UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ZHONGSHAN BROAD OCEAN MOTOR CO., LTD.,
BROAD OCEAN MOTOR LLC, and
BROAD OCEAN TECHNOLOGIES, LLC,
Petitioners,

v.

NIDEC MOTOR CORPORATION,
Patent Owner.

Case IPR2014-01122
Patent 7,208,895 B2

Before BENJAMIN D. M. WOOD, JAMES A. TARTAL, and
PATRICK M. BOUCHER, *Administrative Patent Judges*.

BOUCHER, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

A. Background

Zhongshan Broad Ocean Motor Co., Ltd., Broad Ocean Motor LLC, and Broad Ocean Technologies, LLC ("Petitioners") filed a corrected Petition (Paper 7, "Pet.") pursuant to 35 U.S.C. §§ 311–319 to institute an *inter partes* review of claims 9 and 21 of U.S. Patent No. 7,208,895 B2 ("the '895 patent"). After consideration of a Preliminary Response (Paper 14, "Prelim. Resp.") filed by Nidec Motor Corporation ("Patent Owner"), the Board instituted trial with respect to claims 9 and 21 on January 21, 2015. Paper 20 ("Dec."). A Request for Rehearing filed by Petitioners with respect to certain denied grounds was denied on February 24, 2015. Paper 25.

During the trial, Patent Owner timely filed a Patent Owner Response (Paper 29, "PO Resp."), and Petitioners timely filed a Reply to the Patent Owner Response (Paper 32, "Reply"). An oral hearing was held on October 16, 2015. Paper 40 ("Tr.").

We have jurisdiction under 35 U.S.C. § 6(c). This Decision is a Final Written Decision under 35 U.S.C. § 318(a) as to the patentability of the claims on which we instituted trial. Based on the record before us, Petitioners have shown, by a preponderance of the evidence, that claims 9 and 21 of the '895 patent are unpatentable.

B. The ’895 Patent (Ex. 1001)

The ’895 patent relates to torque control of permanent magnet rotating machines. Ex. 1001, col. 1, ll. 15–17. Figure 1 of the ’895 patent is reproduced below.

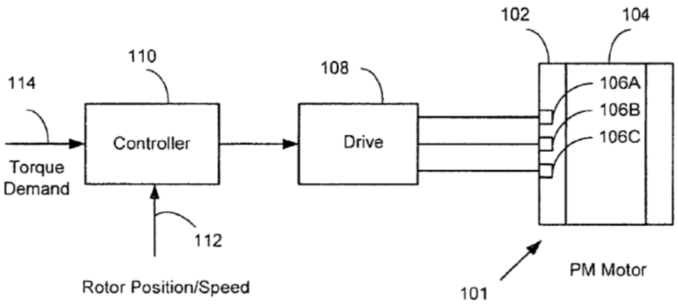


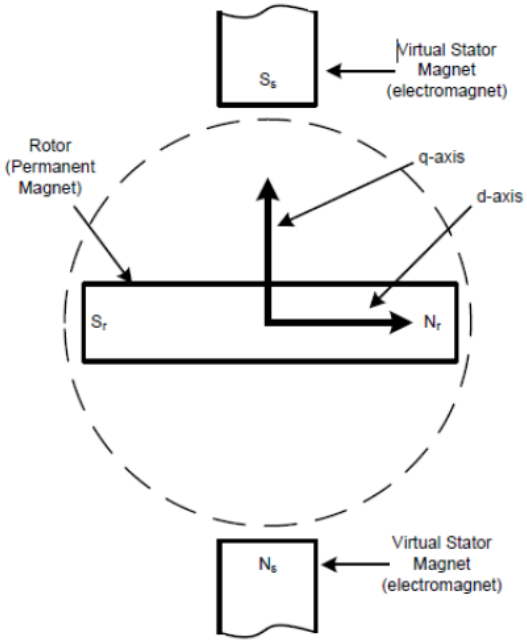
FIG. 1

Figure 1 is a block diagram of a rotating permanent magnet machine system. *Id.* at col. 2, ll. 4–6. Rotating permanent magnet electric machine 101 includes rotor 104 and stator 102, around which energizable phase windings 106A, 106B, and 106C are wound. *Id.* at col. 2, ll. 14–22. Drive 102 receives control inputs from controller 110, which receives rotor position and speed data 112 from sensors coupled to the machine. *Id.* at col. 2, ll. 24–30.

When operated in a torque control mode, input torque demand 114 is provided to a torque scalar that produces a scaled torque demand. *Id.* at col. 2, ll. 63–67. In one embodiment, calculation of the scaled torque demand is the sum of three components: (1) the torque offset, which is the minimum torque required to run the motor without a load; (2) the product of the torque demand and a torque multiplier; and (3) a speed offset, which may be determined from a look-up table containing speed-torque table values for the particular motor being controlled. *Id.* at col. 4, ll. 15–35, Fig. 3. The torque multiplier and the torque offset value "are preferably motor-specific parameters which compensate for individual motor characteristics." *Id.* at col. 4, ll. 20–22. A constant motor torque output with increasing motor speed may be achieved by increasing the value of the demanded torque by the control system as the motor operating speed increases, thereby making the torque lines flatter with speed. *Id.* at col. 4, ll. 39–43.

The scaled torque demand is used to calculate an "IQr demand" using motor-specific torque-to-IQr map data. *Id.* at col. 2, l. 67–col. 3, l. 3. The IQr demand is concatenated with an "Idr demand" (also referred to as a "dr-axis injection current") from an Idr injection block into a vector quantity, "IQdr demand." *Id.* at col. 3, ll. 3–6. The resulting IQdr demand takes into account the torque contribution, if any, of the dr-axis current. *Id.* at col. 3, ll. 10–12.

These parameters, "IQr demand" and "Idr demand," are not defined expressly in the specification of the '895 patent. Petitioners' witness, Dr. Mark Ehsani, explains that "vector control" provides one method of controlling permanent-magnet synchronous motors, and that "[t]he concept of vector control, which typically uses d and [Q] current components, arises from [a] principle [in which] torque arrives from the interaction of two magnetic fields, one originating from the stator and one originating from the rotor." Ex. 1010 ¶ 13. The drawing from page 7 of Dr. Ehsani's Declaration is reproduced below.



The drawing from Dr. Ehsani's Declaration illustrates a rotor, which has a permanent magnet having north and south poles N_r and S_r, respectively, and illustrates a stator, which includes electromagnets that result in a virtual stator magnet having north and south poles N_s and S_s, respectively. *Id.* ¶ 15. The d axis is aligned with the rotor and the Q axis[1] is offset 90° from the d axis. The motor commutates the winding currents to maintain orthogonality of the d and Q axes as the rotor turns. *Id.* ¶ 16.

C. Claims

The challenged claims are as follows.

> 9. A permanent magnet rotating machine and controller assembly configured to perform the method of claim 1.

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[1] Dr. Ehsani uses a lower-case letter q in referring to this axis. We use an upper-case letter Q for consistency with the claims that are before us.

> 21. A permanent magnet rotating machine and controller assembly configured to perform the method of claim 12.

Claims 9 and 21 incorporate the limitations of claims 1 and 12, respectively, which are as follows.

> 1. A method of controlling a permanent magnet rotating machine, the machine including a stator and a rotor situated to rotate relative to the stator, the stator having a plurality of energizable phase windings situated therein, the method comprising:
>
> receiving a rotor torque demand; and
>
> calculating a scaled torque demand from the received torque demand as a function of a speed of the machine to obtain a substantially constant rotor torque over a range of rotor speeds.
>
> 12. A method of controlling a permanent magnet rotating machine, the machine including a stator and a rotor situated to rotate relative to the stator, the stator having a plurality of energizable phase windings situated therein, the method comprising:
>
> calculating an IQr demand from a speed or torque demand;
>
> calculating a dr-axis injection current demand as a function of a speed of the rotor; and
>
> combining the IQr demand and the dr-axis injection current demand to produce an IQdr demand that is compensated for any torque contribution of dr-axis-current.

D. Grounds of Unpatentability

Petitioners rely on the following references.

Chen	US 6,498,449 B1	Dec. 24, 2002	Ex. 1006
Kusaka	US 5,569,995	Oct. 29, 1996	Ex. 1007
Walters	US 6,407,531 B1	June 18, 2002	Ex. 1008

We instituted trial based on the following grounds. Dec. 21–22.

Reference	Basis	Claim Challenged
Chen	§ 102(b)	9
Kusaka	§ 102(b)	21
Walters	§ 102(b)	21

II. ANALYSIS

A. Claim Construction

The Board interprets claims of an unexpired patent using the broadest reasonable construction in light of the specification of the patent in which they appear. *See* 37 C.F.R. § 42.100(b); *In re Cuozzo Speed Techs., LLC,* 793 F.3d 1268, at 1277–1279 (Fed. Cir. 2015); Office Patent Trial Practice Guide, 77 Fed. Reg. 48,756, 48,766 (Aug. 14, 2012).

In the Institution Decision, we adopted the following constructions. Dec. 7–10. We see no reason to modify those constructions in light of development of the parties’ positions during the trial, and adopt them for this Final Written Decision.

Claim Term	Construction
“scaled torque demand”	torque calculated from the received torque demand based on machine-specific parameters
“substantially constant rotor torque over a range of rotor speeds”	requires that the rotor torque not vary substantially over a range of rotor speeds
“IQr demand”	Q-axis demand current
“dr-axis injection current demand”	d-axis injection current
“IQdr demand”	a current demand that includes Q- and d-axis current demands

B. Anticipation of Claim 9 over Chen

Petitioners challenge claim 9 as anticipated by Chen under 35 U.S.C. § 102(b). Pet. 4. Chen discloses a method and apparatus for controlling the torque of a permanent magnet motor without using current sensors. Ex. 1006, abst. Figure 1 of Chen is reproduced below.

FIG. 1

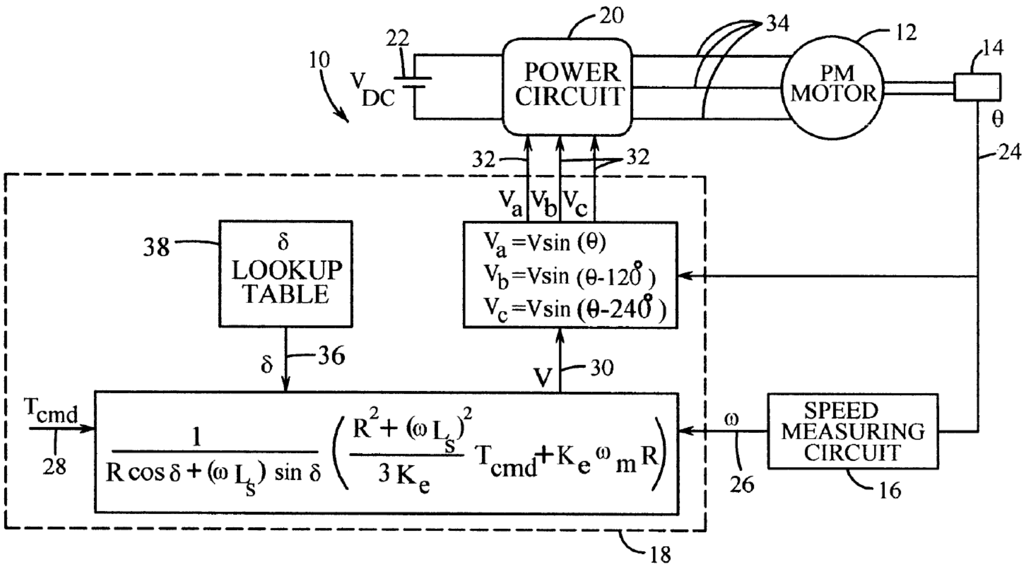

Figure 1 is a block diagram of a system for controlling the torque of a sinusoidally excited permanent magnet motor. *Id.* at col. 2, ll. 43–45. Included within Figure 1 is an expression for motor input voltage V as a function of commanded torque T_{cmd} :

$$V = \frac{1}{R\cos\delta + (\omega L_s)\sin\delta}\left(\frac{R^2 + (\omega L_s)^2}{3K_e}T_{cmd} + K_e\omega_m R\right).$$

Of relevance to our analysis, the commanded torque T_{cmd} is modified by $(R^2 + (\omega L_s)^2)/3K_e$, where R is the winding resistance, ω is the excitation frequency, L_s is the motor inductance, and K_e is the EMF constant. *Id.* at col. 3, ll. 17–19, 60. Petitioners identify calculation of the product of T_{cmd} with this coefficient as corresponding to "calculating a scaled torque demand from the received torque demand as a function of a speed of the machine to obtain a substantially constant rotor torque over a range of speeds." Pet. 28–30; *see* Tr. 6:14–7:7.

We agree with Petitioners' analysis. Pet. 26–30. In particular, the intermediate calculation of $[(R^2 + (\omega L_s)^2)/3K_e]T_{cmd}$ is a "scaled torque demand," as we have construed the term, because it is calculated from the received torque demand T_{cmd} based on at least the machine-specific parameters for winding resistance R and motor inductance L_s. As Petitioners observe, Chen itself makes clear that these are motor specific parameters by specifying the value of the parameters for an "exemplary motor." Reply 11–12 (citing Ex. 1006, col. 4, ll. 26–49). The result of the intermediate calculation is also a "function of a speed of the machine" ω, as required by claim 9 through reference to claim 1.

We are not persuaded by Patent Owner's responses. First, we disagree with Patent Owner's contention that "one of ordinary skill would understand [the winding resistance R, motor inductance L_S, and EMF constant K_e] to be *theoretical values* associated with a motor design." PO Resp. 12 (emphasis added). Notably, Patent Owner's witness, Gary Blank, Ph.D., does not draw an unambiguous distinction between machine-specific parameters and "theoretical values associated with a motor design." Instead, Dr. Blank asserts that "the Chen reference (Ex. 1006) does not disclose relying *on the same type* of machine specific parameters in the disclosed control equation that Petitioners point to as disclosing the claim limitation." Ex. 2001 ¶ 14 (emphasis added). Dr. Blank asserts that the winding resistance R, motor inductance L_s, and EMF constant K_e "are *not the type* of machine specific parameters that can only be obtained by characterizing individual machines as they are manufactured," and "are not specific to each individual motor that is placed into a system." *Id.* (emphasis added).

We agree with Petitioners that Patent Owner and its witness draw so overly fine a distinction among *types* of machine-specific parameters that the argument loses sight of the original claim language. *See* Reply 2–3. As Petitioners assert, "[t]here is nothing in the ordinary meaning of the word 'scaled' that would distinguish between 'theoretical values associated with a motor design' and 'machine specific parameters that can only be obtained by characterizing the individual machines as they are manufactured.'" *Id.* Patent Owner thus provides no persuasive reasoning to explain why one of skill in the art would not understand that Chen's equations apply to individual motors, even if they are presented in broader theoretical fashion.

Indeed, during the oral hearing, Patent Owner acknowledged that it does not take a position that the equations in Chen do not apply to real motors and that "[t]he Chen equation could work for some motors." Tr. 37:20–25.

Second, we are not persuaded by Patent Owner's contention that "[e]ven if Chen were found to use motor specific parameters, it still fails to anticipate" because "the control equation . . . specifically uses T_{cmd}, the original demanded torque as the operand in the equation without having calculated a compensated or scaled torque demand." PO Resp. 14–15. This reasoning insufficiently accounts for Chen's intermediate calculation of a modified torque demand based on machine-specific parameters. Patent Owner focuses too narrowly on the raw inputs to the calculation without accounting for the calculation of intermediate results.

We conclude that Petitioners have demonstrated, by a preponderance of the evidence, that claim 9 is anticipated by Chen.

C. Anticipation of Claim 21 by Kusaka

Petitioners challenge claim 21 as anticipated by Kusaka under 35 U.S.C. § 102(b). Pet. 4. Kusaka discloses a method and apparatus for driving and controlling a permanent magnet motor, including execution of "field weakening" by including a d-axis current in addition to a Q-axis current when the motor turns at high speeds. Ex. 1007, col. 1, ll. 9–17, col. 12, l. 51–col. 14, l. 17. In some motors, the d-axis current used for field weakening may produce a torque, in which case compensation is made for that contribution on the Q-axis current. *Id.* at col. 16, ll. 45–58.

Figure 1 of Kusaka is reproduced below.

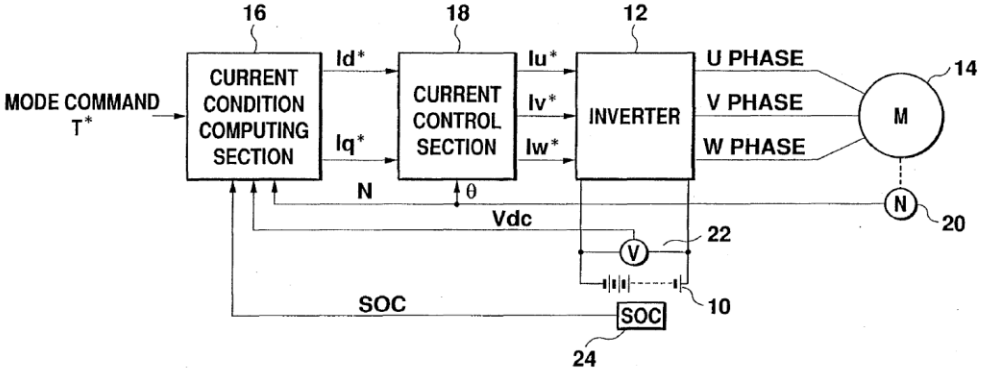

Fig. 1

Figure 1 illustrates an electrical vehicle drive system and its controller. *Id.* at col. 11, ll. 47–50. Power conversion in inverter 12 is vector-controlled by current condition computing section 16 and current control section 18, with the current condition computing section determining d- and Q-axis field reference currents in accordance with a reference torque. *Id.* at col. 11, ll. 53–62.

Petitioners contend that such determinations of d- and Q-axis field reference currents disclose the limitations of underlying claim 12 requiring calculations of an “IQr demand” and a “dr-axis injection current demand,” noting that Kusaka discloses calculation of the d-axis reference current as a function of rotor speed. Pet. 33–35 (citing Ex. 1007, col. 13, ll. 37–49). In addition, Petitioners contend that Kusaka discloses combining the IQr demand and the dr-axis injection current demand, noting Kusaka’s disclosure of compensating for torque contributions by the d-axis current. Pet. 36–38. Petitioners cite portions of Kusaka explaining that current control section 18 receives angular position θ and reference currents designated Id* and Iq* in the drawing, and outputs phase reference currents designated Iu*, Iv*, and Iw* in the drawing, which are subsequently fed to inverter 12. *Id.* at 36 (citing Ex. 1007, col. 12, ll. 6–21). Petitioners' analysis is supported by the declaration testimony of Dr. Ehsani. Ex. 1010 ¶¶ 63–71. We are persuaded by Petitioners' analysis and find that the set of Iu*, Iv*, and Iw* is an IQdr demand as we have construed the term, and that it is produced as a result of combining the IQr demand and the dr-axis injection current demand, as required by underlying claim 12.

Patent Owner responds that "[n]othing in this description discloses combining 'IQr,' or 'Q-axis demand current' with 'dr-axis injection current demand' into an IQdr demand or 'a current demand that includes Q- and d-axis current demands.'" PO Resp. 23. Patent Owner further asserts that "[t]here are in fact multiple possible operations being carried out in the current control section 18 to convert the Iq and Id currents into I_U, I_V, and I_W." *Id.* at 23–24. Patent Owner points to testimony by Dr. Blank that "this control section could perform a standard form of transformation from the rotating frame of reference to the stationary frame without combining Q and d axis currents," and that "this alternative does not require that an IQdr demand current is developed." *Id.* at 24 (citing Ex. 2001 ¶¶ 27–29).

Dr. Blank testifies that "a typical transform from the d-q frame of reference to the abc (uvw) frame of reference" is the following:

$$I[u] = Id\cos\Theta - Iq\sin\Theta$$

$$I[v] = Id\cos(\Theta - 2\pi/3) - Iq\sin(\Theta - 2\pi/3)$$

$$I[w] = Id\cos(\Theta + 2\pi/3) - Iq\sin(\Theta + 2\pi/3).$$

Ex. 2001 ¶ 27. Dr. Blank concludes that, "[a]s can be seen in the above transformation, it is not necessary to combine the Id and Iq currents to create the abc (uvw) values. *Id.* at ¶ 28. Both Patent Owner and Dr. Blank take the position that this transformation, which intermixes the Iq and Id currents, is not "combining the IQr demand and the dr-axis injection current demand" because operations are performed with trigonometric coefficients:

> JUDGE BOUCHER: But in these equations, though, haven't Iq and Id been combined in each of I[u, v, and w]? I mean, I realize there are certain factors associated with those, but there is an intermixing between the Iq and Id components versus the I[u, v, and w] components, isn't there?
>
> MR. BROWN: I don't agree with that, no. First off, let's look at I[u]. So I[u], this is an equation for how you are going to develop the phase current which is in the non-rotating frame of reference, in the stationary frame of reference.
>
> And the terms there, Iq sine theta is not Iq. It is sine theta of Iq. And Id cosine theta is not Id. It is cosine theta of Id. And there is no disclosure in here that you are going to get to IQdr before you perform these calculations that are set forth in this paragraph.
>
> So we don't believe that this does show combining Iq and Id to arrive at an IQdr.

Tr. 27:23–28:13; *see* Ex. 2001 ¶ 28. Patent Owner's position that "[c]ombining Iq and Id requires that they be combined before they be further operated on" applies too restrictive a meaning of "combining." *See* Tr. 28:17-18.

Nor are we persuaded by Patent Owner's contention that Petitioners are relying on an inherency argument merely because Dr. Ehsani stated in his testimony that the operation of combining the Q-axis demand current with the dr-axis injection current demand is "implied." *See* PO Resp. 24

(citing Ex. 2002, 132:9–18). As recently reiterated by the Federal Circuit, "a reference can anticipate a claim even if it 'd[oes] not expressly spell out' all the limitations arranged or combined as in the claim, if a person of skill in the art, reading the reference, would 'at once envisage' the claimed arrangement or combination." *Kennametal, Inc. v. Ingersoll Cutting Tool Co.*, 780 F.3d 1376, 1381 (Fed. Cir. 2015) (citing *In re Petering*, 49 CCPA 993, 301 F.2d 676, 681 (1962)). Patent Owner confirmed at the oral hearing that Dr. Blank provides no example in which Iu, Iv, and Iw involve only one of Iq and Id. Tr. 29:9–13.

We conclude that Petitioners have demonstrated, by a preponderance of the evidence, that claim 21 is anticipated by Kusaka.

D. Anticipation of Claim 21 by Walters

Petitioners challenge claim 21 as anticipated by Walters under 35 U.S.C. § 102(b). Pet. 4. Similar to Kusaka, Walters discloses controlling a permanent magnet motor over a range of speeds to improve efficiency, including a recognition that a current demand in the d-axis due to field weakening contributes to the output torque. Ex. 1008, col. 2, l. 66–col. 3, l. 27, col. 6, ll. 26–31. In such instances, the Q-axis current demand is adjusted to compensate for that torque contribution. *Id.* Figure 3 of Walters is reproduced below.

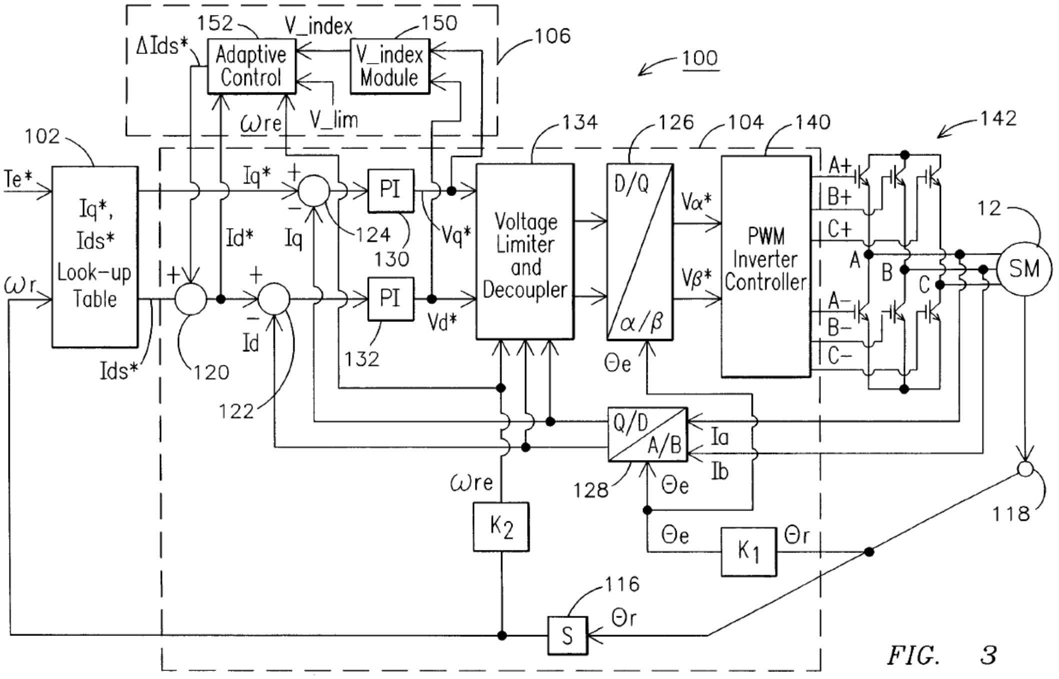

FIG. 3

Figure 3 is a block diagram illustrating a field vector control system with an adaptive control module. *Id.* at col. 4, ll. 39–42.

Walters teaches that d-axis current reference I_{ds}^* and Q-axis current reference I_{qs}^* may be adjusted as a function of commanded torque T_e^* and rotor speed ω_r using analytically and/or experimentally derived flux-adjusting values. *Id.* at col. 6, ll. 52–58. Petitioners contend that such determinations of d- and Q-axis currents disclose the limitations of claim 12 requiring calculations of an “IQr demand” and a “dr-axis injection current demand,” noting that Walters discloses calculation of the d-axis current as a function of rotor speed. Pet. 41–43 (citing Ex. 1008, col. 6, ll. 52–62). In addition, Petitioners contend that Walters discloses combining the IQr demand and the dr-axis injection current demand, noting Walters’s disclosure of compensating for torque contributions by the d-axis current.

Pet. 43–45. Petitioners' analysis is supported by the declaration testimony of Dr. Ehsani. Ex. 1010 ¶¶ 72–76.

Patent Owner responds that "Walters does not disclose that a combined IQdr current demand, a demand that includes both Q and d axis current demands[,] is created." PO Resp. 24–25. We agree with Patent Owner.

As Patent Owner observes, "Walters shows in its block diagrams that Iq and Id are generated, then individually transformed to respective Vq and Vd demanded voltage, then those voltages are back transformed from the rotating frame of reference to three phase voltages." *Id.* at 25. As evident from the drawing reproduced above, Iq* and Id* are developed by a look-up table in block 102, based on a demanded torque and speed. These are then combined individually at blocks 122 and 124 with calculated actual Iq and Id, fed individually to plus-integral ("PI") current regulators 130 and 132 to obtain voltages Vq* and Vd* that are then back-transformed. *See id.* at 26–27 (citing Ex. 1008, col. 7, l. 60–col. 8, l. 25).

In light of this, Patent Owner challenged the conclusions of Petitioners' witness, Dr. Ehsani, who responded at his deposition that "the combination is done in a -- in a different way to the same end effect." Ex. 2002, 134:8–16. In evaluating whether claim 21 is anticipated by Walters, it is not merely the end effect that is relevant, but whether that end effect is achieved in the manner recited in the claim. Upon further questioning, Dr. Ehsani also testified more explicitly that Walters does not perform the recited "combining":

> Q. (BY MR. BROWN) Where does Walters show that they combine the IQr demand and the dr-axis injection current demand to [produce] an IQdr demand?
>
> A. You know, it doesn't show that; but there's a mathematical equivalence to this. You can derive that from these. The fact of the matter is that this process produces Vd and Vq. And the '895 process starts with Id and Iq and produces Vd and Vq. That is what's needed to happen. So there's an equivalence between these.

Ex. 2002, 138:14–22. We determine that Dr. Ehsani's testimony does not support the anticipation ground advanced by Petitioners.

We conclude that Petitioners have not demonstrated, by a preponderance of the evidence, that claim 21 is anticipated by Walters.

III. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that, based on a preponderance of the evidence, claims 9 and 21 of U.S. Patent No. 7,208,895 B2 are unpatentable; and

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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