

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

VERANCE CORP.,
Petitioner,

v.

MZ AUDIO SCIENCES, LLC,
Patent Owner.

IPR2022-01544
Patent 7,289,961 B2

Before KARL D. EASTHOM, DAVID C. McKONE, and
IFTIKHAR AHMED, *Administrative Patent Judges*.

EASTHOM, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining No Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

The Board instituted *inter partes* review of claims 1–10 of U.S. Patent No. 7,289,961 B2 (Ex. 1001, “the ’961 patent”) based on a Petition filed by Sony Group Corp. (Japan), Sony Corp. of America, Sony Interactive Entertainment LLC, Sony Pictures Entertainment Inc., Sony Electronics Inc. (now terminated as petitioner, (Paper 17)), and Verance Corp. (sole remaining “Petitioner”). Paper 7 (“Pet.”).

After the Institution Decision (Paper 12), MZ Audio Sciences, LLC (“Patent Owner”) filed a Response to the Petition (Paper 27, “PO Resp.”), Petitioner filed a Reply (Paper 28, “Reply”), and Patent Owner filed a Sur-reply (Paper 29, “Sur-reply”). The parties participated in an oral hearing and a copy of the transcript is in the record. Paper 36.

We have jurisdiction under 35 U.S.C. § 6 to enter this Final Written Decision under 35 U.S.C. § 318(a). Petitioner has the burden of proving unpatentability of the challenged claims by a preponderance of the evidence. 35 U.S.C. § 316(e). Having reviewed the parties’ arguments and cited evidence based on the full record, for the reasons discussed below, we determine that Petitioner has not demonstrated by a preponderance of the evidence that claims 1–10 of the ’961 patent are unpatentable. To the extent this Final Written Decision may conflict with the Institution Decision, “the Board has an obligation to assess the [validity] question anew after trial based on the totality of the record.” *In re Magnum Oil Tools Int’l, Ltd.*, 829 F.3d 1364, 1377 (Fed. Cir. 2016); *see also Trivascular, Inc. v. Samuels*, 812 F.3d 1056, 1068 (Fed. Cir. 2016) (“The Board is free to change its view of the merits after further development of the record, and should do so if convinced its initial inclinations were wrong.”).

A. Related Matters

The parties indicate that Patent Owner asserted the '961 patent in district court lawsuits, including *MZ Audio Sciences, LLC v. Sony Group Corp. (Japan)*, No. 1:21-cv-0166 (D. Del.), and *MZ Audio Sciences, LLC v. Sony Group Corp. (Japan)*, No. 2:22-cv-00866 (C.D. Cal.). Pet. xi; Paper 9, 1. The parties identify no other related proceedings.

B. The Asserted Grounds

Petitioner asserts the following grounds of unpatentability (Pet. 2):

Claim(s) Challenged	35 U.S.C.¹ §	Reference(s)/Basis
1–10	103(a)	Srinivasan ² , Cabot ³ , Kudumakis ⁴
2, 3, 5, 7, 8, 10	103(a)	Srinivasan, Cabot, Kudumakis, Hobson ⁵
1–10	103(a)	Kudumakis, Tilki ⁶ , Cabot

¹ The Leahy-Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284 (2011) (“AIA”), amended 35 U.S.C. § 103 (effective Mar. 16, 2013). Petitioner points out that “[t]he application from which U.S. Patent No. 7,289,961 issued claims priority to U.S. Provisional Application No. 60/479,438, filed June 19, 2003.” Pet. xi. Because the earliest possible effective filing date for the '961 patent precedes the effective date of the applicable AIA amendment, the pre-AIA version of § 103 applies.

² Srinivasan, US 6,272,176 B1, issued Aug. 7, 2001. Ex. 1005.

³ R. C. Cabot et al., *Detection of Phase Shifts in Harmonically Related Tones*, J. AUDIO ENG. SOC., VOL. 24, No. 7 (Sept. 1976). Ex. 1006.

⁴ Kudumakis et al., Int. Pub. WO 01/58063, published Aug. 9, 2001. Ex. 1007.

⁵ Hobson et al., US 6,633,653 B1, issued Oct. 14, 2003, filed Feb. 4, 2000. Ex. 1042.

⁶ J.F. Tilki et al., *Encoding a Hidden Auxiliary Channel onto a Digital Audio Signal Using Psychoacoustic Masking*, PROCEEDINGS IEEE

In support, Petitioner relies on the testimony of Dr. Michael Scordilis (Ex. 1003).0

C. The '961 Patent

The '961 patent relates to embedding data in an audio signal for watermarking, steganography, or other purposes. Ex. 1001, code (57). “The present invention is directed to a system and method for insertion of hidden data into audio signals and retrieval of such data from audio signals and is more particularly directed to such a system and method using a phase encoding method.” *Id.* at 1:20–24. The process divides the audio signal into time frames that contain frequency bands representing the audio signal. *Id.* at code (57). Then, “the relative phases of one or more frequency bands are shifted to represent the data to be embedded.” *Id.* at code (57).

The invention exploits the randomness of the relative phases of frequency components in typical audio speech or music. Ex. 1001, 3:47–53 (“So far, however, the apparent randomness of the phase has not been exploited for data hiding purposes.”).

The method involves dividing an audio signal into time frames, sampling the time frames, and transforming the representation of the signal into its frequency components. *See* Ex. 1001, 5:30–67. Then, the method involves selecting at least two frequency components, the first of which is a fundamental tone, and the other(s) of which is/are an overtone or harmonic of the fundamental tone, obtaining the relative phase difference(s) between

SOUTHEASTCON '97, “Engineering the New Century,” Apr. 12–14, 1997. Ex. 1008; *see also* Pet. 52–53 (arguing that Tilki is prior art under §§ 102(a)–(b)) (citing Ex. 1025, 1–8; Ex. 1026, 1–2; Ex. 1027, 2; Ex. 1030, 1–2; Ex. 1032, 48; Ex. 1033, 2719).

the at least two frequency components, altering the phase of at least one of the overtones or harmonics to embed the desired hidden data into the signal, and inverse transforming the frequency components back into a digital representation of the time varying signal. *Id.* at 5:30–6:28.

The specification states that “in addition to steganography and watermarking, any suitable use for hidden data falls within the present invention.” Ex. 1001, 8:66–67.

D. Challenged Claims

Petitioner challenges all ten claims of the '961 patent. Of these, claims 1, 4, 6, and 9 are independent. For purposes of this Final Written Decision, claim 1 is representative. Claim 1 follows (information added to conform to Petitioner's nomenclature):

1. [1PRE] A method for embedding data in an audio signal, the method comprising:

[1A] (a) dividing the audio signal into a plurality of time frames and, in each time frame, a plurality of frequency components;

[1B] (b) in each of at least some of the plurality of time frames, selecting at least two of the plurality of frequency components; and

[1C] (c) altering a phase of at least one of the plurality of frequency components in accordance with the data to be embedded, wherein:

[1C-1] step (b) comprises selecting a fundamental tone and at least one overtone; and

[1C-2] step (c) comprises quantizing a phase difference of the at least one overtone relative to the fundamental tone to embed at least one bit of the data to be embedded.

II. ANALYSIS

A. Legal Standards

“In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable.” *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (requiring *inter partes* review petitions to identify “with particularity . . . the evidence that supports the grounds for the challenge to each claim”)). This burden of persuasion never shifts to the patent owner. *Dynamic Drinkware, LLC v. Nat’l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015).

Resolving the legal question of obviousness requires resolving underlying factual considerations including (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when in evidence, objective evidence of nonobviousness. *Graham v. John Deere Co. of Kan. City*, 383 U.S. 1, 17–18 (1966).

Often, it will be necessary for a court to look to interrelated teachings of multiple patents; the effects of demands known to the design community or present in the marketplace; and the background knowledge possessed by a person having ordinary skill in the art, all in order to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue. To facilitate review, this analysis should be made explicit.

KSR Int’l Co. v. Teleflex Inc., 550 U.S. 398, 418 (2007) (citing *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) (“[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness”)).

B. Level of Ordinary Skill in the Art and Dr. Scordilis's Testimony

Petitioner asserts that a person of ordinary skill in the art “would have had a bachelor’s degree in electrical engineering or a related field with coursework in signal processing, plus two years of academic and/or industry experience in signal processing or a related field. More education could substitute for experience, and vice versa.” Pet. 7. “Patent Owner does not dispute Petitioners’ definition of a [person of ordinary skill in the art].” PO Resp. 2.

Based on a review of the record, we adopt Petitioner’s proposed level of ordinary skill in the art because it is consistent with the evidence of record, including the asserted prior art, other references of record, and the ’961 patent specification.

C. Claim Construction

In *inter partes* reviews, the Board interprets claim language using the district-court-type standard, as described in *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc). See 37 C.F.R. § 42.100(b) (2020). Under this standard, claim terms have their ordinary and customary meaning, as would be understood by a person of ordinary skill in the art at the time of the invention, in light of the language of the claims, the specification, and the prosecution history. See *Phillips*, 415 F.3d at 1313–14.

Petitioner relies on the plain and ordinary meaning and contends that it is unnecessary to construe any claim terms explicitly. See Pet. 8 (citing 37 C.F.R. §42.100(b)). Patent Owner “agrees with Petitioner that, for purposes of this Response only, all terms of the ’961 patent have their plain and ordinary meaning.” PO Resp. 23. As Petitioner contends, it is not necessary

to construe any claim terms explicitly. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (stating that “we need only construe terms ‘that are in controversy, and only to the extent necessary to resolve the controversy’” (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999))).

D. Summary of Asserted Prior Art References

1. Srinivasan (Ex. 1005)

Srinivasan relates to an encoder that adds an inaudible binary code to an audio signal, and a decoder for retrieving that code, using a phase modulation scheme. *See* Ex. 1005, code (57), 1:5–7, 3:16–19, 11:25–30. The code “may be used . . . in order to identify a broadcast program.” *Id.* at 1:8–10.

Srinivasan’s Figure 1 follows:

FIGURE 1

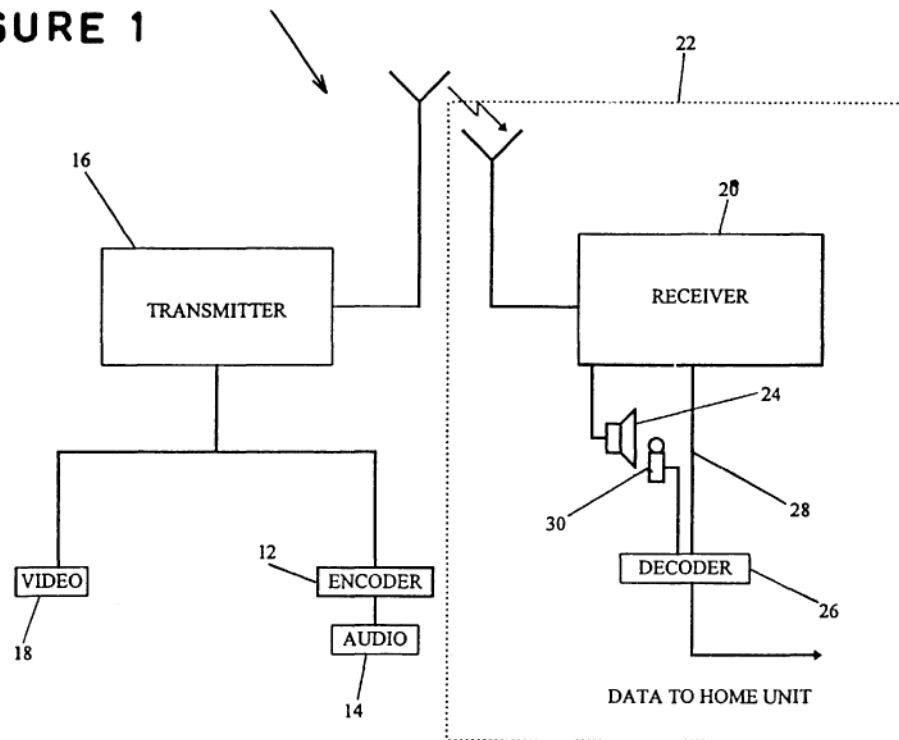


Figure 1 is a schematic block diagram of an audience measurement system employing signal coding and decoding arrangements, and illustrates encoder 12 for adding codes to a digital representation of audio signal derived from audio signal portion 14 of a broadcast signal transmitted to receiver 20 for decoding the codes via decoder 26 and replaying the audio in speaker 24. *See* Ex. 1005, 5:52–54, 7:29–41.

After sampling an audio block to provide 512 samples and computing a Fast Fourier Transform (FFT) of the block (*see* steps 40–44, Fig. 2), Srinivasan’s “method comprises the following steps,” which result in phase encoding of frequency components of the audio signal:

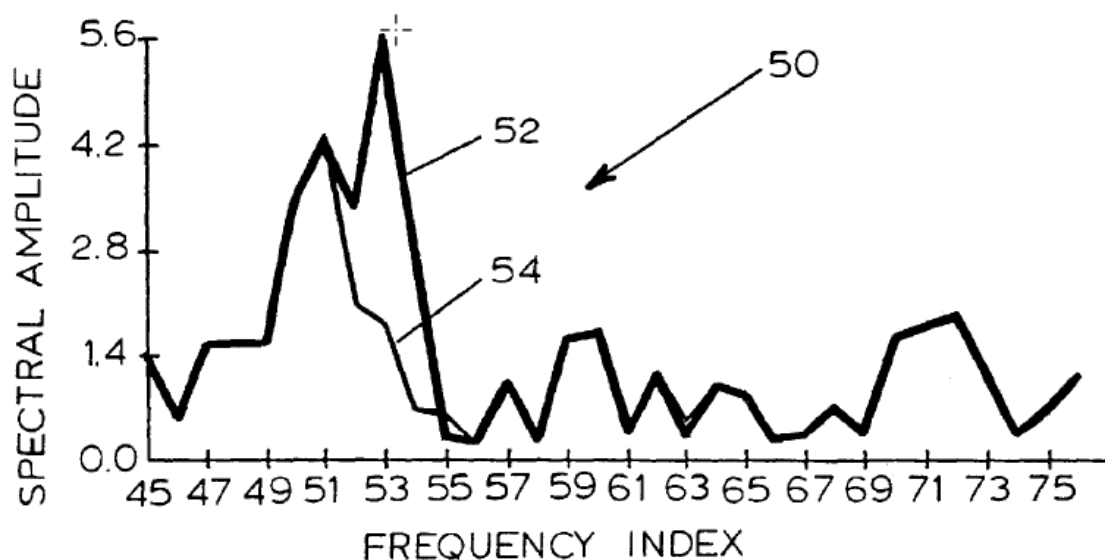
- a) selecting, within the block, (i) a reference frequency within the predetermined signal bandwidth, (ii) a first code frequency having a first predetermined offset from the reference frequency, and (iii) a second code frequency having a second predetermined offset from the reference frequency; b) comparing the spectral amplitude of the signal near the first code frequency to the spectral amplitude of the signal near the second code frequency; c) selecting a portion of the signal at one of the first and second code frequencies at which the corresponding spectral amplitude is smaller to be a modifiable signal component, and selecting a portion of the signal at the other of the first and second code frequencies to be a reference signal component; and d) selectively changing the phase of the modifiable signal component so that it differs by no more than a predetermined amount from the phase of the reference signal component.

Ex. 1005, 3:3–19.

To select the frequencies to encode, Srinivasan’s method “determine[s] a frequency index I_{max} at which the spectral power of the audio signal, as determined as the step 44 [of Figure 2], is a maximum in the low frequency band extending from zero Hz to two kHz.” Ex. 1005, 8:51–54. Then, “[t]he code frequency indices l_1 and l_0 are chosen relative to . . . I_{max}

so that they lie in a higher frequency band at which the human ear is relatively less sensitive.” *Id.* at 8:59–63. Srinivasan states that the less sensitive frequency ranges (for embedding codes) are frequencies in the 4.8–6 kHz range “in order to exploit the higher auditory threshold in this band.” *Id.* at 7:64–67. “[E]ach successive bit of the code may use a different pair of code frequencies f_1 and f_0 denoted by corresponding code frequency indexes I_1 and I_0 .” *Id.* at 7:67–8:3. “[T]wo preferred ways of selecting the code frequencies f_1 and f_0 . . . create an inaudible wide-band noise like code.” *Id.* at 8:3–5.

Srinivasan’s Figure 3 follows:



Srinivasan’s Figure 3 above, is a spectral plot illustrating the result of taking the FFT (Fast Fourier Transform) of a time block, where as a result of amplitude modulation coding, “spectrum 52 shows the audio block after coding of a ‘1’ bit, and a spectrum 54 shows the audio block before coding.” *See Ex. 1005, 9:48–53.* In other words, there is a visual difference in the plot between encoded audio waveform and the original audio waveform.

Srinivasan describes one phase encoding technique as follows:

In order to encode a binary number, the phase angle of one of these components, usually the component with the lower spectral amplitude, can be modified to be either in phase (i.e., 0°) or out of phase (i.e., 180°) with respect to the other component, which becomes the reference. In this manner, a binary 0 may be encoded as an in-phase modification and a binary 1 encoded as an out-of-phase modification.

Ex. 1005, 11:26–32.

To minimize the audible perception of coding the phase shifts, Srinivasan explains that “it is not essential to perform phase modulation to th[e] extent of [a maximum phase change of 180°], as it is only necessary to ensure that the two components are either ‘close’ to one another in phase or ‘far’ apart.” *Id.* at 11:44–47. Therefore, Srinivasan assigns two phase neighborhoods, one $\pm 45^\circ$ ($\pm \pi/4$ radians) for a reference phase, and another $\pm 45^\circ$ of 180° out of phase with the reference phase, to represent a “0” and “1,” and then modifies the phase angle of “[t]he modifiable spectral component . . . into one of these phase neighborhoods depending upon whether a binary ‘0’ or a binary ‘1’ is being encoded.” *Id.* at 11:26–54. With this variation, “approximately 30% of the segments are ‘self-coded’ . . . and no modulation is required.” *Id.* at 11:56–57.

2. *Kudumakis (Ex. 1007)*

Kudumakis relates to “a method of labelling . . . an audio or video signal prior to broadcast or distribution to provide an audit trail.” Ex. 1007, 1:4–8. Because prior art systems employed watermarking techniques using frequency notches at predictable frequencies to embed an inaudible code, Kudumakis “appropriately select[s] the part of the frequency spectrum where each watermark code is inserted, providing improved audio quality and extra security in the form of frequency hopping.” *Id.* at 2:23–25. The location in the frequency spectrum that includes the embedded code “is

chosen adaptively with regard to the frequency content of the signal.” *Id.* at 2:29–30. Therefore, Kudumakis’s frequency selection techniques introduce unpredictability as to the frequency location of the embedded codes. *Id.* at 3:17–18.

Kudumakis’s method embeds the codes using the same “notch” filtering as the prior art, which places “notches” in the audio signal to remove the original signal, and then replaces the removed signal with a frequency carrying the desired code using either amplitude or phase modulation. Ex. 1007, 1:17–18, 3:4–9, 6:1–2.

For each input block, Kudumakis’s system “find[s] both the fundamental and its harmonics” of the audio input signal using known techniques such as FFT. Ex. 1007, 4:26–30. Using the fundamental and its harmonics to determine where to embed the codes enhances security against malicious attacks because those frequencies vary throughout the audio signal. *Id.* at 4:26–5:9. Kudumakis’s method embeds the notch filters and codes at the “edges” of “these harmonics.” *Id.* at 4:30–31. Codes are more perceptible if they “coincide with the main frequency component of the signal,” yet “they have to be placed in a part of the spectrum with sufficient energy so that frequent masking conditions can be met.” *Id.* at 3:5–9.

3. *Cabot (Ex. 1006)*

Cabot relates to testing “the audibility of phase shifts in two component octave complexes.” Ex. 1006, 568. The tests involved groups listening to “headphones with fundamental and third-harmonic signals” of an audio signal. *Id.*

“The experiment shows phase shifts of harmonic complexes to be detectable, but judging from the difficulty experienced by the subjects, the effect appear to be small.” Ex. 1006, 570. In one experiment, subjects

correctly identified a phase shift of 22.5 degrees between a fundamental and a harmonic with a 60 % corrected rate P. *Id.* (Table II).

Cabot's Figure 2a follows:

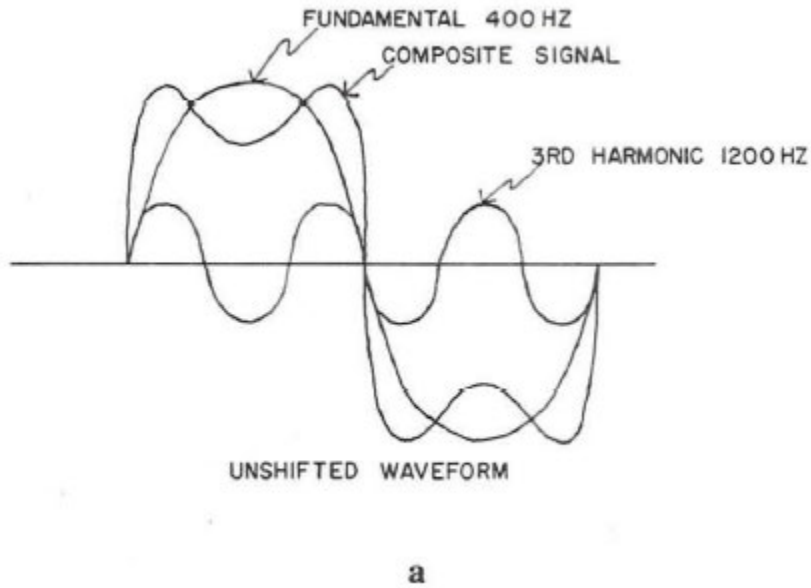


Figure 2a above illustrates a time varying waveform (with time along the horizontal axis and amplitude along the vertical axis), which is equal to the sum of its fundamental harmonic at 400Hz plus its third harmonic at 1200 Hz, as depicted.

Cabot's Figure 2b follows:

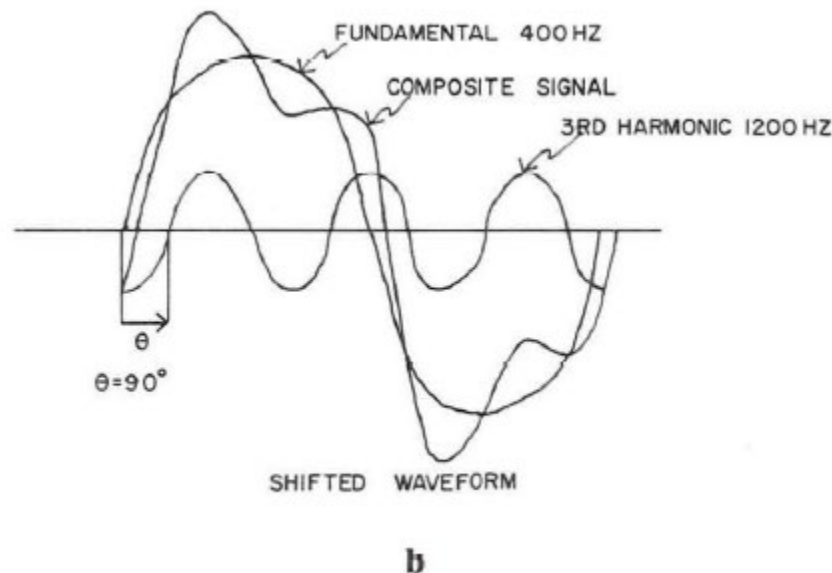


Figure 2b above illustrates a time varying composite signal (with time along the horizontal axis and amplitude along the vertical axis), which is equal to the sum of its fundamental harmonic at 400Hz plus its third harmonic at 1200 Hz, which is shifted by a phase of 90 degrees relative to the fundamental harmonic, as depicted. Notice that the composite signal in Figure 2a is different from the composite signal in Figure 2b, due to the relative phase shift of the third harmonic.

Cabot states that its “results, both quantitative and qualitative, correlate well with those of previous researchers using both similar and very different experimental techniques.” Ex. 1006, 571. Cabot states that “[a]lthough differences were detectable, they were subtle,” and “[t]his raises the question of its audibility compared to the more familiar forms of distortion.” *Id.*

E. Obviousness Ground 1: Srinivasan, Cabot, and Kudumakis

Petitioner contends that the subject matter of claims 1–10 would have been obvious over Srinivasan, Cabot, and Kudumakis. Pet. 2. Patent Owner argues that Petitioner’s showing is insufficient. PO Resp. 23–47.

1. Independent Claim 1

a. Step 1PRE: “A method for embedding data in an audio signal, the method comprising:”

Petitioner contends that “Srinivasan’s differential phase encoding method that ‘add[s] an inaudible code to an audio signal’ as ‘bit[s]’” satisfies the preamble. Pet. 29 (citing Ex. 1003 ¶ 139; quoting Ex. 1005, 1:5–7, 7:67).

b. Step 1A: “(a) dividing the audio signal into a plurality of time frames and, in each time frame, a plurality of frequency components”

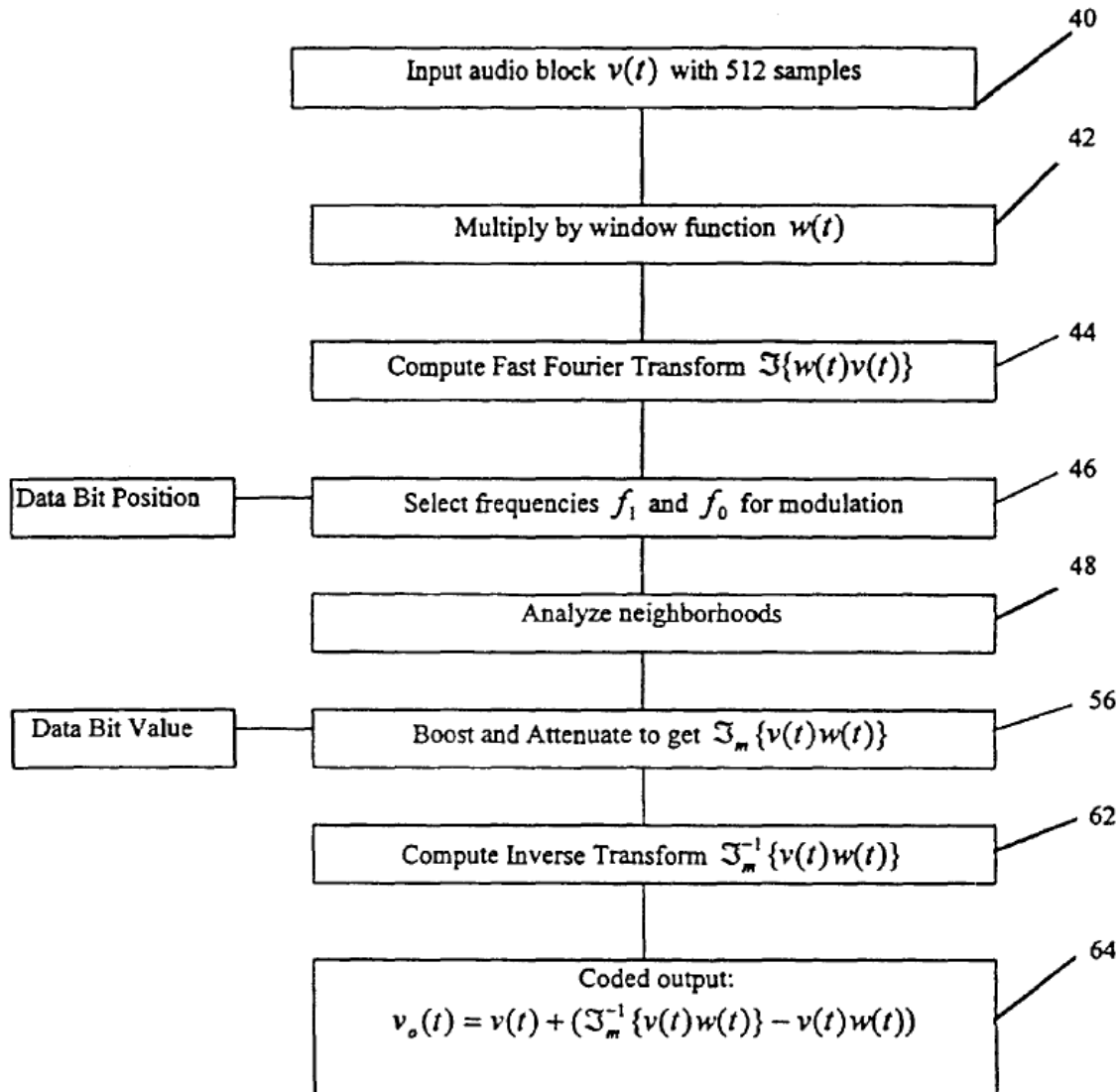
Petitioner contends that Srinivasan discloses this step. Pet. 29–31. According to Petitioner, Srinivasan discloses sampling an audio signal, dividing the digitized audio signal into a plurality of time frames called “blocks,” and then dividing each block into a plurality of frequency components by taking the FFT (Fast Fourier Transform). *See id.* (reproducing Ex. 1005, Figs. 2, 5; quoting *id.* at 7:33–42 (“a first block $v(t)$ of jN_c samples is derived from the audio signal portion 14 . . . where $v(t)$ is the time-domain representation of the audio signal within the block”)).

c. Step 1B: “(b) in each of at least some of the plurality of time frames, selecting at least two of the plurality of frequency components; and”

Petitioner contends that Srinivasan’s method selects “two of the plurality of frequency components as the code frequencies f_1 and f_0 (also represented by frequency indices I_1 and I_0 , respectively).” Pet. 32 (citing Ex. 1005, 7:64–8:3; Ex. 1003 ¶ 143). Petitioner quotes Srinivasan as teaching that “[t]he code frequencies f_i used for coding a block may be

chosen from the Fourier Transform $\mathfrak{F}\{v(t)\}$ at a step 46'' of Figure 2. *Id.* (quoting Ex. 1005, 7:64–66).

Srinivasan's Figure 2 follows:



Srinivasan's Figure 2 is a flow chart of steps performed by an encoder. Ex. 1005, 5:56–57. Petitioner relies on Srinivasan's Figure 2 above (step 46) to illustrate that Srinivasan's technique involves selecting two frequencies f_1 and f_0 in each audio block of 512 samples (step 40). *See* Pet. 32–33 (citing Ex. 1003 ¶¶ 143–144).

d. Step 1C: “altering a phase of at least one of the plurality of frequency components in accordance with the data to be embedded, wherein,”

Petitioner contends that Srinivasan’s system modifies “the phase of one of the spectral components f_0 or $f_1 \dots$ with respect to the other,” where Srinivasan refers to modified and reference phases as ϕ_M and ϕ_R , respectively. Pet. 34 (citing Ex. 1005, 11:26–39). Petitioner explains that Srinivasan’s method

assign[s] two phase neighborhoods (one being $\pm 45^\circ$ ($\pm \pi/4$ radians) of reference phase ϕ_R and another being $\pm 45^\circ$ of $\dots 180^\circ$ (π radians) out of phase with ϕ_R) to represent, e.g., a “0” and “1,” respectively, and by modifying the phase angle ϕ_M of the modifiable spectral component “at the step 56 so as to fall into one of these phase neighborhoods depending upon whether a binary ‘0’ or a binary ‘1’ is being encoded.”

Id. (citing Ex. 1005, 11:26–54; Ex. 1003 ¶ 145; Pet. § VI.A).

e. Step 1C-1: “wherein $\dots$ step b comprises selecting a fundamental tone and at least one overtone” and Step 1C-2: “and step (c) comprises quantizing a phase difference of the at least one overtone relative to the fundamental tone to embed at least one bit of the data to be embedded.”

For step 1C-1, Petitioner contends that “[t]he Srinivasan/Cabot/Kudumakis Combination selects a fundamental tone and the third harmonic (an overtone) as the code frequencies based on Kudumakis’s and Cabot’s teachings.” Pet. 35 (citing Pet. §§ VI.E, VI.E.3; Ex. 1003 ¶ 147). For step 1C-2, Petitioner similarly contends that “[t]he Srinivasan/Cabot/Kudumakis Combination uses Srinivasan’s method that quantizes a phase difference between code frequencies f_1 and f_0 to embed a bit of data.” *Id.* (citing Ex. 1008, 11:26–54; Ex. 1003 ¶ 148). In other words, as discussed further below, Petitioner primarily relies on Cabot and Kudumakis to address encoding the phase difference between an

overtone relative to a fundamental tone and its stated reasons for combining the three references to address steps 1C-1 and 1C-2.

Further as to step 1C-2, Petitioner relies on Srinivasan's method as described above, which quantizes phase differences between code frequencies f_0 and f_1 to represent either a binary 1 or 0. According to Petitioner, a person of ordinary skill in the art

would have understood that establishing one phase difference value (0°) or neighborhood of values (within 45° of in-phase) to represent one binary value, and another phase difference value (180°) or neighborhood of values (within 45° of out-of-phase) to represent a different binary value is quantizing the phase difference between the two frequency components as claimed.

Pet. 35–36 (citing Ex. 1003 ¶ 149).

In other words, Petitioner employs Srinivasan's method of phase encoding wherein a phase difference shift may be about 45° , because a phase for f_1 relative to f_0 may fall anywhere between 45° and 135° (e.g., 90°), and when Srinivasan's method shifts that phase so that it falls in the closest neighborhood, the phase shift is as high as 45° . *See* Ex. 1003 ¶¶ 145–149.

Petitioner explains that a person of ordinary skill in the art “would have been motivated by Cabot and Kudumakis to modify Srinivasan to use the fundamental and third harmonic as the coding frequencies f_0 and f_1 to improve robustness and expand the applications for which Srinivasan's system was suitable.” Pet. 22. Petitioner advances other reasons as to why an artisan of ordinary skill would have selected the fundamental and third harmonic as the coding frequencies. *See id.* at 21–28.

For example, Petitioner contends that it would have been obvious to implement Cabot's and Kudumakis's suggestions to use the fundamental and

third harmonic frequencies to modify Srinivasan's system so that it can protect spoken speech and word recordings, which involve lower frequencies of the human audio spectrum than music. *See* Pet. 26–27.

According to Petitioner, “[b]ecause such audio [speech] content commonly has frequencies up to about only 4 kHz, Srinivasan's embedding band from 4.8 kHz–6 kHz would not work with such narrowband voice applications.” *Id.* (citing Ex. 1003 ¶ 132). Petitioner explains that “[c]hoosing the fundamental and third harmonic as the coding frequencies would have expanded the useful applications of Srinivasan's watermarking system to narrowband voice applications.” *Id.* at 27.

Petitioner contends that a person of ordinary skill in the art would have “understood from Cabot that there was an alternative way to achieve low-visibility differential phase encoding.” Pet. 22 (citing Ex. 1003 ¶ 120). According to Petitioner,

Cabot confirmed that modifying the phase of the third harmonic relative to the fundamental is inaudible for small phase changes and “subtle” at larger phase changes, even under pristine listening conditions where (1) the fundamental and third harmonic are isolated from all other sounds that might mask the phase change and (2) the listener, wearing headphones, is familiarized with the sound of the difference and given unlimited opportunities to try to detect the difference.

Id. at 22–23 (citing Ex. 1006, Abstract, 570–71 (Observations & Discussions at ¶ 4, Conclusions); Ex. 1003 ¶ 120).

Petitioner explains that a person of ordinary skill in the art would have understood that using the third harmonic and fundamental as Srinivasan's code frequencies f_1 and f_0 . . . would have provided the low visibility Srinivasan desires, particularly *under real-world conditions where the listener is unaware of the phase shift and the audio signal has other sounds masking the phase shift.*

Pet. 23 (emphasis added) (citing Ex. 1003 ¶¶ 121–124; Ex. 1006, 570–71; Ex. 1028 (Risset), 114 (noting there is a “remarkable insensitivity to phase” between harmonics of periodic tones and stating further that although changing the phase between the harmonics of a periodic tone can alter the timbre of audio under certain conditions, “this effect is quite weak, and it is generally inaudible in a normally reverberant room where phase relations are smeared.”); Ex. 1031 (Lipshitz), 584 (noting symmetrical waveforms like those resulting from Cabot’s use of the fundamental and third harmonic give rise to “much less pronounced phase effects” than those displayed by asymmetrical signals)).

With respect to security, Petitioner explains that “because the fundamental frequency and its harmonics change unpredictably throughout the audio signal, using them to determine where to embed a code ‘[e]nhance[s] security against malicious attacks’ seeking to remove the code.” Pet. 24 (quoting Ex. 1007, 5:3; citing *id.* at 3:3–18, 6:1–2; Ex. 1003 ¶ 127). Kudumakis teaches that “[i]f the code frequencies change frequently, then it becomes more difficult for an attacker to remove all the codes without introducing significant distortion to the original signal content.” Ex. 1007, 5:5–7. Therefore, Petitioner contends that “[p]lacing the watermark in perceptually less-significant regions (like Srinivasan did) leaves it susceptible to low-pass filtering that would remove the code by only retaining lower frequencies of the signal perceptible to the listener.” Pet. 25.

With respect to robustness, Petitioner contends that “the modification would have resulted in using perceptually more significant lower frequencies less susceptible to common signal distortions and malicious attacks.”

Pet. 24 (citing Ex. 1003 ¶ 128; Ex. 1020, Abstract (“a watermark must be placed in perceptually significant components of a signal if it is to be robust to common signal distortions and malicious attack.”); Ex. 1018, 4:32–37 (“The higher the level of embedded signal, the more corrupted a copy can be and still be identified.”)).

Petitioner explains that for audio files including speech, “the perceptually significant frequencies with the most energy were well below the 4.8–6 kHz range Srinivasan used and include the fundamental and its harmonics.” Pet. 24 (citing Ex. 1003 ¶ 128; Ex. 1008 (Tilki), 331 (“lower frequencies (below say 2 kHz) . . . typically contain the most energy in common audio signals”); Ex. 1020 (“Cox-1995”), 11 (“spectrum analysis of images and sounds reveals that most of the information in such data is located in the low frequency regions”); Ex. 1055 (“Cox-SWW”), 1667).

Therefore, according to Petitioner, “[p]lacing the watermark in perceptually less-significant regions (like Srinivasan did) leaves it susceptible to low-pass filtering that would remove the code by only retaining lower frequencies of the signal perceptible to the listener.” Pet. 25 (citing Ex. 1003 ¶ 129; Ex. 1020, Abstract; Ex. 1021 (“Wu”), Table 4, 390 (“[L]ow pass filtering . . . could effectively eliminate the embedded watermark. However, since our watermark is embedded in the frequency bands with the highest energy, filtering out the inserted watermark also greatly effects the sound quality.”)).

Petitioner also explains that “by placing the embedded data in frequency components that will typically be of relatively low energy, Srinivasan risks having the data be non-recoverable due to common signal

distortions like additive noise.” Pet. 25 (citing Ex. 1003 ¶ 129; Cox-1995, Abstract; Ex. 1021, Table 4, 390 (revealing that white noise is detrimental to watermarks in weaker frequencies)).

Petitioner contends that a person of ordinary skill in the art “would have understood the fundamental and at least some of its harmonics are commonly strong, perceptually-significant frequency components in typical audio files.” Pet. 25 (citing Ex. 1003 ¶ 130; Ex. 1007, 3:5–14, 4:26–31 (implying fundamentals and harmonics are “in a part of the spectrum with sufficient energy so that frequent masking conditions can be met”); Ex. 1043, 9:3–6). Therefore, Petitioner asserts that selecting code frequencies in the 4.8–6 kHz range “made Srinivasan’s system susceptible to the above-discussed types of intentional (malicious attacks) and unintentional (common distortions) watermark destruction.” *Id.* at 25–26 (citing Ex. 1003 ¶ 131). Based on the considerations as outlined above, Petitioner asserts that a person of ordinary skill in the art “would have understood selecting the fundamental and third harmonic (typically below 4 kHz as in Cabot) would have improved the robustness of Srinivasan’s watermarking system by placing the watermark in perceptually significant frequencies less susceptible to intentional or unintentional destruction.” *Id.* at 26 (citing Ex. 1003 ¶ 131).

Petitioner also explains that because “Srinivasan uses *differential phase encoding* instead of notch encoding [as Kudumakis teaches], a [person of ordinary skill in the art] would have understood it was unnecessary for inaudibility to place the codes at the ‘edges’ of the fundamental and its harmonics.” Pet. 28 (citing Ex. 1003 ¶ 136; Pet. § VI.B (asserting phase shifts were known to be inaudible)). Petitioner contends that Kudumakis teaches that codes are more perceptible if they “coincide

with the main frequency component of the signal.” *Id.* at 20 (quoting Ex. 1007, 3:4–9). Petitioner also alleges a reasonable expectation of success based on the use of known techniques to identify a fundamental and its harmonics for use in embedding a code in an audio signal. *See id.* (citing Ex. 1003 ¶ 136; Ex. 1005, 7:43–47; Ex. 1007, 3:22–30, 4:21–30).

As indicated above, in addition to Cabot and Kudumakis, Petitioner relies upon other references (e.g., Lipshitz, Risset, Cox-1995, Cox-1995) and asserts that modifying the phase of an audio signal’s third harmonic, under real-world conditions, does not distract a listener. *See* Pet. 21 (citing references), 23 (arguing that an artisan of ordinary skill would have recognized that implementing Cabot’s phase shifting “would have provided the low visibility Srinivasan desires, particularly under real-world conditions where the listener is unaware of the phase shift and the audio signal has other sounds masking the phase shift”), 24 (citing references), 25–26 (arguing that Cabot’s phase modulation scheme would have provided benefits to Srinivasan’s scheme).

Petitioner also contends that Cabot’s phase-testing scheme suggests modifying the phase of harmonics under real-world conditions because that type of phase shift results in imperceptible changes. Pet. 23. Petitioner also contends that “[u]sing the fundamental and its harmonics to determine where to embed the codes enhances security against malicious attacks because those frequencies vary throughout the audio signal.” *Id.* at 20. Petitioner also argues that Kudumakis teaches that “the inserted code may be amplitude or phase modulated.” *Id.* at 20 (citing Ex. 1007, 6:1–2; Ex. 1003 ¶ 87).

In summary, Petitioner proposes using the fundamental frequency as a reference phase for adjusting the phase of the fundamental’s third

harmonic in Srinivasan's modified system as further suggested by Cabot and Kudumakis. *See id.* at 36 (“[T]he Srinivasan/Cabot/Kudumakis Combination quantizes a phase difference of at least one overtone (third harmonic) relative to the fundamental tone to embed at least one bit of the data to be embedded as claimed.”).

f. Reasons to Combine Analysis

As summarized above, Petitioner relies on combining Cabot and Kudumakis (and other references that are similar to Cabot) with Srinivasan to address step 1C-2, which recites “quantizing a phase difference of the at least one overtone relative to the fundamental tone to embed at least one bit of the data to be embedded.”

Patent Owner notes that “Petitioner argues that a [person of ordinary skill in the art] would be motivated to ‘modify Srinivasan to use the fundamental and third harmonic as the coding frequencies f_0 and f_1 .’” PO Resp. 37 (citing Pet. 22). Patent Owner points out that “*Cabot* is the only reference Dr. Scordilis and Petitioner relied upon for using phase shifts between fundamentals and harmonics to encode data” to modify Srinivasan's coding frequencies to include a fundamental and harmonic. *See id.* at 33. Patent Owner argues that “[i]f *Cabot* is not applicable to watermarking, which is what the '961 patent is directed to, Cabot cannot be used in the combinations proposed by Dr. Scordilis and Petitioner and, thus, teaches away per Dr. Scordilis' testimony.” *Id.* Patent Owner also argues that “Dr. Scordilis admitted that none of the references in his declaration have a watermarking algorithm that modifies fundamentals and harmonic frequencies.” *Id.* (citing Ex. 2011, 90:4–20).

The record supports Patent Owner's characterization of Dr Scordilis's testimony. Dr. Scordilis does not rely on any references that “have a

watermarking algorithm that modifies fundamentals and harmonic frequencies specifically.” *See* Ex. 2011, 90:4–8 (testifying such references are “[n]ot in [his] report”). Moreover, Dr. Scordilis testifies that “[t]he value . . . of Cabot’s work is that he points to the fact that even in this very controlled experiment, although phase is detectable in an A/B type of setup under many, many repetitions, *it really opens the venue for exploration that a [person of ordinary skill in the art] would try to capitalize and explore further to develop a watermark.*” *Id.* at 75:16–22 (emphasis added). In summary, Dr. Scordilis testifies that no references (including Cabot) cited in his declaration discuss phase encoding of a harmonic phase relative to a fundamental phase for watermarking, and Cabot merely opens the door so that a person of ordinary skill in the art would “*try to . . . explore further to develop a watermark*” using harmonic phase coding data. *Id.*

Petitioner’s showing primarily relies on Cabot and the testimony of Dr. Scordilis. Based on the record, Petitioner fails to provide a sufficient reason to arrive at the claimed invention and satisfy the burden of showing obviousness. As Patent Owner essentially argues, Cabot (and all references relied upon by Petitioner and Dr. Scordilis) do not pertain to “quantizing a phase difference of the at least one overtone relative to the fundamental tone to embed at least one bit of the data to be embedded” as step 1C-2 requires. *See* PO Resp. 32–33. Petitioner also relies on Kudumakis to modify Srinivasan in asserting that step 1C-2 would have been obvious, but Petitioner’s reliance on Kudumakis is also faulty as explained below. *See* Pet. 22–27 (relying on Ex. 1006 (Cabot), Ex. 1007 (Kudumakis); Ex. 1028 (Risset), Ex. 1031 (Lipshitz), Ex. 1055 (“Cox-SSSW”); Ex. 1020 (“Cox-1995”); Ex. 1021 (“Wu”)).

In summary, as discussed below, Petitioner fails to provide “some articulated reasoning with some rational underpinning” to show that one of ordinary skill in the art would have had a sufficient reason to modify Srinivasan’s frequencies to embed a quantized phase difference between a fundamental and its harmonic into the harmonic as step 1C-2 requires. *See Kahn*, 441 F.3d at 988 (“[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness”)); *In re Fine*, 837 F.2d 1071, 1075 (Fed. Cir. 1988) (“teachings of references can be combined *only* if there is some suggestion or incentive to do so”) (quoting *ACS Hosp. Sys., Inc. v. Montefiore Hosp.*, 732 F.2d 1572, 1577 (Fed. Cir. 1984)).

As noted above, Dr. Scordilis states that Cabot merely “opens the venue for exploration” for an artisan of ordinary skill to “try to . . . explore” watermarks. Ex. 2011, 75:16–22. Dr. Scordilis’s testimony relates to an “obvious to try” rationale, but neither Dr. Scordilis’s testimony, nor Petitioner’s showing, satisfies the conditions to support that rationale. In particular, Dr. Scordilis does not testify, and Petitioner does not show, that the technique of embedding phase difference codes into a harmonic relative to its fundamental was one of “a finite number of identified, predictable solutions” and a “known option[]” for hiding data. *Cf. KSR*, 550 U.S. at 402 (indicating that under an “obvious to try” rationale, “[w]hen there is a design need or market pressure to solve a problem and there are *a finite number of identified, predictable solutions*, a person of ordinary skill in the art has good reason to pursue the *known options* within his or her technical grasp” (emphasis added)).

Not only does Cabot fail to disclose or suggest that its experimental data results translate to inaudible digitized phase codes in general, Cabot does not suggest that its small inaudible phase shifts at low harmonic frequencies translate to relatively inaudible watermarks in Srinivasan's digital phase encoding technique, which employs larger phase shifts in higher frequencies. Cabot's results, summarized in Table II thereof, represent how well subjects in an experiment were able to detect a phase shift of an analog third harmonic frequency (1200 Hz) relative to its fundamental frequency (400 Hz). *See* Ex. 1006, Fig. 2; *supra* § II.D.3 (summarizing Cabot's teachings). Cabot's results show that five subjects were able to detect a phase shift of 22.5° of the third harmonic relative to its fundamental at a corrected rate of 60%. Ex. 1006, 570 (Table II). As Patent Owner argues, Cabot "found that a 30° shift *was still fairly well recognized*" where that phase shift was noticeable 75% of the time (by 15 subjects at a corrected rate). *See* PO Resp 16 (quoting Ex. 1006, 570 (emphasis added)); Ex. 1006, 570 (Table 2). Larger phase shifts varying from 60°–90° were more recognizable—noticeable at a corrected rate of at least 81%. Ex. 1006, 570 (Table 2).

Petitioner also contends that Risset (another reference relied upon by Petitioner that is similar to Cabot) teaches a "remarkable insensitivity to phase . . . for the phase relationship between the harmonics of periodic tones." *See* Reply 7–8 (quoting Ex. 1003 ¶ 122; Ex. 1028, 114). Here again, like Cabot, and all other references relied upon by Petitioner (as mentioned above), Risset does not address or relate to transformation of quantized phase differences between a fundamental and a harmonic in digital phase encoding applications including watermarking. Petitioner fails to show persuasively that an artisan of ordinary skill would have thought

that any alleged phase detection insensitivity described in generic harmonic studies like that of Cabot, Risset, Lipshitz, and any other prior art relied upon by Petitioner, would have been expected by an artisan of ordinary skill to transfer to relative inaudibility with respect to phase-shifted harmonics in phase encoding techniques including watermarking like that of Srinivasan.

Moreover, contrary to Petitioner's conclusory allegations, simply using a harmonic's phase relative to its fundamental in a phase shifting watermarking application like that of Srinivasan does not necessarily result in "an alternative way to achieve low-visibility differential phase encoding." *See* Pet. 22. Rather, the inventors of the '961 patent further developed hidden data technology beyond inserting phase shifts relative to a fundamental at a harmonic. That is, Patent Owner shows that "the audibility/inaudibility of phase shifts in strong harmonically related components in more complex sounds was not a settled issue at the time of filing." PO Resp. 35–36. Patent Owner explains that it "is the inventors' realization through listening experiments that phase shifts of harmonically related tones for the purpose of watermarking applications become audible as clicks (or broadband/white noise)," and the inventors made "proposals for ways to render phase changes inaudible and more suitable for audio watermarking applications." *Id.* 35–36 (citing Ex. 1001, 7:52–8:31; Ex. 2011, 35:12–36:16).

The record supports Patent Owner's arguments. As the parties recognize (PO Resp. 35–36, Reply 9–10), the '961 patent describes "[a]n artifact of the phase manipulation method . . . is a small discontinuity at the frame boundaries *caused by reassignment of the phase of one of the spectral components.*" Ex. 1001, 7:53–56 (emphasis added). The '961 patent states that "[d]epending upon the magnitude of the discontinuity, there may be a

broad spectral component, appearing as white noise.” *Id.* at 7:56–58. To reduce the magnitude of the discontinuity, the ’961 patent describes “three techniques.” *Id.* at 7:59–60. One technique involves “forc[ing] the phase shifts to go to zero at the frame boundaries.” *Id.* at 8:26–27. The ’961 patent also observes that “[a]nother factor is the ratio of power between the selected harmonics,” where, “[i]n some frames, the power ratio is too low to allow robust encoding and those frames will be skipped.” *Id.* at 7:41–43. The ’961 patent reveals that a “power ratio of 1.5 maintains the robustness.” *Id.* at 7:44–45.

Petitioner does not dispute Patent Owner’s showing in this regard. *See* Reply 9–10 (agreeing that “[t]he ’961 patent further proposes three different modifications to its basic phase embedding technique to mitigate those artifacts” (citing Ex. 1001, 7:56–8:24)). This uncontradicted evidence corroborates Dr. Scordilis’s testimony that Cabot does no more than “open[] *the venue for exploration that a [person of ordinary skill] would try to capitalize and explore further to develop a watermark.*” Ex. 2011, 75:16–22 (emphasis added). Petitioner does not address, let alone show, that the line of development that the ’961 patent inventors explored in order to achieve hidden embedded data (i.e., inaudible data) would have been obvious.

Dr. Scordilis agrees that “[t]he ’961 patent . . . proposes three different techniques to allegedly improve the audibility,” which the record supports. *See* Ex. 1003 ¶ 124 (citing Ex. 1001, 7:58–8:31). On the other hand, Dr. Scordilis also testifies that a person of ordinary skill in the art “would have readily recognized Cabot’s described results as demonstrating that phase shifting the third harmonic relative to the fundamental would have provided an acceptable degree of audibility for at least some audio watermarking applications,” which the record does not support. *See id.* ¶ 123. This latter

testimony is conclusory and unsupported because it does not account for Dr. Scordilis's other testimony and evidence showing that merely inserting phase shift data into a harmonic (i.e., without further processing to improve the audibility as disclosed in the '961 patent) results in "an acceptable degree of audibility." *See id.* ¶¶ 123–124. As noted above, Dr. Scordilis later admitted during his deposition that Cabot merely "opens the venue for exploration" into "watermarks." Ex. 2011, 75:16–22. Dr. Scordilis also does not quantify "an acceptable degree audibility for at least some watermarking applications." *See* Ex. 1003 ¶ 123. As explained further below, Dr. Scordilis and Petitioner do not address how Cabot's allegedly inaudible small phase shifts work in combination with the large phase shifts involved in Srinivasan to achieve low audibility watermarks. As also explained further below, Dr. Scordilis's testimony otherwise supports Patent Owner because he generally testifies in several places that watermarks must essentially be inaudible. *See, e.g.*, Ex. 1003 ¶ 108 (testifying that "watermarks . . . must demonstrate several characteristics to be useful and reliable, including being 'perceptually inaudible,' 'statistically undetectable,' 'robust' to signal manipulation and processing including noise, compression, cropping and others" (quoting Ex. 1013, 338)).

In particular, Petitioner fails to point to sufficiently supported evidence in the record to show that an artisan of ordinary skill would have explored Cabot's experimental analog auditory data and applied it to Srinivasan's digital watermarking techniques, which, similar to the '961 patent's data hiding technique, includes sampling and frequency transformation in order to digitize the analog audio signals and create a useful watermark. *See, e.g.*, Ex. 1005, Fig. 2 (transforming audio data into 512 samples and using Fast Fourier Transforms followed by inverse

transformation to arrive at a coded digital output), 11:41–59 (modifying the phase of a frequency component prior to the inverse transformation); Sur-reply 2–3 (arguing that Dr. Scordilis does not testify about “the audibility of phase shifts under any other circumstances/conditions other than those in Cabot, despite Petitioner’s insistence that Cabot’s express teachings can and should be disregarded outside Cabot’s purported ‘pristine laboratory conditions’” (citing Reply 6)).

Stated differently, even though Cabot describes “subtle” albeit “detectable” audibility of minor phase shifts of a third harmonic relative to its fundamental in the analog domain of time varying signals (Ex. 1006, 571), Petitioner fails to show that an artisan of ordinary skill would have expected Cabot’s “subtle” phase shifts to remain subtle in Srinivasan’s digital phase data hiding technique, which as described above involves sampling and other transformations, and which likely adds noise artifacts to the otherwise “subtle” noise according to the ’961 patent. In terms of claim 1, Petitioner fails to show that an artisan of ordinary skill would have considered Cabot’s experimental data as a useful guide for implementing claim 1’s method for “quantizing a phase difference of the at least one overtone relative to the fundamental tone to embed at least one bit of the data to be embedded,” wherein the claimed method involves “dividing the audio signal into a plurality of time frames, in each time frame, a plurality of frequency components.”

Even though the challenged claims do not require watermarking or any of the techniques disclosed in the ’961 patent to mitigate noise artifacts as Petitioner argues (Reply 9–10), the uncontradicted evidence shows that merely picking a third harmonic and shifting its phase will create noise artifacts absent other adjustments, as explained above. Therefore, Petitioner

fails to show sufficiently why an artisan of ordinary skill would have attempted to use the phase relationship between a lower frequency harmonic and its fundamental from Cabot's experimental analog data in place of Srinivasan's digital technique of using the phase relationship between higher frequencies to achieve low-visibility differential phase encoding. *See* Pet. 22. As Patent Owner argues, Petitioner fails to account for Srinivasan's purpose, where Srinivasan states that "[t]he present invention relates to a system and method for adding an *inaudible code* to an audio signal and retrieving that code." (emphasis added)). *See* Ex. 1005, 1:6–8; Sur-reply 4 (arguing that "Petitioner's read of *Srinivasan* would render the stated purpose of the disclosed invention—'a system and method for adding an inaudible code to an audio signal[]'—meaningless" (quoting Ex. 1005, 1:6–8)).

Petitioner's assertion, based on Kudumakis, that "the fundamental frequency and its harmonics change unpredictably" so that "using them to determine where to embed a code '[e]nhance[s] security against malicious attacks' seeking to remove the code" similarly relies on impermissible hindsight. Pet. 24 (citing Ex. 1007, 3:17–18, 5:3–16, 6:1–2; Ex. 1003 ¶ 127). So too does Petitioner's related assertion that "the modification would have resulted in using perceptually more significant lower frequencies less susceptible to common signal distortions and malicious attacks." *Id.* (citing Ex. 1003 ¶ 128; Ex. 1008, 331; Ex. 1018 (the '604 patent), 4:32–37; Ex. 1020; Ex. 1055; Ex. 1008)). These assertions rely on impermissible hindsight because Petitioner does not contend, and the record does not show, that any of the cited references, including Kudumakis, discuss embedding phase data into a harmonic based on the harmonic's phase relationship to the fundamental, as indicated above and as Dr. Scordilis candidly admits. *See*

Pet. 24; Ex. 2011, 82:20–22 (testifying it “is correct” in answer to Patent Owner’s assertion that “Kudumakis leaves the fundamentals and harmonics unaltered”), 90:4–8 (testifying that there are no references he relies upon in his “report” (i.e., declaration) that describe “a watermarking algorithm that modifies fundamentals and harmonic frequencies specifically”).

Further as to Kudumakis, as Patent Owner argues, Kudumakis “pertains to manipulating the weaker masked spectral components surrounding stronger harmonics, not the manipulation of the harmonics themselves.” Sur-reply 11. In other words, as Patent Owner also argues, Kudumakis discloses using notch filters at the *upper or lower edges* of harmonics, but does not teach altering the phase of a harmonic of the original audio signal. *See id.* at 10–11 (citing Ex. 1007, 4:30–31).

Nevertheless, Petitioner argues that “Kudumakis . . . provided further motivation for using locations of harmonic and fundamentals to enhance security against malicious attacks since those locations changed unpredictably throughout the audio signal.” Reply 12. Contrary to the premise of this line of argument, however, and as the record shows as described above, Kudumakis does not disclose or suggest employing a phase shift at a harmonic or any frequency in the original audio signal. That is, as Dr. Scordilis testifies, Kudumakis does not disclose “an adjustment of the phase *of the host audio*” as step 1C-2 requires. *See* Ex. 2011, 84:14–15 (emphasis added). Rather, Kudumakis teaches adding *an audio signal frequency with a phase shift code into the original signal* using “notch filers . . . in the upper or lower *edges* of these harmonics.” *See* Ex. 1007, 4:30–31; *see also* Sur-reply 11 (similar argument regarding edges of harmonics). Dr. Scordilis agrees. *See* Ex. 2011, 84:9–11 (testifying that Kudumakis

suggests “phase information,” “[b]ut . . . it would be *the signal that is added to the host audio rather than the host audio itself*” (emphasis added)).

Moreover, other frequencies in sound or voice naturally vary randomly in amplitude and phase to produce distinct sounds or voices so that picking and choosing a harmonic’s phase relationship to its fundamental to quantify for that alleged benefit amounts to impermissible hindsight. *See* PO Resp. 5 (“The presence of additional frequency components allows one to distinguish between sounds of the same pitch and loudness produced by two different instruments or voices.” (citing Ex. 2002, 202)). In summary, Kudumakis employs notch frequencies at other than the harmonic next to “[t]he band with the maximum energy content” to provide “a degree of randomness or unpredictability” and to provide “masking.” *See* Ex. 1006, 3:7–8, 17–18, 29–30. Therefore, contrary to Petitioner’s stated reliance on Kudumakis, Kudumakis teaches that increased security and robustness occurs by coding added lower frequency components that are adjacent to harmonics. *See id.* Accordingly, Petitioner’s reliance on Kudumakis for its masking and randomness benefits to allegedly suggest embedding a phase difference into a harmonic amounts to impermissible hindsight, because Kudumakis does not discuss, teach, or suggest adding a phase code to a harmonic.

In an attempt to support its showing, Petitioner also cites Tilki (discussed further with respect to another ground below), which, like Srinivasan, generally relates to embedding phases into frequencies. *See* Pet. 24 (citing Ex. 1008, 331); *infra* § II.G.1 (summarizing Tilki). In particular, Petitioner cites Tilki as teaching that “lower frequencies (below say 2 kHz) . . . typically contain the most energy in common audio signals.” *Id.* (quoting Ex. 1008, 331).

However, this reliance on Tilki further implicates hindsight reliance, because like Kudumakis, Tilki does not mention lower harmonic frequencies or phases relative to the fundamental. Rather, Tilki shows that artisans of ordinary skill knew that *lower frequencies in general* (i.e., not lower harmonics specifically) help to enhance security against malicious attacks and provide for robustness, but Tilki's solution *involves not encoding the lower frequencies*, as Patent Owner argues. PO Resp. 64 ("Petitioner's assertion contradicts Tilki's directive that "the lower frequencies (below say 2 kHz), which typically contain the most energy in common audio signals, are left untouched." (quoting Ex. 1008, 331)). As Patent Owner also argues, Tilki explains that "stronger [unmodified] low frequency components help to mask the changes made in the higher frequency region." *Id.* (quoting Ex. 1008, 331). Therefore, Petitioner fails to provide a sufficient non-hindsight reason to focus on harmonics relative to a fundamental for phase embedding techniques in digital applications. *See* Pet. 23–26.

Similar remarks apply to Petitioner's rationale that "narrowband voice applications having only vocalized speech (e.g., telephony and videoconferencing applications that were achieving prominence in the early 2000s, and other spoken word recordings) benefitted from watermarking." Pet. 26. Petitioner explains that "[c]hoosing the fundamental and third harmonic as the coding frequencies would have expanded the useful applications of Srinivasan's watermarking system to narrowband voice applications." *Id.* at 27 (citing Ex. 1003 ¶ 132). Petitioner explains further that "such audio content commonly has frequencies up to about only 4 kHz," and "Srinivasan's embedding band from 4.8 kHz–6 kHz would not work with such narrowband voice applications." *Id.* (citing Ex. 1003 ¶ 132). Again, even if Petitioner's arguments may show a sufficient reason for

modifying Srinivasan to use lower frequencies for encoding phase shifts in general, Petitioner points to nothing of record to sufficiently suggest using harmonic phase shifts relative to a fundamental to embed phase codes in Srinivasan's watermarking system. *See id.* at 26–27.

Turning to the combination based on Cabot, as Patent Owner also explains, Cabot's data is not helpful to Petitioner to suggest modifying Srinivasan's system. For example, as Patent Owner shows, “[f]or a phase shift of 22.5° (i.e., $\pi/8$), the detection rate reported was 83%, and the false alarm rate was 58%. . . . And 58% of the time, the listeners thought they could hear a difference when there was none.” PO Resp. 25 (citing Ex. 1006, Table II). At cited Table II, as noted above, Cabot reveals that for a phase shift of 22.5° (i.e., $\pi/8$), listeners detected the phase shift at a rate of 60% (corrected rate).

Petitioner simply does not address what level of audibility an artisan of ordinary skill would have interpreted with respect to applying Cabot's phase shift of 22.5° (i.e., $\pi/8$) or any other phase shift specified in Cabot, *in Srinivasan's scheme*. *See* Pet. 22–36. Petitioner does not address how much noise any phase shift in Cabot would create in Srinivasan's modified scheme. *See id.* Therefore, without quantifying the phase shift and its added noise and without relating it to either Cabot's data or Srinivasan's scheme, Petitioner fails to support its conclusory allegation that a person of ordinary skill in the art “would have understood that using the third harmonic and fundamental as Srinivasan's code frequencies f_1 and f_0 . . . would have provided the *low visibility* Srinivasan desires, particularly under real-world conditions where the listener is unaware of the phase shift and the audio signal has other sounds masking the phase shift.” Pet. 23 (citing Ex. 1003 ¶¶ 121–124).

Petitioner acknowledges that Srinivasan employs “the phase angle . . . ϕ_M of the modifiable spectral component” so that it falls into “one of two phase neighborhoods (one being $\pm 45^\circ$ ($\pm \pi/4$ radians) of reference phase ϕ_R and another being $\pm 45^\circ$ of being 180° (π radians) out of phase with ϕ_R) to represent, e.g., a ‘0’ and ‘1,’ respectively.” Pet. 34. But Petitioner does not specify the actual resulting size of Srinivasan’s modified phase shift in a harmonic based on any phase data in Cabot. *See id.* at 22–36. That is, Petitioner does not specify what level of Cabot’s various phase shifts would apply to a hypothetical harmonic in Srinivasan’s scheme. *See id.* Therefore, Petitioner fails to show that an artisan of ordinary skill would have had a sufficient reason to modify Srinivasan’s watermarking technique based on Cabot and Kudumakis or the other cited references, because Petitioner fails to address whether Srinivasan’s larger phase shifts apply at lower frequency harmonics to produce a suitable watermark or whether an artisan of ordinary skill would have considered using Srinivasan’s system to produce suitable watermarks with smaller phase shifts of 22.5° (i.e., $\pi/8$) at lower frequency harmonics.

Moreover, Srinivasan does not employ small phase shifts of 22.5° (i.e., $\pi/8$). Rather, as discussed above, Srinivasan discloses phase shifts that may change as much as at least 45° (i.e., $\pi/4$), because as Petitioner contends, Srinivasan’s system modifies the embedded phase of a frequency component so that it falls in a range of plus or minus $\pi/4$ (i.e., 45°), wherein Srinivasan codes the shift as a 1 or 0. *See Ex. 1005, 11:40–56; Pet. 23.*⁷

⁷ For example, if the harmonic or modifiable frequency component is 90° out of phase with the fundamental or reference frequency in the original audio signal, Srinivasan’s system would shift it 45° so that it falls within a

As summarized above, Petitioner also argues that person of ordinary skill in the art “would have understood selecting the fundamental and third harmonic (typically below 4 kHz as in Cabot) would have improved the robustness of Srinivasan’s watermarking system by placing the watermark in perceptually significant frequencies less susceptible to intentional or unintentional destruction.” Pet. 25 (citing Ex. 1003 ¶ 131). However, as explained above, Cabot’s experimental analog results (and any other relied-upon reference) does not suggest using phase codes for watermarking or similar data hiding applications, and Kudumakis, which relates to watermarking, does not suggest embedding data into harmonics as “perceptually significant frequencies.” *See id.*

Moreover, although Petitioner argues that Cabot’s data would be less audible “under real-world conditions,” this argument misses the mark. *See* Pet. 23; Reply 6–7. As indicated above, Petitioner simply does not explain how perceptible a 45° phase shift of a lower frequency harmonic relative to a fundamental would be in Srinivasan’s modified system. As Patent Owner argues, according to Cabot (Ex. 1006, Table II), a 22.5° phase shift and a 30° phase shift produce an audible perception 60% and 75% of the time, respectively. *See* PO Resp. 25 (citing Ex. 1006, Table II), 60 (same). Yet, as explained above, Srinivasan’s method includes phase shifts as large as 45°. *See* Ex. 1005, 11:41–58; *supra* note 7. Petitioner does not account for how modifying Srinivasan’s system for use at lower frequencies with phase shift codes up to 45° produces a suitable watermark in place of Srinivasan’s

45° window of 0° for a binary 1, or shift it the other way to 135° so that it falls within a 45° window of 180° for a binary 0. *See* Ex. 1005, 11:41–58.

45° phase shift codes at higher frequencies. *See* PO Resp. 25, 60; Ex. 1006, Table II; Ex. 1005, 11:41–58.

As Patent Owner also argues, Srinivasan’s system encodes phase data in the 4.8–6 KHz range, which is higher than most third harmonics (*see, e.g.*, Ex. 1006, 568 (third-harmonic 1200 KHz)), “specifically to ‘exploit the masking properties of the human ear’” at higher frequencies to render phase changes inaudible. *See* PO Resp. 38 (quoting Ex. 2011, 77:13–79:14). Therefore, as Patent Owner argues, implementing Petitioner’s proposed modification to include lower harmonic phase changes below Srinivasan’s 4.8–6 KHz range would result in losing Srinivasan’s masking advantage based on the perception of the human ear exploited by Srinivasan to help hide the data by encoding higher frequencies. *See id.* (arguing that “[c]hanging the frequency range would impact the masking properties upon which Srinivasan is founded”), *id.* at 40 (“To use a fundamental and third harmonic, the frequency range would have to be lowered, bringing it to within the more sensitive range of human hearing, which contradicts what Srinivasan teaches.”). Importantly, as noted above and as Patent Owner argues, Srinivasan’s “invention relates to a system and method for adding *an inaudible code* to an audio signal.” *See* Ex. 1005, 1:37–43 (emphasis added).

Nevertheless, Petitioner contends that implementing Srinivasan’s method at lower frequencies would have produced trade-off advantages based on stronger masking signals in the lower frequency range to mask the harmonics, robustness due to the inability to filter out the strong signal components without destroying the sound, and use in lower frequency voice systems not possible in Srinivasan’s higher frequency system. *See* Reply 2–3. But Petitioner’s arguments incorrectly assume that the modification to

Srinivasan’s system, which Srinivasan shows may involve large audible phase shifts of up to 45° (audible according to Cabot’s data and the noise artifacts as described in the ’961 patent as outlined above) would amount to using a known technique to obtain a suitable option such that a person of ordinary skill would have entertained the asserted trade-offs as a reason to implement the proposed modification. *See* Pet. 22–27; *cf. Intel Corp. v. PACT XPP Schweiz AG*, 61 F.4th 1373, 1381 (Fed. Cir. 2023) (“If there’s a known technique to address a known problem using ‘prior art elements according to their established functions,’ then there is a motivation to combine . . . [and] ‘[i]t’s not necessary to show that a combination is the best option, only that it be a suitable option.’”).

That is, Petitioner fails to show that exploiting the phase difference between a harmonic and its fundamental was a “known technique” to obtain a “suitable option” for Srinivasan’s watermark such that considering trade-offs would have been feasible. *Cf. Intel. Corp.*, 61 F.4th at 1381 (indicating that “a suitable option” using a “known technique” may provide “motivation to combine”). Rather, as noted above, Dr. Scordilis testifies that Cabot merely “opens the venue for exploration that a [person of ordinary skill in the art] would try to capitalize and explore further to develop a watermark.” Ex. 2011, 75:16–22.

Therefore, Petitioner fails to show persuasively that an artisan of ordinary skill would have entertained the trade-offs. Rather, as explained above, Petitioner assumes that its asserted trade-off rationale includes replacing Srinivasan’s *inaudible watermark* with a *suitable* option involving a *relatively inaudible watermark*. For example, Petitioner argues that the modification based on Cabot’s teachings “would have produced watermarks *that were not audible in any practical scenario*, and would have produced

only *subtle changes* for some larger phase shifts detectable in a laboratory setting by trained listeners.” Reply 8 (emphasis added). As another example, Petitioner argues that “[t]he combination also improves robustness by *embedding watermarks* in perceptually more significant lower frequencies that are less susceptible to common signal distortions and malicious attacks.” Reply 2 (emphasis added). Similarly, Petitioner contends that “[p]lacing the watermark in perceptually less-significant regions (like Srinivasan did) leaves it susceptible to low-pass filtering that would remove the code by only retaining lower frequencies of the signal perceptible to the listener.” Pet. 25 (emphasis added).

That is, for all of its reasons to modify Srinivasan, Petitioner contends that its proposed modification results in a suitable low frequency harmonic watermark as a replacement for Srinivasan’s inaudible high frequency watermark (although the challenged claims do not require a watermark).⁸ However, for the reasons above, Petitioner does not show that an artisan of ordinary skill would have considered that the proposed modified low harmonic frequency watermark would be sufficiently inaudible so that an artisan of ordinary skill would have considered modifying Srinivasan’s watermark to even consider the trade-offs as feasible.

Regarding watermark inaudibility, as Patent Owner notes, Dr. Scordilis’s describes watermark technology as follows:

Watermark technology is geared towards *not being detectable by anybody*, any listener, whether it’s a casual listener or a non[-]casual listener or even an acoustics expert. It would

⁸ The specification states that “in addition to steganography and watermarking, any suitable use for *hidden data falls within the present invention*.” Ex. 1001, 8:66–67 (emphasis added).

be desirable that even an acoustics expert would *not detect audibly the presence of the watermark*. That's a very – that's something that is extremely desirable for any watermarking method.

Sur-reply 9 (emphasis added) (quoting Ex. 2011, 76:5–12). Patent Owner also notes that Dr. Scordilis testifies that “you don't want to make it audible. You want to make it detectable to the system that will detect it and extract it and do whatever it needs to do with it, *but certainly you don't want to make it detectable by anybody else or anybody, period.*” *Id.* (quoting Ex. 2011, 59:5–60:19) (emphasis added). In context, at the cited passage, Dr. Scordilis testifies that “[o]f course, *the purpose of inserting a watermark is so that you can detect it by -- of course, you cannot -- you do not detect it by listening. You detect it by technical analysis.*” Ex. 2011, 59:13–17 (emphasis added).

In other words, the record shows that that the purpose of a watermark is to hide data, which is similar to Srinivasan's purpose of providing an “inaudible code.” Ex. 1005, 1:6; *see also supra* note 8 (noting the '961 patent specification states that “in addition to steganography and watermarking, any suitable use for *hidden data* falls within the present invention” (Ex. 1001, 8:66–67) (emphasis added)); Sur-reply 5 (“The specification further describes that “[t]he present invention has the advantage over existing Verance algorithms of being **undetectable** and robust to blind signal processing attacks and of being uniquely robust to digital to analog conversion processing.” (Quoting Ex. 1001, 4:31–34); “The entire purpose of the method for embedding data in audio signals as disclosed in the phase encoding steps of the Challenged Claims is to create a resulting audio signal in which the embedded data is *hidden* (i.e., inaudible).” (Citing Ex. 1001, 1:1–2, 1:20–22, 4:31–34)).

On the other hand, Petitioner correctly observes that “the challenged claims do not recite any limitations that impose a particular audibility requirement of the embedded watermarks.” Reply 8. Petitioner also observes that artisans of ordinary skill would have known that “there are tradeoffs between audibility (visibility), robustness and data capacity” and between other metrics (security, use at lower frequency ranges). *See id.* at 9 (citing Ex. 1001, 2:3–15; Ex. 1003 ¶¶ 103–116).

Nevertheless, as outlined above, Petitioner’s rationale ultimately relies on replacing Srinivasan inaudible data with a suitable watermark option. As also discussed above, in summary, Dr. Scordilis testifies that the purpose of a watermark is “you do not detect it by listening.” Ex. 2011, 59:13–17. Similarly, Dr. Scordilis testifies that artisans of ordinary skill knew that “*watermarks . . . must demonstrate several characteristics to be useful and reliable, including being ‘perceptually inaudible,’ ‘statistically undetectable,’ ‘robust’ to signal manipulation and processing including noise, compression, cropping and others.*” *See* Ex. 1003 ¶ 108 (quoting Ex. 1013, 338) (emphasis added).

For the reasons discussed above, Petitioner does not show that the resulting watermark based on modifying Srinivasan’s data hiding technique is relatively undetectable as a suitable watermark option such that an artisan of ordinary skill would even consider Petitioner’s stated trade-offs, namely trading off a relatively inaudible watermark for robustness, security, and suitability for lower voice channel frequencies. As Patent Owner argues, “using a fundamental and third harmonic as Srinivasan’s code frequencies would contradict the express purpose of Srinivasan.” Sur-reply 6; *see also* PO Resp. 36–41.

Nevertheless, Petitioner contends that “[e]ven if . . . the proposed combination produced some *subtle audible artifacts* (an assertion that is not correct, and is not corroborated by any supporting evidence), it would not undermine a finding of obviousness.” Reply 10 (emphasis added). According to Petitioner, “any purported *subtle increase in audibility* in the proposed system compared to Srinivasan would have been counterbalanced by improvements gained in security and robustness, as well as expanded use in low-band audio applications.” *Id.* at 11 (emphasis added). Contrary to this line of argument, for the reasons discussed above, Petitioner fails to show that the artifacts in Srinivasan’s modified system would be “subtle,” especially where Petitioner fails to address the size of the modified phase shift or the resulting noise artifacts resulting from Srinivasan’s similar method to that of the ’961 patent disclosure. Stated differently, as found above, even if Cabot’s data shows subtle audibility at relatively low phase shifts for analog signals, Petitioner fails to show that an artisan of ordinary skill would have considered any subtle audibility with respect to Cabot’s analog data to remain subtle after the digital processing of large phase shifts involved in Srinivasan’s digital sampling techniques that produce inaudible phase codes involved in watermarking. *See* Sur-reply 2–3 (arguing that Dr. Scordilis does not testify about “the audibility of phase shifts under any other circumstances/conditions other than those in Cabot, despite Petitioner’s insistence that Cabot’s express teachings can and should be disregarded outside Cabot’s purported ‘pristine laboratory conditions’” (citing Reply 6)). And Petitioner fails to account for the central purpose of Srinivasan’s system. *See* Ex. 1005, 1:37–43 (Srinivasan’s “invention relates to a system and method for adding an *inaudible* code to an audio signal”).

On the other hand, Petitioner is correct that “[e]vidence concerning whether the prior art teaches away from a given invention must relate to and be commensurate in scope with the ultimate claims at issue.” Reply 10 (quoting *Idemitsu Kosan Co., Ltd., v. SFC Co., Ltd.*, 870 F.3d 1376, 1381 (Fed. Cir. 2017) (“Idemitsu’s teaching away argument is of questionable relevance anyway. Evidence concerning whether the prior art teaches away from a given invention must relate to and be commensurate in scope with the ultimate claims at issue.”)).

However, there is no need to reach the issue of teaching away here. For the reasons stated above, Petitioner’s rationale is not persuasive because Petitioner fails to show that Cabot, Kudumakis, and the other relied-upon references would have suggested modifying Srinivasan to embed data in the phase of a harmonic or overtone relative to the phase of a fundamental. Petitioner also fails to show that its proposed modification relies on a known technique to produce a suitable replacement watermark with relative inaudibility according to Srinivasan’s scheme for producing inaudible codes, rendering Petitioner’s trade-off rationales, which depend on a suitable watermark in the first instance, not feasible. *See Winner Int’l Royalty Corp. v. Wang*, 202 F.3d 1340, 1349 (Fed. Cir. 2000) (“Trade-offs often concern what is feasible, not what is, on balance, *desirable*. Motivation to combine requires the latter.” (emphasis added)).

In *Winner*, the court analyzed a district court’s reversal of the Board’s finding in an interference trial that there was sufficient motivation to combine four references at issue. *Winner*, 202 F.3d at 1349. The *Winner* court affirmed the district court, reasoning, in part, as follows:

First, although there was conflicting evidence before the district court on whether one would see the trade-off between

using a dead-bolt and using a ratcheting mechanism and conclude that the more secure dead-bolt should be replaced with the more convenient ratcheting mechanism, the district court did not clearly err in finding that one of ordinary skill in the art would not have reasonably elected trading the benefit of security for that of convenience. Trade-offs often concern what is feasible, not what is, on balance, desirable. Motivation to combine requires the latter.

Winner, 202 F.3d at 1349. Here, analogous to the situation in *Winner*, “one of ordinary skill in the art would not have reasonably elected trading the benefit” of relative inaudibility in Srinivasan’s data hiding scheme for that of robustness, security, or a limited low frequency speech channel. *See id.* Like trading away the purpose of *Winner*’s dead-bolt, security, trading away the purpose of Srinivasan’s data hiding technique, relative inaudibility of the hidden data, would not have been feasible, because here, Srinivasan’s purpose is to hide embedded phase data, and Petitioner fails to show a sufficient reason to embed relative phase data into harmonics and also fails to show that the resulting noise in Srinivasan’s modified watermarks at lower harmonic frequencies would have been expected to be relatively inaudible.

g. Summary as to Obviousness of Claim 1 under Srinivasan, Kudumakis, and Cabot

Based on the foregoing analysis and discussion, we determine that Petitioner fails to show by a preponderance of evidence that claim 1 would have been obvious over the combined teachings of Srinivasan, Kudumakis, and Cabot.

2. Claims 2–10

Petitioner contends that the subject matter of independent claims 4, 6, and 9, and dependent claims 2, 3, 5, 7, 8, and 10 would have been obvious

over Srinivasan, Kudumakis, and Cabot. Pet. 36–50. Petitioner’s showing for the independent claims tracks its showing for claim 1. *See id.* Patent Owner relies on its arguments with respect to claim 1. *See* PO Resp. 36–47.

Petitioner’s showing for these claims is deficient for the same reasons as outlined above with respect to claim 1 and alleged obviousness over the combined teachings of Srinivasan, Kudumakis, and Cabot.

F. Obviousness Ground 2: Srinivasan, Cabot, Kudumakis, and Hobson

Petitioner contends that the subject matter of claims 2, 3, 5, 7, 8, and 10 would have been obvious over Srinivasan, Cabot, Kudumakis, and Hobson. Pet. 50–52. Petitioner relies on Hobson in the event that “the Board disagree[s] that Kudumakis teaches encoding data at multiple frequencies in a time frame as relied on in Ground 1.” *Id.* at 50–51.

Patent Owner disputes Petitioner’s showing for the same reasons it argues that Ground 1 is deficient. *See* PO Resp. 47. Patent Owner relies on other reasons that we decline to reach given our holding.

Petitioner’s showing for these claims is deficient for the same reasons as outlined above with respect to claim 1 and alleged obviousness over the combined teachings of Srinivasan, Kudumakis, and Cabot.

G. Obviousness Ground 3: Kudumakis, Cabot, and Tilki

Petitioner contends that the subject matter of claims 1–10 would have been obvious over Tilki, Kudumakis, and Cabot. Pet. 52–64. Patent Owner argues that Petitioner’s showing is insufficient. PO Resp. 56–67.

1. Tilki (Ex. 1008)

Tilki relates to “a method of encoding an auxiliary channel onto a digital audio signal such that it is imperceptible to human observers.”

Ex. 1008, 331 (Abstract). Tilki explains that “[t]he ability to add extra hidden information to a signal could be useful in many applications,” including modifying audio compact discs to “to contain artist information, song titles, song lyrics, karaoke information, still images, and perhaps even video clips.” *Id.* at 331 (Introduction).

In Tilki’s method, “[a] differential phase of $\pi/8$ [(22.5°)] was used to modify the phase of every fourth FFT bin above 2 kHz in 2048 point FFT blocks.” Ex. 1008, 332 (Simulation Results).

2. Independent Claim 1

a. *Step 1PRE*: “A method for embedding data in an audio signal, the method comprising:”

Petitioner contends that it would have been obvious to employ to employ Kudumakis’s and Cabot’s fundamental and harmonics in Tilki’s system, thereby embedding data in an audio signal.⁹ *See* Pet. 57–65.

⁹ In the Institution Decision, we stated that “on this preliminary record,” that “Petitioner implicitly advances either of Tilki or Kudumakis as the “primary” reference, with teachings from the other “secondary” reference modifying the “primary” reference. *See* Pet. 57–58, 74–76 (addressing claims 9–10); [*In re*] *Mouttet*, 686 F.3d [1322, 1333 Fed. Cir. 2012] (“[W]here the relevant factual inquiries underlying an obviousness determination are otherwise clear, characterization by the examiner of prior art as ‘primary’ and ‘secondary’ is merely a matter of presentation with no legal significance.”) (citing *In re Bush*, [] 296 F.2d 491, 496 (1961)); *In re Krammes*, [] 314 F.2d 813, 816–17 (1963)).

Inst. Dec. 47 n.13. Neither party addresses whether Tilki or Kudumakis is the “primary reference.” Considering the full record, we determine that Petitioner relies on Tilki as the primary reference, modified to include embedding a phase shift relative to a fundamental phase into the third harmonic, based on alleged teachings in Kudumakis and Cabot. *See* Pet. 63–65 (stating for steps 1C and 1C-2 that “[t]he Kudumakis/Tilki/Cabot Combination uses Tilki’s differential phase encoding,” and for step 1C-2

Petitioner generally relies on the combined teachings of Tilki, Kudumakis, and Cabot to suggest modifying Tilki's phase shifting technique to use the fundamental's harmonic tones for phase encoding as allegedly suggested by Kudumakis and Cabot. *See id.* at 57–62. Petitioner argues that it would have been obvious “to combine Kudumakis's teaching of using the fundamental and overtones to determine where to embed a watermark to enhance security, with Tilki's differential phase encoding.” *Id.* at 57.

b. Step 1A: “(a) dividing the audio signal into a plurality of time frames and, in each time frame, a plurality of frequency components”

Petitioner contends that Tilki and Kudumakis each disclose this step. Pet. 62–63. According to Petitioner, “Kudumakis's ‘frames’ are time frames” and “each is ‘transform[ed] into the frequency domain’ which is dividing the audio signal into frequency components.” Pet. 63 (quoting Ex. 1007, 3:11–12). Petitioner also contends that Tilki discloses a “‘modified signal block’ and ‘subsequent signal blocks’ of [an] audio signal which are time frames” and “each is divided into ‘FFT bin[s]’ which are frequency components.” *Id.* (quoting Ex. 1008, 331–32; citing Ex. 1003 ¶ 208).

c. Step 1B: “(b) in each of at least some of the plurality of time frames, selecting at least two of the plurality of frequency components; and”

Petitioner relies on Kudumakis's fundamental and harmonic tones as the frequency components in the combined system of “[t]he ‘Kudumakis/Tilki/Cabot Combination,’” based on alleged suggestions in Cabot and Tilki. *See* Pet. 57 (arguing that Tilki teaches that “that humans are relatively insensitive to certain types of phase distortions” (quoting

that “[i]n the Kudumakis/Tilki/Cabot Combination, the selection of Tilki's reference and signal frequency bins is modified, based on Kudumakis and Cabot”).

Ex. 1008, 332)), 60 (“Cabot teaches differential phase shifts of the third harmonic relative to the fundamental are inaudible even under extreme testing conditions” (citing Pet. § VI.B; Ex. 1003 ¶ 200)), 63 (relying on the “Kudumakis/Tilki/Cabot Combination” to teach employing “the fundamental and the third harmonic (which are ‘at least two of the plurality of frequency components’) as the reference and signal bins based on Kudumakis and Cabot” (citing Pet. § VIII.B.3; Ex. 1003 ¶ 209)).

d. Step 1C: “altering a phase of at least one of the plurality of frequency components in accordance with the data to be embedded, wherein”

Petitioner relies on the combined teachings of Tilki, Kudumakis, and Cabot to suggest implementing Tilki’s phase shifting technique with fundamental and harmonic tones as allegedly suggested by Kudumakis and Cabot. *See* Pet. 57–62 (providing reasons for the combination and resulting system, including that phase shifting of harmonics is relatively imperceptible), 63–64. Petitioner contends that “Tilki’s differential phase encoding . . . alters the phase of the signal bin (corresponding to the third harmonic [of Kudumakis] which is ‘one of the plurality of frequency components’) in accordance with the data to be embedded such that the phase difference between the signal and reference bins is either $+\phi$ or $-\phi$ (where ϕ can be $\pi/8$) to embed a digital one or zero, which are data.” *Id.* (citing Ex. 1008, 331–32; Ex. 1003 ¶ 210).

e. Step 1C-1: “wherein . . . step b comprises selecting a fundamental tone and at least one overtone” and Step 1C-2: “and step (c) comprises quantizing a phase difference of the at least one overtone relative to the fundamental tone to embed at least one bit of the data to be embedded.”

Regarding step 1C-1, indicated above, Petitioner relies on implementing the fundamental tone and harmonic tones of Kudumakis for

phase shifting in Tilki's reference and signal frequency bins. *See* Pet. 63.

Petitioner states as follows:

In the Kudumakis/Tilki/Cabot Combination, the selection of Tilki's reference and signal frequency bins is modified, based on Kudumakis and Cabot, to select the fundamental and the third harmonic (which is an overtone) to achieve a robust low-visibility watermarking system As Kudumakis explains, numerous known techniques (e.g., FFT) could be used "to find both the fundamental and its harmonics." [Ex. 1007] 4:26–30; [Ex. 1003] ¶ 211.

Pet. 64.

Regarding step 1C-2, Petitioner relies on Tilki's differential phase encoding. Pet. 64–65. According to Petitioner,

[t]he Kudumakis/Tilki/Cabot Combination uses Tilki's differential phase encoding that quantizes the phase difference between the signal bin (the third harmonic [of Kudumakis] which is "at least one overtone") and the reference bin (fundamental tone) to embed at least one bit of data by adjusting the phase of the signal bin so that the phase difference is one of two values, either $+\phi$ (clockwise rotation) which represents a data bit of "1" or $-\phi$ (counterclockwise rotation) which represents a data bit of "0."

Id. (citing Pet. § VIII.B; Ex. 1008, 331–332 (Encoding); Ex. 1003 ¶ 212 (setting the phase difference to one of two values is quantization)).

g. Reasons to Combine Analysis

As summarized above, Petitioner advances several reasons to combine the teachings of Kudumakis and Cabot with Tilki to address limitation 1C-2, which recites "quantizing a phase difference of the at least one overtone relative to the fundamental tone to embed at least one bit of the data to be embedded." *See* Pet. 57–62. Many of the reasons overlap with the reasons advanced in connection with Ground 1, with Petitioner citing to Tilki instead

of Srinivasan. We incorporate our analysis and findings with respect to Ground 1 above to the extent they overlap. *See supra* § II.D.1–3, E.1.f.

Initially, Petitioner alleges that Tilki’s phase encoding is “a suitable alternative to Kudumakis’s notch encoding for embedding a watermark for at least four reasons.” Pet. 57. First, Petitioner contends that Tilki’s differential phase encoding provides embedded data advantageous for watermarks because it uses “fast algorithms which allow real time processing.” *Id.* (quoting Ex. 1008, Abstract). Second, Petitioner contends that “phase encoding avoids the complexity of removing a portion of the audio signal that notch encoding requires.” *Id.* at 58 (citing Ex. 1003 ¶ 191). Third, Petitioner contends that “notch encoding and phase encoding were known alternatives for encoding an audio signal.” *Id.* (citing Ex. 1003 ¶ 192; Ex. 1005, 1:44–58, 11:17–59). Fourth, Petitioner contends that Tilki bases its technique on the “well-known [principle] that humans are relatively insensitive to certain types of phase distortions,” rendering it useful to “*imperceptibly embed a watermark.*” *Id.* (emphasis added) (alteration in original) (quoting Ex. 1008, 332) (citing Ex. 1003 ¶ 193).

The first three reasons are not germane to whether it would have been obvious to modify Tilki’s phase encoding scheme, because Petitioner employs Tilki as the base reference. *See supra* note 9. That is, Petitioner asserts at the outset that “[t]he system that would have resulted from using Tilki’s differential phase encoding/decoding to embed/retrieve a watermark using the fundamental and the third harmonic as the reference and signal bins (as motivated by Kudumakis and Cabot) is referred to herein as ‘the Kudumakis/Tilki/Cabot Combination.’” Pet. 62. As summarized above, Petitioner then analyzes the claim 1 steps based on modifying Tilki’s phase encoding system to include harmonics. *See id.* at 62–65.

Therefore, first, whether Tilki's differential phase encoding provides embedded data advantageous for watermarks because it uses "fast algorithms which allow real time processing" is irrelevant as to whether a skilled artisan would have sought the teachings of Kudumakis and Cabot because, as indicated above, Petitioner modifies Tilki's phase shifting at specific frequency bins to include phase encoding of a harmonic frequency relative to the phase of its fundamental frequency. *See* Pet. 56. Second, Petitioner's contention that "phase encoding avoids the complexity of removing a portion of the audio signal that notch encoding requires" is also irrelevant for the same reason. *See id.* at 58. Third, Petitioner's contention that Kudumakis's "notch encoding and [Tilki's] phase encoding were known alternatives for encoding an audio signal" is also irrelevant for the same reason. *See id.* Fourth, Petitioner's contentions that Tilki's technique relies on the "well-known [principle] that humans are relatively insensitive to certain types of phase distortions" and Tilki's technique "could imperceptibly embed a watermark" cuts against Petitioner's showing because, for the reasons discussed below, Petitioner fails to show that Tilki's modified system as proposed by Petitioner would have resulted in relatively imperceptible phase shifts of a watermark. *See id.*

To the extent Petitioner relies on Kudumakis as the base reference in the Petition for claim 1 (*but see supra* note 9), the Petition's showing fails because as determined above, the Petition relies on Tilki as the base reference for steps 1PRE, 1B, 1C, 1C-1, or 1C-2. Moreover, the Petition does not allege that Kudumakis discloses steps 1PRE, 1B, 1C, 1C-1, or 1C-2, and the Petition does not provide any reason to modify Kudumakis's system to reach steps 1PRE, 1B, 1C, 1C-1, or 1C-2. *See* Pet. 62–65; *supra* note 9.

Petitioner also argues that a person of ordinary skill “had the above [four] reasons to implement a watermark . . . scheme [to implement] Tilki’s differential phase encoding/decoding with frequencies selected based on the fundamental and harmonics for the security reasons taught by Kudumakis.” Pet. 58 (citing Ex. 1003 ¶ 194). But as explained above, three of Petitioner’s four reasons as outlined above have nothing to do with modifying Tilki’s phase technique to include use of a fundamental frequency and harmonic frequencies—they only relate to using Tilki’s phase encoding scheme in general as discussed above. The record does not support the fourth reason as explained further below.

In any event, according to Petitioner, Kudumakis teaches that a “*watermark should be inaudible* and robust against ‘malicious attacks.’” Pet. 58 (emphasis added) (quoting Ex. 1007, 5:1–5; citing Ex. 1003 ¶ 195; Pet. § VI.D). Petitioner explains that “Kudumakis teaches the fundamental and its harmonics were advantageous selections for determining the location of a watermarking code because they vary through the audio signal which introduces security-enhancing unpredictability.” *Id.* at 59.

Petitioner explains that in contrast to Kudumakis’s use of unpredictable frequencies, Tilki’s “frequency selection technique . . . ‘modif[ies] the phase of every fourth FFT bin above 2 kHz.’” Pet. 59 (citing Ex. 1008, 332). Therefore, according to Petitioner, employing harmonics in Tilki’s scheme for coding provides robustness enhancement because 1) “Tilki’s frequencies remain constant across time frames and do not unpredictably vary like the fundamental and its harmonics do,” and 2) “the fundamental and its harmonics (e.g., third harmonic) are typically in the perceptually more-significant frequencies (below 2 kHz) in speech-dominated audio content, and it was known that robustness increases by

embedding hidden data in the most perceptually significant frequencies.” *Id.* (citing Ex. 1020, Abstract; Pet. § VI.E.1.b).

Patent Owner contends Petitioner fails to show a sufficient reason to modify Tilki’s phase encoding scheme. PO Resp. 57–67. Patent Owner is correct. Petitioner’s rationale is hindsight for reasons similar to those addressed above in Ground 1. In particular, as outlined above, none of the references relied upon by Petitioner (i.e., Cabot, Kudumakis, and other cited references) discuss using a harmonic frequency to embed a coded phase shift relative to its fundamental frequency. Even if Petitioner’s rationale is sufficient for using random lower frequencies in general based on trade-off considerations, Petitioner fails to provide a sufficient reason to use a harmonic frequency to embed a coded phase shift relative to its fundamental frequency in Tilki’s scheme.

Similar to its showing for Ground 1, Petitioner relies on Cabot to “teach that imperceptibility is instead achieved by performing the [differential] phase shift [of Tilki] directly at the fundamental and the third harmonic.” *See* Pet. 60 (citing Pet. § VI.B; Ex. 1003 ¶ 201). Petitioner further relies on Kudumakis and contends that Cabot suggests modifying “Kudumakis’s *notch* encoding” to place the codes directly at the harmonic. *See id.* Petitioner explains that in Kudumakis’s notch encoding system, “the fundamental and its harmonics determine where to insert the codes, but the codes are placed at their ‘edges’ because the ‘codes are more perceptible if the notch frequencies coincide with the main frequency component[] of the signal.’” *Id.* (quoting Ex. 1007, 3:4–9; citing *id.* at 3:30–4:5, 4:26–5:2; citing Pet. § VI.B; Ex. 1003 ¶ 201).

Patent Owner disputes Petitioner’s argument that modifying “Tilki’s technique . . . could imperceptibly embed a watermark.” PO Resp. 59. For

reasons similar to those addressed above with respect to Ground 1, as Patent Owner argues, Petitioner fails to show that the relied-upon references disclose or suggest using phase shifts of a harmonic relative to its fundamental to embed hidden data in a harmonic.

In particular, Patent Owner notes that Petitioner contends that Tilki teaches that “a phase shift of $\pi/8$ suffices to encode/decode binary data values.” PO Resp. 59–60. Patent Owner argues that Cabot teaches that “Tilki’s phase shift of 22.5° ($\pi/8$ radians) would be audible to the listener 60% of the time, and would thus have understood that Tilki’s phase encoding method could not ‘imperceptibly embed a watermark.’” *Id.* at 60. According further to Patent Owner, in Tilki’s system, “[t]he FFT bins immediately preceding the signal bins are used as references for the purpose of applying a phase shift,” so that a person of ordinary skill would not have modified it to include phase shifting harmonics relative to their fundamentals. *See id.* at 60–61 (citing Ex. 1008, 331).

To support this latter argument about Tilki’s frequency bins, Patent Owner points out that Dr. Scordilis confirms that “*Tilki* does not suggest modifying anything other than the immediately adjacent frequency bin,” and “*Tilki* does not teach altering the phase of a fundamental relative to an overtone.” PO Resp. 61 (citing Ex. 1008, Fig. 1; Ex. 2011, 86:16–18, 89:17–90:3). Patent Owner correctly observes that “because of how FFT bins are spaced, a bin’s ‘overtone’ [when Tilki is modified] is dozens of bins away.” *Id.* at 62 (citing Ex. 1008, 332). Petitioner does not dispute Patent Owner’s characterization of Tilki’s modified bin spacing. *See Reply 21* (arguing that “even if Patent Owner’s assertions are taken at face value, they simply state that the gap between selected bins would have increased (compared to Tilki’s example)” (internal footnote omitted)).

Patent Owner's arguments undermine Petitioner's showing. As noted above, Petitioner relies on a "[r]esulting [s]ystem . . . that would have resulted from using Tilki's differential phase encoding/decoding to embed/retrieve a watermark using the fundamental and the third harmonic as the reference and signal bins (as motivated by Kudumakis and Cabot) . . . referred to herein as 'the Kudumakis/Tilki/Cabot Combination.'" Pet. 62.

For reasons similar to those discussed above in connection with Ground 1, Petitioner fails to show that an artisan of ordinary skill would have considered modifying Tilki's system to include a phase shift of an overtone or harmonic to result in a suitable watermark to replace Tilki's frequencies and embedded codes. Tilki's system provides "a digital audio signal . . . that . . . is *imperceptible to human observers*" by employing masking. Ex. 1008, Abstract (emphasis added). Similar to our finding with respect to Ground 1, the record does not show that an artisan of ordinary skill would have considered that, even if Cabot reveals "subtle" audibility for some small phase shifts, the audibility would remain subtle in digital data embedding techniques like that of Tilki. *See* Ex. 1006, 570 (Table II). In particular, Petitioner fails to show that an artisan of ordinary skill would have expected Cabot's phase shifts of 22.5° , which a listener perceives 60% of the time, to translate to an inaudible code when employed in Tilki's phase encoding system as modified to embed phase shift codes in harmonics relative to a fundamental tone. *See id.*

As also noted above in connection with Ground 1, Dr. Scordilis testifies that "Cabot's work . . . *really opens the venue for exploration that a [person of ordinary skill in the art] would try to capitalize and explore further to develop a watermark.*" Ex. 2011, 75:16–22 (emphasis added). Opening the venue to further explore watermarks is not a sufficient reason

on this record to modify Tilki in the manner proposed by Petitioner. Dr. Scordilis’s testimony that an artisan of ordinary skill “would try to . . . explore further to develop a watermark” does not indicate that Cabot discloses or suggests that phase encoding using a harmonic and a fundamental was one of a finite number of predictable “known options” for hiding data. *Cf. KSR*, 550 U.S. at 402 (indicating that under an “obvious to try” rationale, “[w]hen there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill in the art has good reason to pursue the known options within his or her technical grasp”).

As the ’961 patent inventors discovered, as discussed with respect to Ground 1 above, merely picking a harmonic in which to embed a relative phase does not result in an imperceptible watermark, contrary to Petitioner’s unsupported allegations, which rely on replacing Tilki’s watermark to create an imperceptible watermark as a suitable option. *See supra* § II.E.1.f (finding that Petitioner does not dispute that the ’961 patent inventors employed additional techniques to render the embedded phase data in a harmonic inaudible); *cf.* Pet. 58 (arguing that “Tilki’s technique” “could imperceptibly embed a watermark”).

Given the record evidence showing that merely embedding digital phase data in a harmonic does not render the phase shift data inaudible, and the testimony by Dr. Scordilis that characterizes Cabot’s teachings as opening the venue to try to explore watermarks (Ex. 2011, 75:16–22), Petitioner fails to show that an artisan of ordinary skill would have had a sufficient reason to try to create a suitable watermark (i.e., a relatively inaudible watermark) by modifying Tilki using Cabot’s and Kudumakis’s teachings (or any other reference relied upon by Petitioner). *See* Pet. 57–62.

As noted above, Tilki's system provides "a digital audio signal . . . that . . . is *imperceptible to human observers*" by employing masking. Ex. 1008, Abstract (emphasis added).

As Patent Owner argues as noted above, "*Tilki* encodes data by shifting the phase of the signal bin relative to the *immediately* preceding bin, and decodes data 'by comparing the phase at the (known) signal bins to the phase *at the neighboring reference bins*.'" Sur-reply 22 (quoting Ex. 1008, 332). As Patent Owner also notes, Petitioner does not account specifically for how Tilki's system would work with the large and randomly changing bin spacings of a harmonic relative to its fundamental. *See id.* Even if an artisan of ordinary skill could or would have considered using large random bin spacings in Tilki to accommodate harmonics, Petitioner's showing fails for the reasons outlined above and below.

Petitioner generally argues that Tilki teaches modifying the phase of a signal frequency component by 22.5° (or $\pi/8$ radians). Pet. 58. Petitioner is essentially correct. Tilki teaches adding a differential phase of $\pi/8$ radians to the phase Θ_r of frequency reference bin to replace the existing phase Θ_s of the original signal frequency bin, which immediately precedes the reference frequency bin. *See* Ex. 1008, 332 ("Note that it is the phase of the *reference* bin that is used along with the differential phase $[\pi/8]$ to replace the phase of the signal bin."), Fig. 1 (showing phase shifts of $\pi/8$ of the original signal bin o in modified signal bins x).

However, even if an artisan of ordinary skill would have considered modifying Tilki's method to include Petitioner's modification that results in large frequency bin spacings that are random (i.e., using harmonic frequencies relative to fundamental frequencies), Tilki's method, as modified, would not account for the difference in sound *after Petitioner's*

proposed modification as compared to the original audio signal. That is, the third harmonic's phase is naturally random as compared to that of the fundamental, so the phase difference between the two varies from anywhere between 0° to (plus or minus) 180° . *See* Ex. 1001, 3:48–53 (noting “an apparent randomness of the phase” “of various music and speech spectrograms”). Therefore, if one blindly follows Tilki's technique as Petitioner suggests and replaces the phase Θ_s of the signal frequency (the third harmonic) with 22.5° plus Θ_r (the fundamental reference phase), one obtains a phase difference of 22.5° between the harmonic and fundamental frequency (which the parties agree upon). However, because the phase shift of a harmonic relative to its fundamental is naturally random in the original audio, it may be, for example, 180° as noted above. Therefore, comparing Petitioner's modified audio signal to the original audio signal reveals a potential phase difference between the two of $180^\circ - 22.5^\circ = 158.5^\circ$.

Petitioner simply does not address whether an average or skilled listener, who would normally listen to a natural sound with its random phase shifts between a third (or any) harmonic relative to its fundamental (e.g., in a song), would not perceive a difference between that original song and Petitioner's modified song with its smaller fixed phase shift. That is, even if such a small phase shift of 22.5° might be “subtle” or detected only 60% of the time according to Cabot's experimental data as compared to no phase shift, Petitioner fails to address, much less show, that the audible difference between the natural (unmodified) song and the modified song would be “subtle.” *See* Ex. 1006, 571.

Tilki's Figure 1 follows:

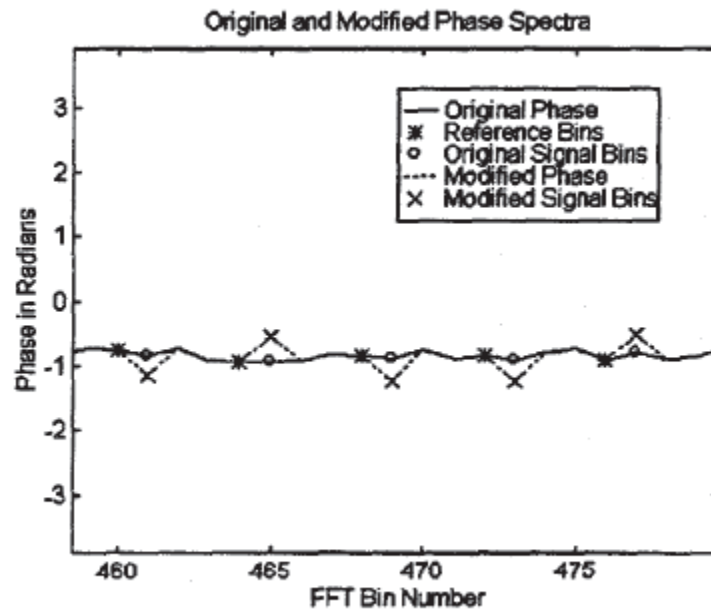


Figure 1. Example Phase Spectra.

Tilki's Figure 1 above shows phase shifts of around 22.5° ($\pi/8$ radians = 0.4 radians) between the phase-modified frequency signal bins x and reference frequency bins *, as Petitioner essentially argues. *See* Pet. 62–63 (“noting ϕ can be $\pi/8$ to embed a digital one or zero, which are data”). It is immediately apparent from the relatively flat line (i.e., “Original Phase” line) in Figure 1 and Tilki's disclosure that the relative phase differences between the original signal bins o and reference bins * in the original audio (i.e., prior to embedding the modified phase) are extremely small or almost zero between adjacent frequency bins. As the parties agree, Tilki's technique involves choosing high frequency bins adjacent to each other to embed Θ_r plus $\pi/8$ as the modified phase “to replace the phase of the signal bin” Θ_s . *See* Ex. 1008, 331 (“Addition of the differential phase represents a digital one and subtraction a digital zero.”), 332 (using a “differential phase of $\pi/8$. . . to modify the phase of every fourth FFT bin above 2 kHz”).

But Petitioner does not address whether the phase differences between harmonic frequencies and their fundamental frequencies in an original audio signal (which would be spread between dozens of bins in Tilki's system as Patent Owner argues) would have the same approximately zero phase difference that Tilki's adjacent frequency bins * and o have as Figure 1 portrays. *See* Pet. 63–64. That is, Tilki's method assumes that adjacent frequency bins have *approximately equal* phases to yield a positive or negative difference of 22.5° ($\pi/8$) after phase quantization, but the '961 patent exploits the random *differences* of phases between harmonics their fundamentals for phase quantization as step 1C-2 requires. *See id.* (relying on Tilki's $\pi/8$ phase encoding scheme to quantize a 1 or 0 bit); PO Resp. 62 (noting that “because of how FFT bins are spaced [in Tilki], a bin's ‘overtone’ is dozens of bins away” (citing Ex. 1008, 332)); Ex. 1008, 331–332 (adding or subtracting $\pi/8$ to quantify the difference); Ex. 1001, 3:48–53 (noting “an apparent randomness of the phase has not been exploited for data-hiding purposes”).

Relatedly, as Patent Owner also argues, Tilki states that “the lower frequencies (below say 2 kHz), which typically contain the most energy in common audio signals, are left untouched.” PO Resp. 64 (quoting Ex. 1008, 331). Patent Owner explains that this is because “stronger [untouched] low frequency components help to mask the changes made in the higher frequency region.” *See id.* (quoting Ex. 1008, 331). Therefore, Tilki teaches how to hide phase changes—using lower untouched frequencies to mask phase adjustments in higher frequencies (in bins adjacent to each other)—whereas Petitioner's modification alters phases in lower frequency harmonics, which results in losing or at least diminishing Tilki's data hiding (masking) mechanism. *See* Ex. 1008, 331. This further undermines

Petitioner's unsupported argument that an artisan of ordinary skill would have considered modifying Tilki's system in view of Cabot and Kudumakis to employ harmonics and fundamentals to produce inaudible phase codes.

In its Reply, Petitioner argues that "Tilki itself contemplated the tradeoffs that affected audibility, and thus Cabot's purported subtle audio quality issues (even if they existed) would not have taught away from the combination." Reply 20. Teaching away is not at issue here. As Patent Owner argues, and as explained above, Petitioner fails to show that Tilki's resulting audibility of the phase shifts, based on modifications by Cabot or any other relied-upon reference, would have been subtle. *See* Sur-reply 20. For reasons similar to those in connection with Ground 1 (e.g., expected noise artifacts due to digitization and phase shifts of the audio signal), Petitioner fails to show that an artisan of ordinary skill would have considered using Cabot's experimental analog signal phase data at lower frequencies to result in a suitable known option to replace Tilki's digital embedded phase shifting technique for hiding data at higher frequencies.

Relying on Kudumakis, Petitioner also argues in its Reply that "selecting frequency components which varied unpredictably in fact provided an added security feature in the proposed combination, and thus would have provided an added motivation for making the combination." Reply 22 (arguing "Tilki's frequencies *are the same in every time frame* and do not unpredictably vary like the fundamental and its harmonics do when using Kudumakis's [sic] technique").

However, as Patent Owner points out, and as discussed in connection with Ground 1, Petitioner's reliance on Kudumakis is faulty, because Kudumakis teaches adding a random frequency component with embedded phase data near a harmonic but does not teach employing a phase shift at an

existing harmonic in the original audio. *See* PO Resp. 18–19; Sur-reply 22–23. As Kudumakis suggests, audio frequencies adjacent to harmonics in general are useful for robustness and masking in watermark applications. And it was well-known that sound or voice frequencies naturally vary in amplitude and phase to produce distinct sounds or voices, including any two random lower frequencies. *See* PO Resp. 5 (“The presence of additional frequency components allows one to distinguish between sounds of the same pitch and loudness produced by two different instruments or voices.” (citing Ex. 2002, 202)). Therefore, Petitioner fails to set forth a sufficient non-hindsight reason for picking and choosing a harmonic to embed a phase shift for coding based on the harmonic’s phase relative to its fundamental.

Petitioner also argues that a person of ordinary skill in the art “would have understood that different aspects of watermarking could be traded off; and a [person of ordinary skill in the art] would have found the proposed combination obvious because it would have provided additional advantages over Tilki in terms of increased security, robustness and *low audibility*.” Reply 23 (emphasis added). However, as found above, Kudumakis shows that increased security and robustness occurs for random lower frequency components in general, with Kudumakis employing notch frequencies adjacent to harmonics and/or next to “[t]he band with the maximum energy content” to provide “a degree of randomness or unpredictability” and to provide “masking.” *See* Ex. 1006, 3:7–8, 17–18, 29–30.

As found above, Petitioner fails to show how Tilki’s system would have resulted in relatively low audibility, and Petitioner fails to set forth a sufficient reason for picking and choosing a harmonic to embed a phase shift for coding based on the harmonic’s phase relative to its fundamental. Therefore, Petitioner also fails to show that any choice between trade-offs

“amounts to an engineering trade-off.” *Cf. Mouttet*, 686 F.3d at 1330 (noting that the Board found adequate reasons to combine the cited references because, among other things, the Board found that “the relative advantages and disadvantages in selecting electrical circuitry in lieu of optical circuitry amounts to an engineering trade-off—a decision well within the level of ordinarily skilled artisans”).

Analogous to the facts in *Winner*, 202 F.3d at 1349 and similar to the findings in connection with Ground 1 and Srinivasan above, “one of ordinary skill in the art would not have reasonably elected trading the benefit” of relative inaudibility in Tilki’s data hiding scheme for that of robustness, security, or a limited low frequency speech channel. *See id.* Like trading away the purpose of *Winner*’s dead-bolt, security, trading away the purpose of Tilki’s data hiding technique, relative inaudibility of the hidden data, would not have been feasible, because here, Tilki’s purpose is to hide embedded data, and Petitioner fails to show a sufficient reason to embed relative phase data into harmonics and also fails to show that the resulting noise in Tilki’s modified watermarks at lower harmonic frequencies would have been expected to be relatively inaudible at least as compared to the original audio.

h. Summary of Claim 1

Based on the foregoing analysis and discussion, we determine that Petitioner fails to show by a preponderance of evidence that claim 1 would have been obvious over the combined teachings of Tilki, Kudumakis, and Cabot.

3. Claims 2–10

Petitioner contends that the subject matter of independent claims 4, 6, and 9, and dependent claims 2, 3, 5, 7, 8, and 10 would have been obvious over Kudumakis, Tilki, and Cabot. Pet. 62–76. Petitioner’s showing for the independent claims tracks its showing for claim 1. *See id.* Patent Owner relies on its arguments with respect to claim 1. *See* PO Resp. 57–67.

Petitioner’s showing for these claims is deficient for the same reasons as outlined above with respect to claim 1 and alleged obviousness over the combined teachings of Kudumakis, Tilki, and Cabot.

III. CONCLUSION

For the foregoing reasons, we determine that Petitioner has not established by a preponderance of the evidence that claims 1–10 of the ’961 patent are unpatentable. In summary:

Claims	35 U.S.C. §	Reference(s)/ Basis	Claims Shown Unpatentable	Claims Not shown Unpatentable
1–10	103	Srinivasan, Cabot, Kudumakis		1–10
2, 3, 5, 7, 8, 10	103	Srinivasan, Cabot, Kudumakis, Hobson		2, 3, 5, 7, 8, 10
1–10	103	Kudumakis, Tilki, Cabot		1–10
Overall Outcome				1–10

IV. ORDER

In consideration of the foregoing, it is hereby

ORDERED that Petitioner failed to meet its burden of showing that claims 1–10 of the '961 patent are unpatentable;

FURTHER ORDERED that, because this is a final written decision, parties to this proceeding seeking judicial review of our Decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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