB / -2.0dB
Linear Deviation	**0.5dB**	**5.0dB**	**4.0dB**	**2.0dB**
THD at 20Hz	0.001%	0.1%	0.2%	0.3%
at 1kHz	0.001%	0.005%	0.005%	0.1%
at 10kHz	0.002%	0.01%	0.01%	0.1%
Distortion at +0dB	**0.005%**	**0.004%**	**0.004%**	**0.3%**
at -10dB	**0.002%**	**0.004%**	**0.004%**	**0.05%**
Phase deviation at 20Hz	+10º	+40º	+70º	+18.5º
at 1kHz	0º	0º	0º	0º
at 20kHz	0º	-38.5º	-50º	-90º
Inter-modulation @+0dB	**0.002%**	**0.02%**	**0.02%**	**0.5%**
Signal to noise max output	108.4dB	111.2dB	103.8dB	111.2dB
Noise floor	-140dB	-125dB	-130dB	-125dB
FEATURE SET				
Low Pass Filter	Yes	-	-	-
Merge function	Yes	-	-	-
48v Phantom powered	Yes	Yes	Yes	Yes
Battery Powering	(Optional)	Yes	-	Yes
AES Standard Pin-2 Hot	Yes	Yes	Yes	-
Ground Lift	Yes	Yes	Yes	Yes
Rackmount Option	Yes	-	-	-
Podium Mount Option	Yes	-	-	-
Warranty	**3 years**	**1 year**	**1 year**	**1 year**

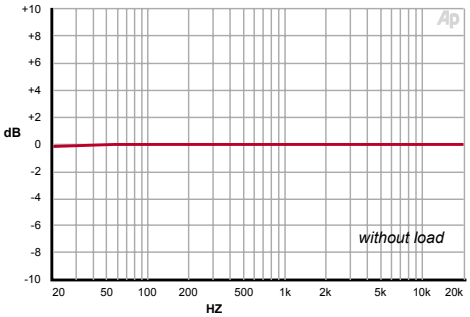
FREQUENCY RESPONSE MEASUREMENT

The frequency response curve determines how linear the device is at all frequencies and is specified in terms of frequency across the listening range versus a drop in decibels. The perfect frequency response would be completely linear from 1Hz to infinity. This is limited for practical purposes within the generally accepted hearing range of 20Hz to 20kHz.

The Radial J48 is perfectly linear from 20Hz to 20kHz. In fact, the Radial J48 was designed to extend well beyond this from 10Hz all the way to 160kHz. The reasoning is simple: higher resolution (i.e.. higher sampling rates) can be heard and therefore is preferable. This test at right shows the performance of the J48 without a 300 foot (100 meter) cable which would be more representative of a studio environment.

Below, these graphs compare the four direct boxes with a cable to better represent a live touring environment. All levels have been normalized.

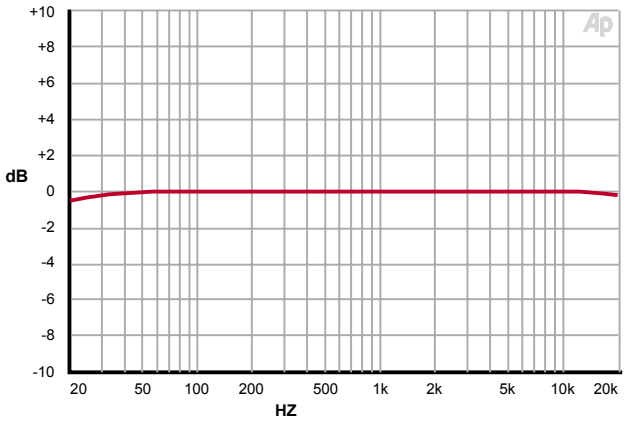
RADIAL J48 FREQUENCY RESPONSE WITHOUT LOAD - 20Hz to 20kHz



Without a load the J48 produces a perfectly linear response.

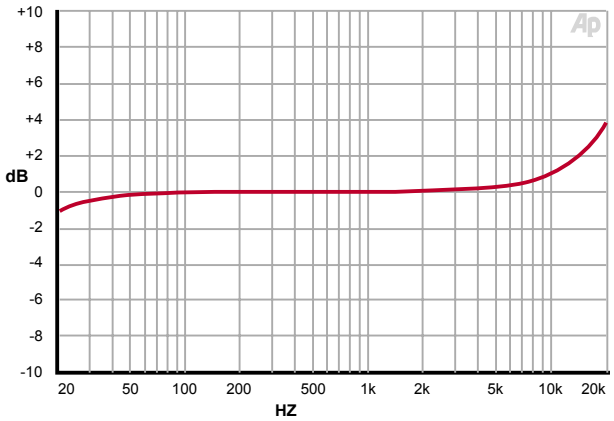
Frequency response	Radial J48	BSS AR133	Klark-Teknik DN100	Countryman 85
(20Hz to 20kHz)	+0dB / -0.5dB	+3dB / -1.0dB	+0dB / -2.0dB	+4dB / -1.0dB
Deviation	0.5dB	5.0dB	4.0dB	2.0dB

RADIAL J48 - FREQUENCY RESPONSE - 22Hz TO 22kHz



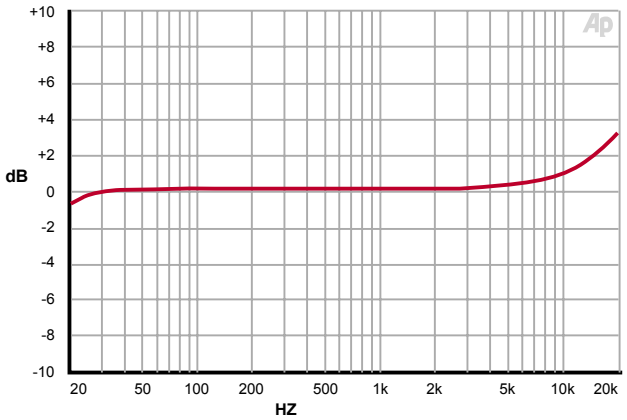
The Radial J48 is exceptionally linear from 20Hz to 20kHz showing less than <1dB of variation throughout the range. The top end drop off is due to capacitive effect of the 300ft of cable.

BSS AR-133 - FREQUENCY RESPONSE - 22Hz TO 22kHz



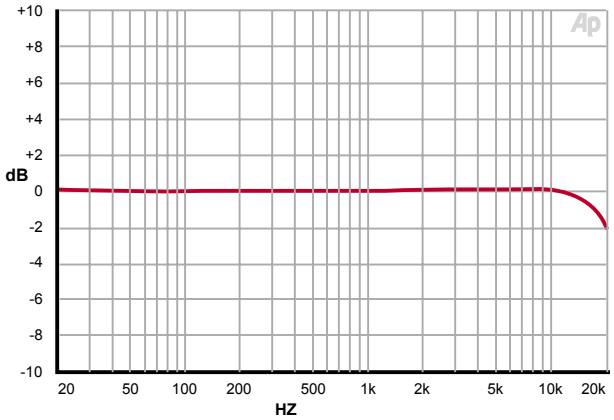
The BSS AR-133 does not fare as well with a 1dB drop in the low end and a significant 4dB rise that begins at 2kHz and really climbs above 10kHz. This rise is attributed to the output transformer.

KT DN-100 - FREQUENCY RESPONSE - 22Hz TO 22kHz



The Klark-Teknik DN-100 does not fare as well with a 1dB drop in the low end and a significant 3dB rise that begins at 3kHz and really climbs above 10kHz. This rise is attributed to the output transformer.

COUNTRYMAN T85 - FREQUENCY RESPONSE - 22Hz TO 22kHz



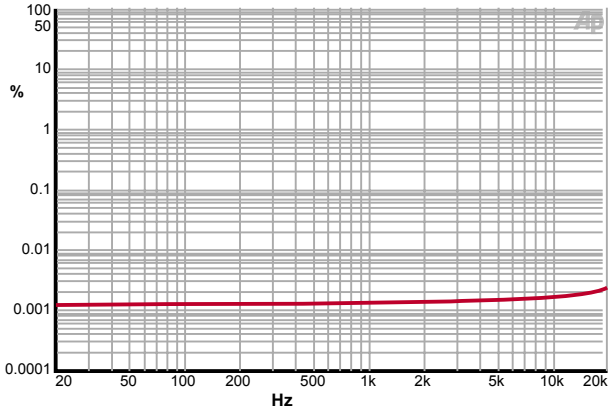
The countryman Type-85 shows a solid bottom end right down to 20Hz but shows a disappointing top end with severe roll-off above 10kHz.

DISTORTION VS FREQUENCY

Testing distortion versus frequency shows how well the pre-amplifier - in this case the active direct box - manages distortion at all frequencies. The perfect direct box will show virtually zero distortion throughout the audio spectrum. It is important to note that bass frequencies, whether in nature or in an electrical circuit contain significantly more energy than high frequencies. This is attributed to the longer wavelengths. Most manufacturers will simply specify a product at 1kHz. This does not however tell us how the direct box is performing throughout the complete listening range.

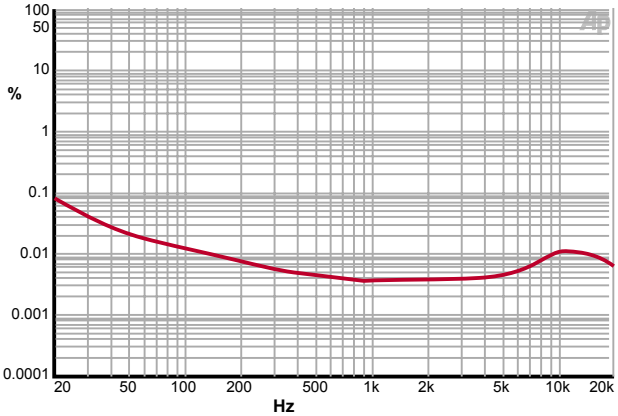
Distortion	Radial J48	BSS 133	KT DN-100	Countryman 85
@ 20Hz	0.001%	0.08%	0.2%	0.3%
@ 50Hz	0.001%	0.02%	0.03%	0.02%
@ 1kHz	0.001%	0.005%	0.003%	0.1%
@ 10kHz	0.001%	0.01%	0.009%	0.1%

RADIAL J48 - THD vs FREQUENCY



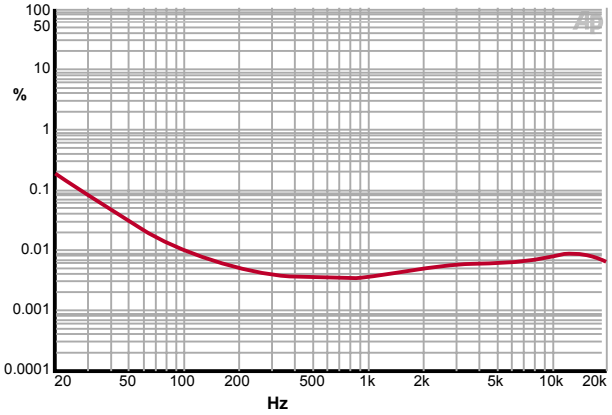
The Radial J48 measures 0.001% distortion in the all important bass region and remains stable throughout the full frequency range. The J48 compares very well above all others tested.

BSS AR-133 - THD vs FREQUENCY



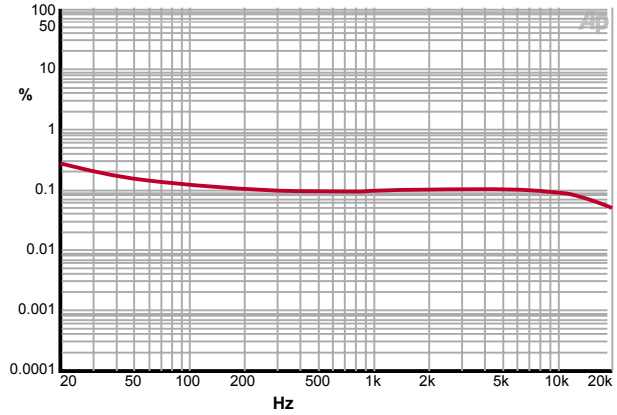
The BSS begins at just under 0.1% distortion - almost 100 times more than the J48 at 20Hz. As predicted, it drops to below 0.01% the 1kHz region, but rises again at 10kHz.

KT DN100 - THD vs FREQUENCY



The Klark-Teknik DN200 does not fare well in the low bass region measuring 0.2% at 20Hz. It does however improve dramatically in the 500Hz to 1kHz region and only rises slightly above 2kHz.

COUNTRYMAN T85 - THD vs FREQUENCY

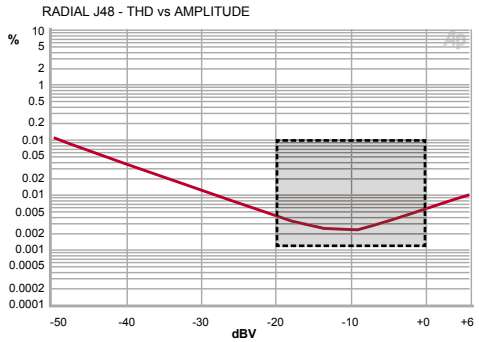


The Countryman shows significantly more distortion than all others at all frequencies measuring 0.3% at 20Hz and a less than impressive 0.1% at 1kHz.

DISTORTION VS AMPLITUDE

Distortion versus amplitude is a test that shows how the direct box amplification circuit performs when subjected to various input levels. As the level increases, distortion becomes all the more audible. When the input level surpasses the rail voltage; the preamplifier overloads causing distortion. In our view the most critical zone is between -20dB and +3dB. This is where the instrument will likely be in level during real world performance.

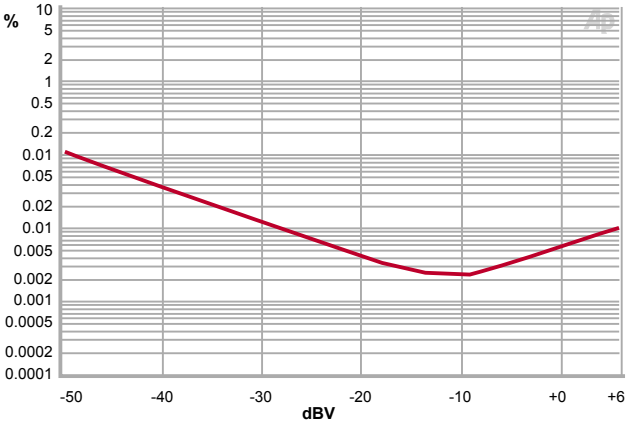
It is important to note that when testing the output of these devices, all four direct boxes performed differently with respect to input level and output response. The Radial J48 output level dropped by 1.5dB. The BSS and Klark-Teknik showed a 6dB drop and the Countryman showed a 16dB drop. In the real world, one would simply adjust the input trim or pad on the direct box to compensate for levels. Once again, all levels were normalized to provide proper comparative graphs.



The most critical zone to test amplitude performance is between -20dB and 0dB where the signal is at optimum level.

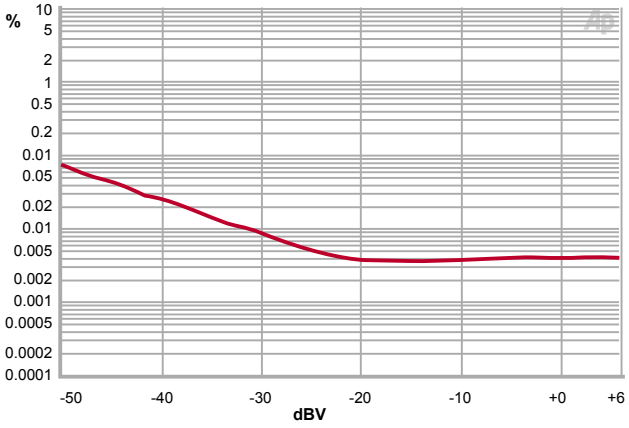
Distortion	Radial J48	BSS 133	KT DN-100	Countryman 85
@ +0dB	0.005%	0.004%	0.004%	0.3%
@ -10dB	0.002%	0.004%	0.004%	0.05%
@ -20dB	0.005%	0.004%	0.006%	0.1%

RADIAL J48 - THD vs AMPLITUDE



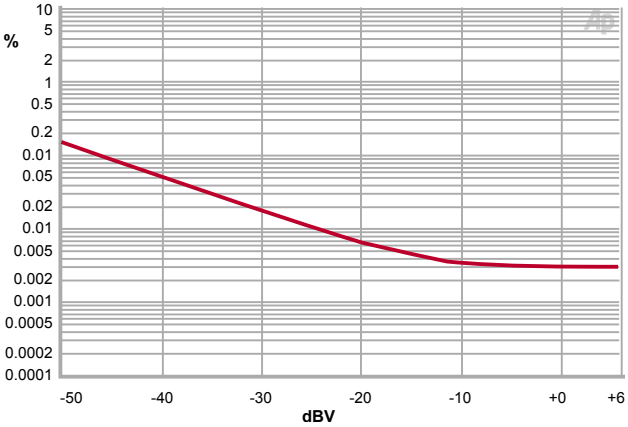
The Radial J48 performs well at -50dB measuring only 0.01% distortion. Like all op-amps it performs best when driven hard. This is clearly shown with less than 0.005% at the nominal +0dB level.

BSS AR-133 - THD vs AMPLITUDE



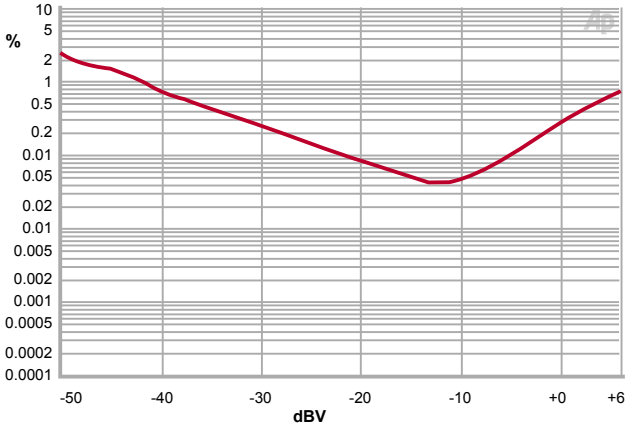
The BSS AR-133 performs well in the bottom end with less 0.01% distortion and shows impressive signal handling throughout and above the nominal level coming in at under 0.005%.

KT DN-100 - THD vs AMPLITUDE



The KT DN-100 performs well in the bottom end at just 0.1% distortion and shows impressive signal handling above the +0dB nominal level coming in at under 0.005%.

COUNTRYMAN T85 - THD vs AMPLITUDE



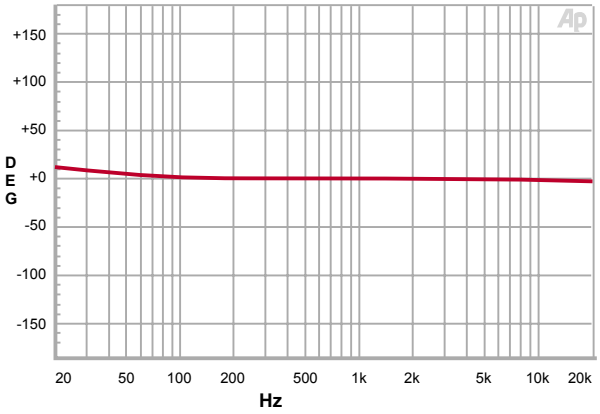
The Countryman does not fare well with over 2% distortion at -50dB and another significant rise to almost 1% distortion when pushed beyond the nominal range.

PHASE DISTORTION

In simple terms, phase distortion is a ‘slowing down’ of some frequencies versus others as the signal passes through the direct box. In other words, bass, mid-range and high frequencies go in together, but come out at different times. Obviously this should be minimized as it will cause the instrument’s sound to change. Phase distortion is most readily heard in the bass frequencies due to the longer wavelengths. As the phase distortion increases, the bass becomes muddy and indistinct. A preamplifier’s ability to transfer a signal without phase distortion is one of the most difficult challenges in circuit design. It is usually only specified at 1kHz which, in our view, is somewhat meaningless since the effect of phase distortion is most noticeable at low frequencies.

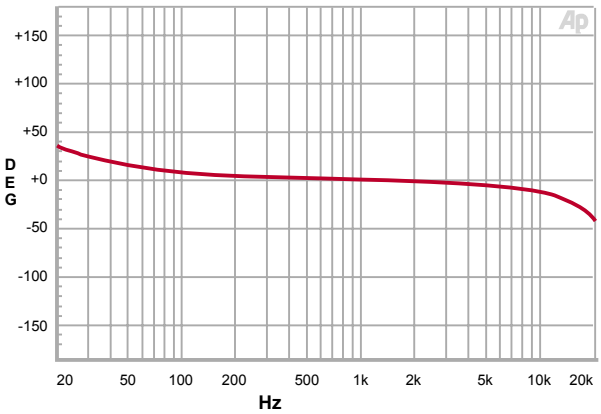
Phase Distortion	Radial J48	BSS AR-133	KT DN-100	Countryman 85
@ 20Hz	+10º	+40º	+70º	+18.5º
@ 50Hz	+2º	+10º	+25º	+10º
@ 1kHz	0º	0º	0º	0º
@ 20kHz	0º	-38.5º	-50º	-90º

RADIAL J48 - PHASE RESPONSE



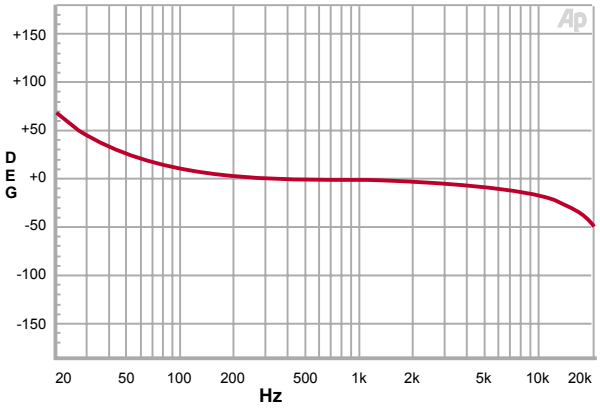
The Radial J48 is impressive with a mere +10º phase shift at 20Hz and virtually 0º phase shift from 100Hz and above. This would indicate the J48 would be well suited for all instruments.

BSS AR-133 - PHASE RESPONSE



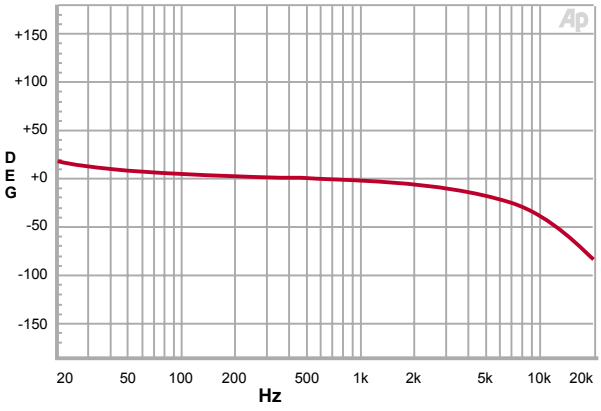
The BSS AR-133 measures a disappointing +40º out of phase at 20Hz and reaches -38.5º at 20kHz. It only shows a perfectly stable phase response between 450Hz and 2kHz.

KT DN-100 - PHASE RESPONSE



The Klark-Teknik does not fare well with respect to its phase response showing close to +70º of phase shift at 20Hz and almost -50º off at 20kHz. It is only phase coherent between 300Hz and 1kHz.

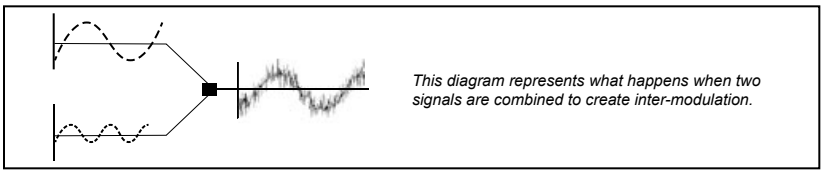
COUNTRYMAN T85 - PHASE RESPONSE



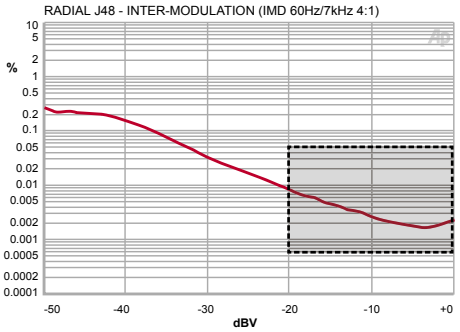
The Countryman shows a respectable +18.5º of phase shift at 20Hz but never seems to reach any stability. The top-end begins to shift at 1kHz and is almost off the scale measuring -90º out at 20kHz.

INTER-MODULATION DISTORTION

IMD or inter-modulation distortion is a test that consists of beating one frequency against another and measuring how the two frequencies interact together. This is like listening to dissonance on a piano. Great pianos sound amazing even when playing dissonant notes while lesser ones just plain sound bad. As with distortion versus amplitude, the critical zone is the nominal or normal level at which the device is used. For the direct box, this is usually between the -20dB and +0dB range. This test was performed using the standard SMPTE 60Hz/ 7kHz at a 4:1 ratio.

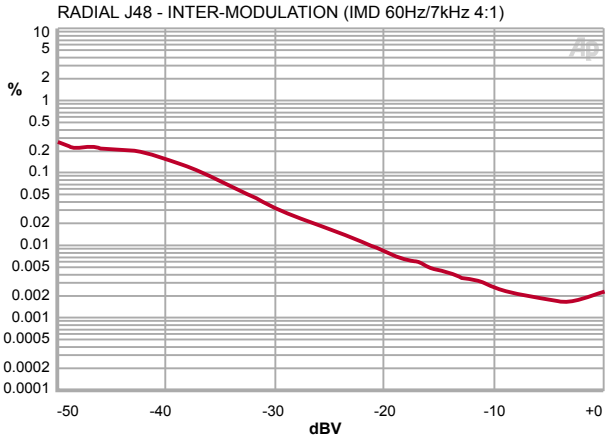


This diagram represents what happens when two signals are combined to create inter-modulation.

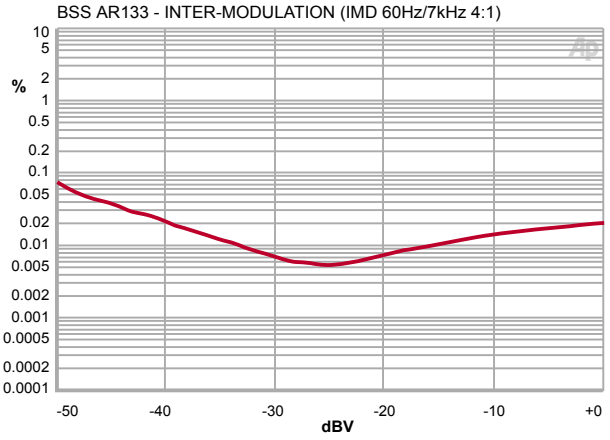


In our view, one should evaluate how the device performs when it is driven hard into the hot zone from -20dB to 0dB. This is where performance is most critical.

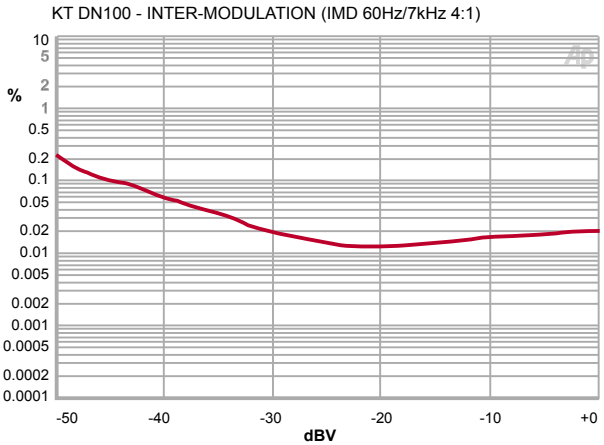
IMD	Radial J48	BSS AR-133	KT DN100	Countryman 85
@ +0dB	0.002%	0.02%	0.02%	0.5%
@ -10dB	0.003%	0.015%	0.017%	0.15%
@ -20dB	0.008%	0.008%	0.012%	0.05%



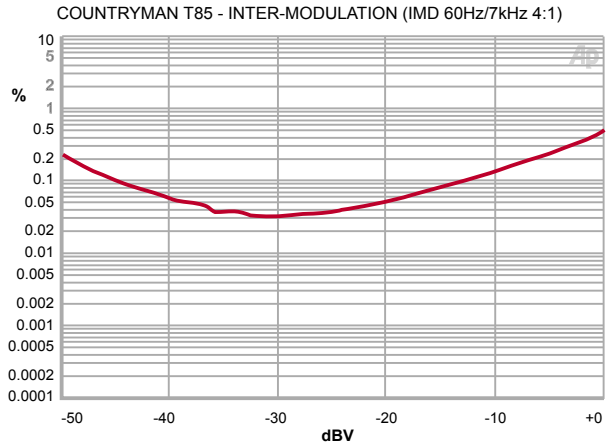
The Radial J48 shows exceptionally low inter-modulation distortion from 0dB down to -10dB at less than 0.002% and a mere 0.01% under the -20dB threshold.



The BSS AR-133 measures a respectable 0.02% at 0dB and maintains low inter-modulation distortion throughout the range.



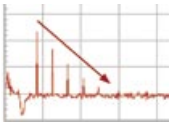
Like the BSS AR-133, the Klark-Teknik DN-100 measures a respectable 0.02% at 0dB and maintains low inter-modulation distortion throughout the range.



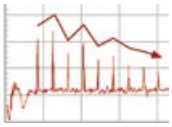
The Countryman Type-85 demonstrates reasonable inter-modulation distortion below 0.5% but is outdone by all others in the measurement group.

FFT - FAST FOURIER TRANSFORM & HARMONIC ANALYSIS

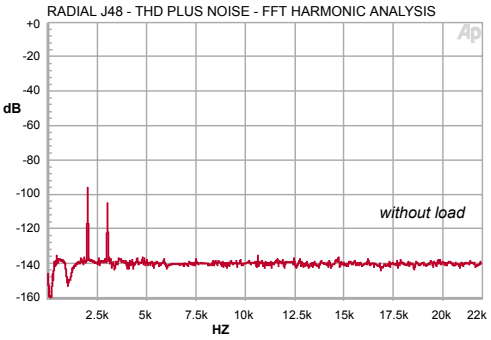
This test is used to tell us how the direct box generates harmonics when driven hard. To do this, a single pure sine wave is generated at 1kHz and then removed with a narrow notch filter so that the resulting harmonics can be viewed. The perfect curve will be a succession of even-order harmonics that cascade down by half the loudness at each octave to produce what is known as a warm Bessel curve. When the order is disrupted with odd harmonics rising in between the natural octaves, one can be certain that the sound will be harsh and unnatural.



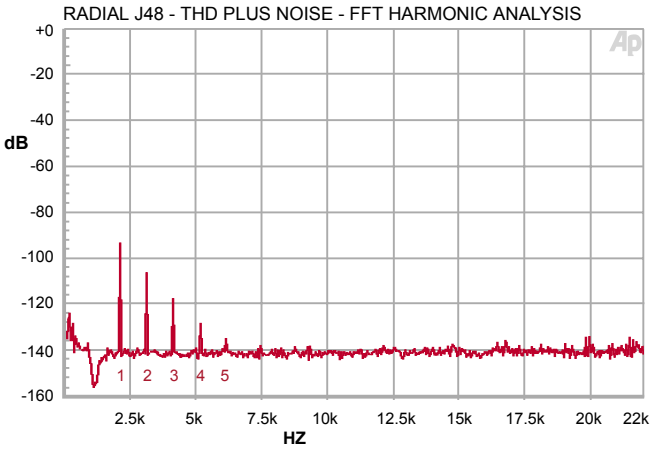
Example shows even-order harmonics peaking at half the loudness per octave.



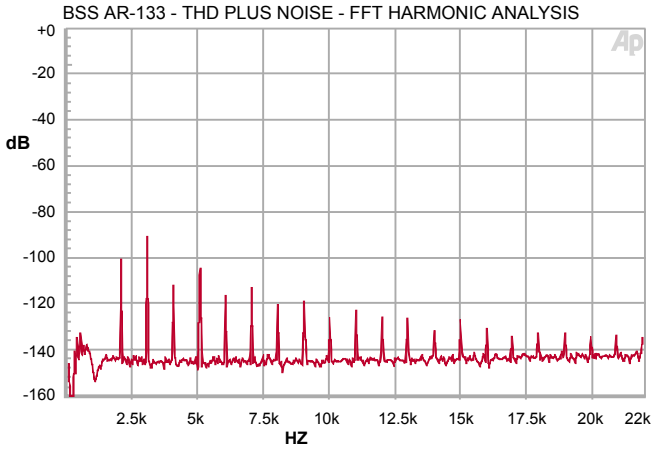
Another example shows odd-order harmonics rising in between the even-order.



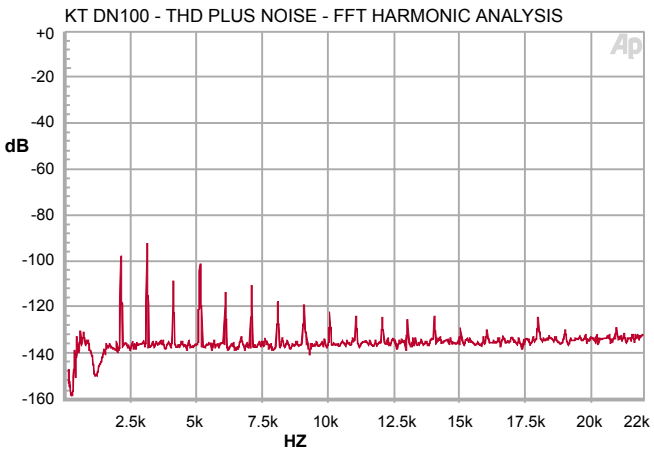
Noise	Radial J48	BSS AR-133	KT DN100	Countryman
@ 10kHz	-140dB	-125dB	-125dB	-120dB
@ 15kHz	-140dB	-127dB	-135dB	-130dB
@ 20kHz	-140dB	-135dB	-137dB	-132dB



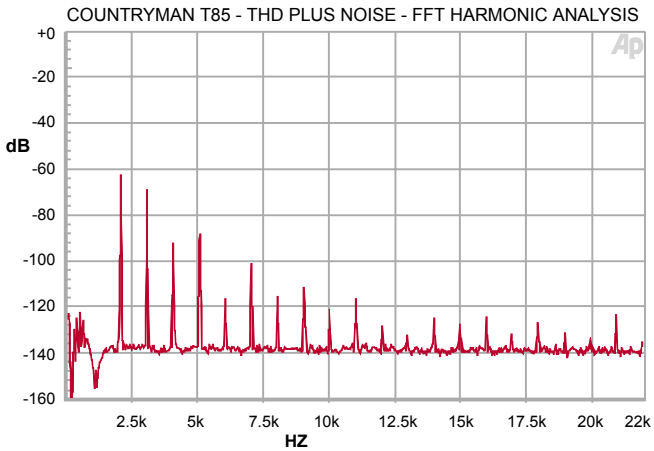
The Radial J48 shows five text book examples of even-order harmonic generation which cascade naturally. Residual noise is measured at an amazingly low -140dB at all frequencies above the excited harmonics.



The BSS AR-133 shows a problematic succession of even, then odd order harmonics from the beginning. This will likely result in a harsher and more brittle tone. Noise is low at -120dB but significantly higher than the J48.



The KT D-100 shows a problematic succession of even, then odd order harmonics from the beginning. This will likely result in a harsher and more brittle tone. Noise is lower than the BSS and Countryman at -130dB but not as low as the J48.



The Countryman T85 shows a problematic succession of even, then odd order harmonics after the second order. This will likely result in a harsher and more brittle tone. Noise is low at -122dB but significantly higher than the J48.

CONSTRUCTION

All four direct boxes presented provide a good external metal box and shielding against magnetic fields.

Radial J48

Radial DIs feature steel I-beam internal construction for maximum strength. The outer metal wrapper uses bookend design which creates an overhang that protects the switches and jacks. The PCB is supported with four welded stand-offs to reduces stress on the PCB. A rubber pad covers the bottom for electrical isolation and helps the DI "stay-put" on top of amps.

BSS AR-133

Front and back panels screw to an aluminum channel. The PCB is supported by the jacks. A hit to the panels is transferred directed to the PCB. The switch and jacks are unprotected.

KT DN100

Similar construction to the BSS. Panels screw to an aluminum channel with the jacks supporting the PCB. The switch and jacks are unprotected. This build process does have one advantage, it reduces cost during manufacturing

Countryman T85

Front and back panels are integrated to a slide-in-frame. Switch and jacks are recessed for protection. PCB is encased in epoxy making repair impossible.

BUILT TOUGH FOR THE ROAD

The image to the right is an actual photo of a Radial DI taken in front of the Radial Engineering facility. Proof you 'can' drive a truck over it! We are serious when we say "built tough for the road". Fourteen gauge steel combined with I-beam construction and a heavy-duty baked enamel finish make the J48 indestructible. The outer shell features bookend design and creates a protective zone around the jacks and switches.

MOUNTING OPTIONS

Radial DIs are easily rackmountable using the J-RAK. As many as eight Radial J-class products can be fitted into just 2RU with your choice of input or output facing the front. For secure mounting of a single J-class DI in covert locations, like inside podiums or racks, the J-CLAMP is available.

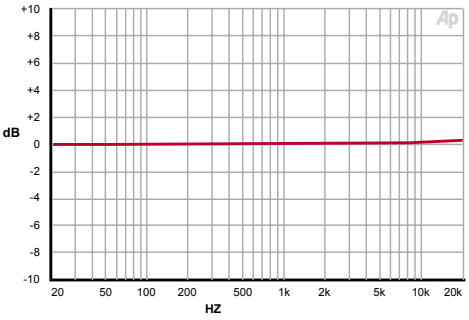
J-RAK

J-CLAMP

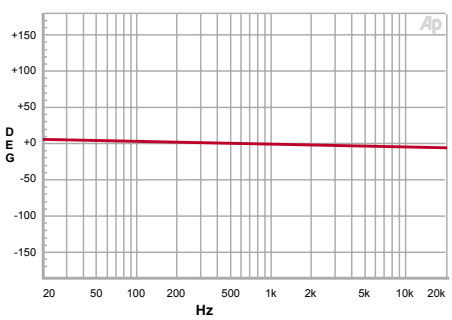
OTHER RADIAL DIRECT BOXES

JDI PASSIVE DI

RADIAL JDI - FREQUENCY RESPONSE - 22Hz TO 22kHz

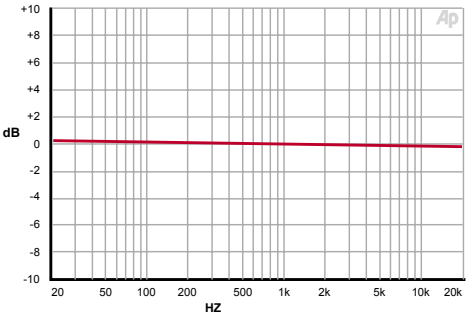


RADIAL JDI - PHASE RESPONSE

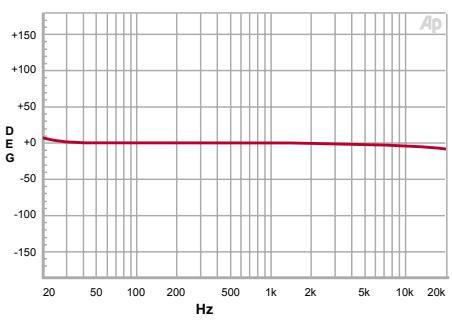


JDV ACTIVE STUDIO DI

RADIAL JDV - FREQUENCY RESPONSE - 22Hz TO 22kHz

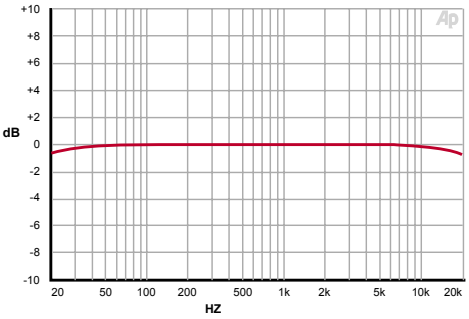


RADIAL JDV - PHASE RESPONSE

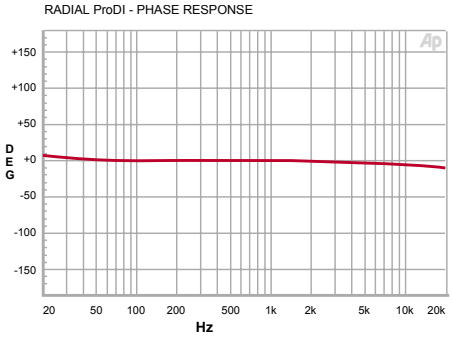


PRO DI PASSIVE DI

RADIAL ProDI - FREQUENCY RESPONSE - 22Hz TO 22kHz

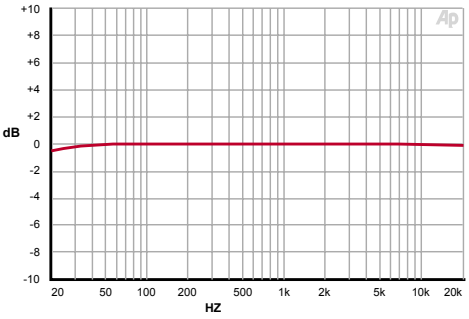


RADIAL ProDI - PHASE RESPONSE

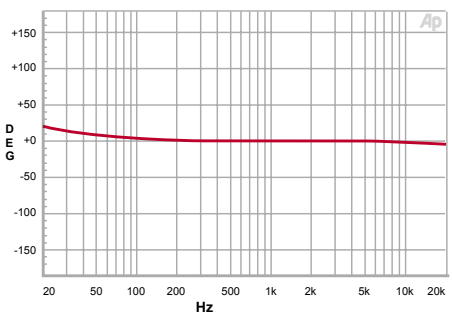


PRO 48 ACTIVE DI

RADIAL Pro48 - FREQUENCY RESPONSE - 22Hz TO 22kHz

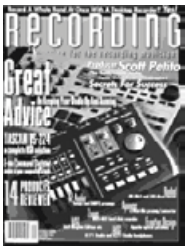


RADIAL Pro48 - PHASE RESPONSE



Test conditions for above charts;

Audio Precision:	*SYSTEM-2622 CASCADE+ DSP*	*Source impedance:*	*600 ohms*
Test Frequency:	*1KHz*	*Test Load:*	*1,200 ohms*
Bandwidth:	*22Hz - 22KHz not weighted*		*(through 3 ft of twisted pair cable*
Level:	*0dbU (774.6 mV RMS)*		*having 100 pfd approximate of total capacity)*



RECORDING magazine

Radial JDI Mk3 & Radial J48 DI Boxes

"... the real difference between passive boxes is entirely due to the quality and sound of the transformer. A better transformer will sound better." "My quick RFI test of keying up a two-watt VHF transceiver (an old Motorola HT220... we use then a lot at festival gigs) was flawless, with no RF pickup even with the antenna very near the cable." "The JDI Mk3 is a great choice when you need a DI box for a synth, and instrument amp, and instrument with active pickups... (it will also work in reverse for some re-amping applications)."

EQ magazine

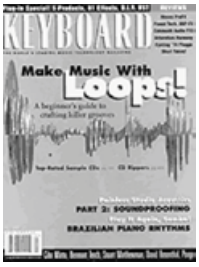
JDI Mk3 and Duplex - Radial juices up direct recording with two new direct boxes

"... the best thing you can say about a direct box is that you forget it's there. The JDI's are transparent and noise free, but they're not forgettable. They performed very well on every source I fed them, including electric and acoustic guitar and bass. Even in an environment that's occasionally prone to grounding problems and noise from computers and monitors, the signal was ultra clean."

Audio Media magazine

Radial J48 DI

"I experimented with a handful of DI's on various instruments here in the studio... in every comparison, the Radial J48 was usually the final choice, simply because it sounded more like I thought the instrument should sound like" ... "While less expensive DI's are easy to find, this one has proven it's worth to me - I intend to buy a couple of them for my studio."



Keyboard magazine

Short takes - Radial Engineering JDI, JDV & JD4 Direct boxes

"...the JDI/JD4 and JDV sound -- in a word -- pure. Compared to these, my old standby active DI has a thinner and harsher tone. No matter what type of signal I put through them, the Radials sounded round and natural". "Radial Engineering has done a superb job with these direct boxes -- I couldn't come up with any gripes about them! I especially like the JDI. Plug it in and it sounds great. If you need a line level output or have a sensitive instrument that could be loaded by a transformer design, the JDV is for you.." " ... they're pricier than some of the competition, but they're worth every penny."

ARTISTS AND ENGINEERS

CHICK COREA
(Electrik Band, Miles Davis)

"Radial direct boxes make everything I put through them warm, punchy and clear. They are great DI's!"
~ Chick Corea

ROBERT SCOVILL
(Matchbox 20, Tom Petty, Rush)

"The Radial products are the most transparent, technically comprehensive devices I have ever run across. They are right at the top of my list of 'gotta haves'."
~ Robert Scovill

TOM SIZE
(Aerosmith, Journey, Steve Miller)

"We were using the Countryman and when we plugged in the Radial JDV, we noticed the sound was more clear, more open and more natural. To sum it up, The JDV sounds darn good!"
~ Tom Size

DAVE NATALE
(Fleetwood Mac, Stevie nicks, Tina Turner, Lionel Ritchie, John Mellancamp)

"Radial's wide variety of direct boxes, iso transformers and splitters are built tough to take the abuse of the road. No one direct box or transformer is suited to the wide variety of applications that I encounter, that's why the choices offered by Radial are so valuable to me."
~ Dave Natale