

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Mercedes-Benz USA, LLC

Petitioner,

v.

Michigan Motor Technologies, LLC

Patent Owner.

IPR2023-01032

**DECLARATION OF C. ARTHUR MACCARLEY, PH.D., P.E. IN
SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 6,581,565**

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I. INTRODUCTION

I, C. Arthur MacCarley, Ph.D., P.E., declare as follows:

1. I have been retained on behalf of Mercedes-Benz USA, LLC (“MBUSA”) for the above-captioned *inter partes* review proceeding to provide my expert opinions and expert knowledge. I understand that this proceeding involves U.S. Patent No. 6,581,565 to Heslop et al. (“the ’565 patent”), titled “Engine Torque Controller,” and that the ’565 patent is currently assigned to Michigan Motor Technologies LLC (“MMT”). I understand that the Petition submitted by MBUSA challenges claims 1- 7 of the ’565 patent.

2. The ’565 patent describes a device and a method for controlling the engine torque output. I am familiar with the technology described in the ’565 patent as of its earliest possible priority date, July 23, 2001.

3. I have been asked to provide my independent technical review, analysis, insights, and opinions regarding the ’565 patent and the references that form the basis for the grounds of unpatentability set forth in the Petition for *inter partes* review of the ’565 patent filed by MBUSA.

4. In preparing this Declaration, I have reviewed and am familiar with all the documents cited herein. I have reviewed and am familiar with the ’565 patent and its file history. I confirm that to the best of my knowledge the accompanying exhibits are true and accurate copies of what they purport to be, and that an expert

in the field would reasonably rely on them to formulate opinions such as those set forth in this Declaration.

5. I am being compensated at my customary rate of \$300 per hour for my work on this case. My compensation is not dependent upon my opinions, my testimony, or the outcome of this case.

II. SUMMARY OF GROUNDS

Ground	'565 Patent Claims	References	Basis
1	1, 4, 7	Suzuki, Cullen, Scherer	§103
2	2, 3, 5, 6	Suzuki, Cullen, Scherer, Takahashi	§103

III. SUMMARY OF OPINIONS

6. In my opinion, the challenged claims of the '565 patent would have been obvious in view of the combinations of references that MBUSA asserts, as well as the state of the art in automotive engine control on or before the year 2001, known to a person of ordinary skill in the art.

7. The terminology used in the claims is not standard in the art. However, in light of the specification and prosecution history of the patent, a POSITA would understand the meanings of the terminology and how the terms correspond to terms that are more commonly used in the art. In the interest of consistency, I will use the terminology used in the '565 patent and explain the plain and ordinary meaning of the terms where necessary. Independent claim 1 of the '565 patent recites a

device for controlling the torque output of an engine. Ex. 1001 at 4:2-3. The claimed device includes components referred to as a torque demand controller for generating a torque demand signal, which is the desired output torque of the engine based upon external and internal feedback inputs. The claim also specifies a torque producer (*Id.* at 4:5-8) that receives the torque demand signal from the torque demand controller, as well as internal inputs to its included estimator that receives as inputs a current spark angle signal, a current air/fuel ratio signal, and an estimated air charge signal, and calculates an estimated torque signal. *Id.* at 4:9-12. The claimed torque producer also includes a comparator which receives as inputs the estimated torque signal and the torque demand signal (stated inconsistently as the desired torque signal), and calculates and outputs a torque difference signal indicative of the difference between the demanded torque and the estimated actual torque from the engine. *Id.* at 4:13-15. This signal is fed to a high-pass filter that receives as its input the torque difference signal and outputs a filtered torque difference signal in which low frequency components are absent. The role of this filter is to isolate abrupt changes in the torque difference signal so that these transients can be used to quickly compensate for these abrupt torque changes by making instantaneous changes in the ignition timing or fuel quantity depending on which of the two modes of operation of the engine is in, either stratified charge or homogeneous charge. These two modes of engine control are possible because the

invention is directed to Direct Injection Spark Ignition Engines that operate in stratified charge mode for light loads and lower speeds, and in the more conventional homogeneous charge mode during higher power/speed operation. *Id.* at 4:16-18. In the wording of the claim, the torque producer includes “a transient torque controller which receives as an input the filtered torque difference signal and outputs a fuel adjustment signal or a spark adjustment signal.” *Id.* at 4:19-22.

8. As discussed in this Declaration, despite the non-standard wording, all these recited elements—for example, the torque demand controller and torque producer having an estimator, a comparator, a high-pass filter, and a transient torque controller—were well-known components found in engine torque control systems as of July 23, 2001, the earliest possible priority date of the '565 patent. And, as discussed in this Declaration, the claimed solution for compensating between estimated and demanded torque during transient engine operations was well-known and had been solved by the prior art in exactly the same way as recited in claims 1-7 of the '565 patent. Moreover, as further discussed in this Declaration, well before the '565 patent's July 23, 2001 earliest possible priority date, a person of ordinary skill in the art would have had a good reason to combine the identified prior art references, and in so doing, they would have had a reasonable expectation of success.

9. Therefore, it is my opinion that the challenged claims would have been obvious in view of the disclosures in the asserted prior art references, as well as

within the expected knowledge of a person of ordinary skill in the art at the time of the alleged invention.

IV. QUALIFICATIONS

10. My experience and education are detailed in my curriculum vitae (“CV”), a copy of which is provided as Ex. 1004. My CV also lists peer-reviewed publications on which I am the primary or a co-author and identifies parties on behalf of whom I have previously provided expert testimony.

11. My research and development work since the late 1970s has focused on advanced control systems in automotive or transportation applications, including developing microprocessor-based engine control systems for regulating air intake, fuel injection, and ignition. As an academic for 34 years, my teaching specialization is control systems and electronics for automotive and similar applications, as well as internal combustion engines and fuels. I have conducted research and managed many projects that are highly relevant to the subject matter of the ’565 patent, some of which are recounted below.

12. I obtained my Bachelor of Science in Engineering (Energy and Kinetics specialization) and my Master of Science (Electrical Engineering) from the University of California, Los Angeles in 1976 and 1978, respectively. I then earned a Ph.D. in Electrical Engineering with a specialty in Computer-based Control Systems in 1987 from Purdue University, West Lafayette, Indiana.

13. Before pursuing my Ph.D., I was employed by the Digital Communications Laboratory of the Hughes Aircraft Corp between 1977 and 1979. Between 1979 and 1983, I was employed by the University of Denver Research Institute and by the American Bosch Division of United Technologies. My work at that time included the design and optimization of electronic diesel and spark ignition engine fuel injection controls. This included responsibility for the development and validation of electronic engine control algorithms. I also designed, constructed, and tested electronic fuel injection and ignition control systems for hydrogen, methanol, and natural gas fueled engines under contract to the U.S. Department of Energy.

14. While earning my Ph.D. at Purdue University, I was the recipient of the David Ross Fellowship for Doctoral Study, and I focused my research on microprocessor-based control systems and indirect sensing methods for automotive fuel injection applications.

15. I am currently a Professor Emeritus of Electrical and Computer Engineering at the California Polytechnic State University, San Luis Obispo (Cal Poly). I have been on the faculty since 1988, tenured since 1994. I have served as the Chair of the Electrical Engineering Department, the Director of the Computer Engineering Program, and as the interim Head of the BioResource and Agricultural Engineering Department, and the Director of the Transportation Electronics Laboratory. I have also served as a Guest Professor of Electrical Engineering at

Olin College in Needham, Massachusetts in 2011, and I continue to teach Electrical, Mechanical, and Automotive Engineering courses in the International Summer School Program at the Munich University of Applied Science in Munich, Germany every year from 2014 to the present.

16. My university teaching and research specialties include digital control systems, microprocessor-embedded systems, automotive and transportation electronics, internal combustion engines, advanced sensors, and alternative engine fuels, all with applications in the field of automotive engineering.

17. I am a Senior Member of the Society of Automotive Engineers (SAE), the Institute of Electrical and Electronic Engineers (IEEE), and Sigma Xi (Scientific Research Honor Society). I have been a Registered Professional Engineer in good standing in the state of Colorado continuously since 1981.

18. Based upon on my education, my professional experience from 1978 through the present, and my scholarly publications, I am considered an expert in the relevant field of the '565 patent at issue here, and I have been an expert in this field since before the '565 patent was filed with the United States Patent and Trademark Office ("USPTO"). I am intimately familiar with how a person of ordinary skill in the art ("POSITA") would have understood and used the terminology found in the '565 patent at the time of its filing.

V. SCOPE OF ASSIGNMENT

19. In forming my opinions regarding the validity of the '565 patent, I have considered the '565 patent's specification, including the Abstract and the figures. I have also considered the language of the patent's claims, as those terms would have been understood by a person having ordinary skill in the relevant field at least at the time of the '565 patent's earliest possible priority date. I have also reviewed the prosecution (the "file history") of the '565 patent.

20. In forming my opinions, I have also considered the Exhibits that are listed in the Petition and any additional materials and information cited in this Declaration. I have also searched for and reviewed technical literature relevant to the field of the '565 patent.

21. I have relied on my personal knowledge, education, training, and professional experience in order to form my opinions concerning the '565 patent, including my experience in researching, studying, developing genetic expression systems.

22. This Declaration explains, based on facts and information currently available to me, the subject matter and opinions related to this Proceeding. As such, I am prepared to provide expert testimony regarding opinions formed resulting from my analysis of the issues and materials considered in this declaration, if asked to do so by the Board or by the parties' attorneys.

23. I may rely on handbooks, textbooks, technical literature, and the like to demonstrate the state of the art in the relevant period and the evolution of relevant technologies.

24. Throughout this Declaration, I refer to specific pages of the '565 patent and other documents, including prior art patents. These citations are intended to be exemplary and are not intended to convey that the citations are the only source of evidence to support the propositions for which they are cited. I reserve the right to amend or alter my analysis and opinions in response to positions Patent Owner may take or upon the discovery of new information.

25. I am being compensated at my customary consulting rate of \$300 per hour for the time I spend on this matter. My compensation is in no way contingent on the nature of my opinions or the outcome of this or any other proceeding. I have no other interest in this proceeding. All of the opinions expressed in this Declaration are my own.

VI. LEGAL UNDERSTANDING

26. In this section I describe my understanding of certain legal standards that I have relied upon in forming my opinions set forth in this Declaration. I have been informed of these legal standards by MBUSA's attorneys. I am not an attorney and I have not thoroughly researched the relevant patent law. I am relying only on instructions from MBUSA's attorneys for these legal standards.

A. Person of Ordinary Skill in the Art

27. I am informed that patent validity is determined from the perspective of a person of ordinary skill in the pertinent art at the time of the invention (“POSITA”). I understand that a POSITA is a hypothetical person who is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity—not an automaton.

28. In forming my opinions, I have relied on my personal knowledge and professional experience in researching, studying, developing, or using recombinant protein expression technology, and on the documents and information referenced in this Declaration.

29. In deciding the level of ordinary skill in the art, I am informed that the following factors may be considered:

- the levels of education and experience of persons working in the field;
- the types of problems encountered in the field; and
- the sophistication of the technology.

B. Claim Construction

30. I am informed that a patent may include two types of claims, independent claims and dependent claims. An independent claim stands alone and includes only the limitations it recites. A dependent claim can depend from an independent claim or another dependent claim. I am informed that a dependent

claim includes all the limitations that it recites, in addition to the limitations recited in the claim from which it depends.

31. I understand that patent claim terms can be interpreted, or “construed.” I understand that, in construing a claim, the words of patent claims are given their plain meaning, as a POSITA would understand them at the time of the invention, view of the patent and file history, unless their meaning is defined or disclaimed. I am informed that dictionaries, treatises, and other “extrinsic” sources of evidence may assist in determining the plain meaning of a term, but they cannot override a meaning that is otherwise unambiguous based on the intrinsic evidence.

32. I understand that in construing claims in an IPR proceeding, words in a claim are given their plain meaning, which is the meaning understood by a person of ordinary skill in the art in view of the patent and file history, unless specifically defined in the patent or prosecution history. I also understand that dictionaries or other extrinsic sources may assist in determining the plain and ordinary meaning but cannot override a meaning that is unambiguous from the intrinsic evidence.

33. I have been informed by MBUSA’s counsel that claim construction is a matter of law for the arbiter of law to decide. I am informed that, in an *inter partes* review, the Patent Trial and Appeal Board (“PTAB”) interprets claims in the same way as a district court would. Likewise, I understand that a POSITA interprets claims in the same way in both types of proceedings.

34. I reserve my right to amend or alter my analysis and opinions in view of any claim constructions adopted by the arbiter of law.

C. Obviousness

35. I am informed that a patent claim is unpatentable and invalid if the subject matter of the claim as a whole would have been obvious to a person of ordinary skill in the art of the claimed subject matter as of the time of the inventions at issue. I am informed that the following factors must be evaluated to determine whether the claimed subject matter is obvious: (1) the scope and content of the prior art; (2) the difference or differences, if any, between each claim of the patent and the prior art; and (3) the level of ordinary skill in the art at the time the patent was filed. Unlike anticipation, which allows consideration of only one item of prior art, I am informed that obviousness may be shown by considering more than one item of prior art. Moreover, I understand that objective indicia of non-obviousness, also known as “secondary considerations,” like the following also may be considered when assessing obviousness: (1) commercial success; (2) long-felt but unresolved needs; (3) copying of the invention by others in the field; (4) initial expressions of disbelief by experts in the field; (5) failure of others to solve the problem that the inventor solved; and (6) unexpected results. I also understand that evidence of objective indicia of non-obviousness must have a nexus with the claimed subject matter.

VII. THE '565 PATENT

A. Level of Ordinary Skill in the Art

36. In my opinion, a POSITA at the time of the '565 patent's alleged invention would have had a B.S. degree in Electrical Engineering, Mechanical Engineering, or Automotive Engineering (or equivalent), as well as at least 2–4 years of industry or research experience in a relevant field of engine control systems or, alternatively, at least an M.S. degree in Electrical Engineering or Mechanical Engineering.

37. I am well qualified to determine the level of ordinary skill in the art. First, I am very familiar with the technology of the '565 patent as of the July 23, 2001 timeframe. My academic and teaching background in both Electrical and Mechanical Engineering also provides significant insight into the expectations of a person of a given academic level or graduate certification. As mentioned above, by 2001, I had acquired extensive experience relating to engine control systems in vehicles, including developing microprocessor-based engine control systems for regulating air intake, fuel injection, and ignition. Specifically, by 2001, I had over 20 years of experience working with advanced control technologies for internal combustion engines, technologies including, for example: electronic control of fuel and air delivery, ignition timing, electronic equipment for regulating engine torque for conventional and direct cylinder injection automotive engines.

B. Claims

38. The '565 patent contains 7 claims, 2 independent claims and 5 dependent claims. Claim 1 is representative and reproduced below:

A device for controlling a torque output of an engine, the device comprising:

a torque demand controller for generating a torque demand signal; and

a torque producer which receives the torque demand signal, the torque producer includes:

an estimator which receives as inputs a current spark angle signal, a current air/fuel ratio signal and an estimated air charge signal and outputs an estimated torque signal;

a comparator which receives as inputs the estimated torque signal and a desired torque signal and outputs a difference signal;

a high pass filter which receives as an input the difference signal and outputs a filtered difference signal in which low frequency components are absent; and

a transient torque controller which receives as an input the filtered difference signal and outputs a fuel adjustment signal and a spark adjustment signal.

I previously provided brief explanations of each of the elements of claim 1 in Section III regarding my Summary of Opinions above.

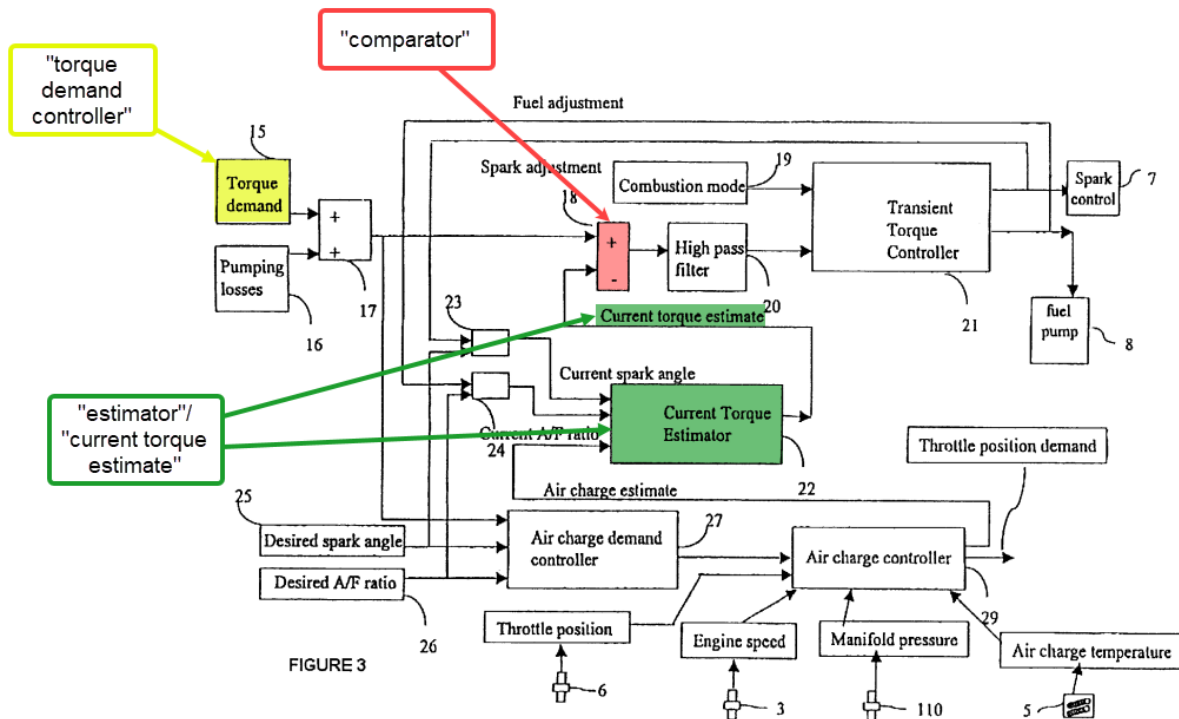
C. Specification

39. The '565 patent issued June 24, 2003, from U.S. Application No. 10/191,641 ("the '641 application"), which was filed on July 9, 2002. Ex. 1001.

The '565 patent claims priority to European Application No. 01306301, filed July 23, 2001.

40. The '565 patent claims systems and methods for controlling torque in a spark ignition, direct injection internal combustion engine based on a calculated difference between a signal representing desired torque signal a signal representing an estimate of the current torque. *See* Ex. 1001 at Abstract. The challenged claims recite the basic concept of a feedback loop based on a comparison of a desired value with a current value.

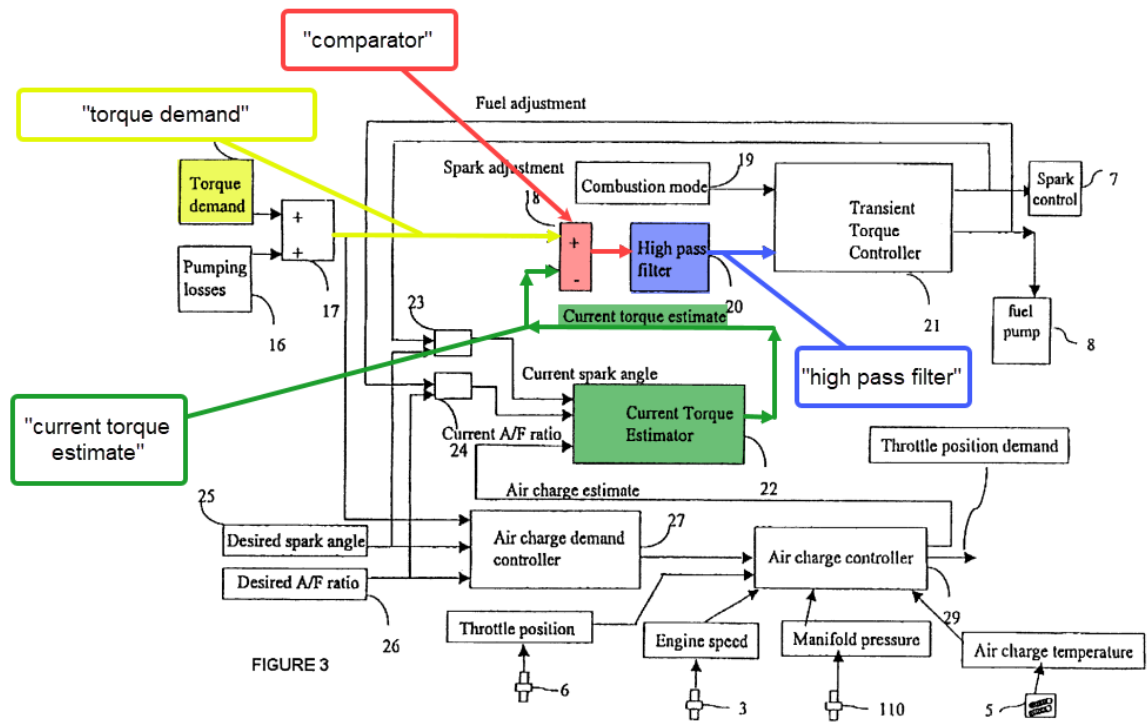
41. The '565 patent discloses a “torque demand controller 11 [that] calculates a required output torque signal”; and a “current torque estimator 22” that “generate[s] a signal representing an estimate of the current torque.” *Id.* at 3:1-33. This is shown, for example, in Figure 3 below:



Id. at Fig. 3 (annotated).

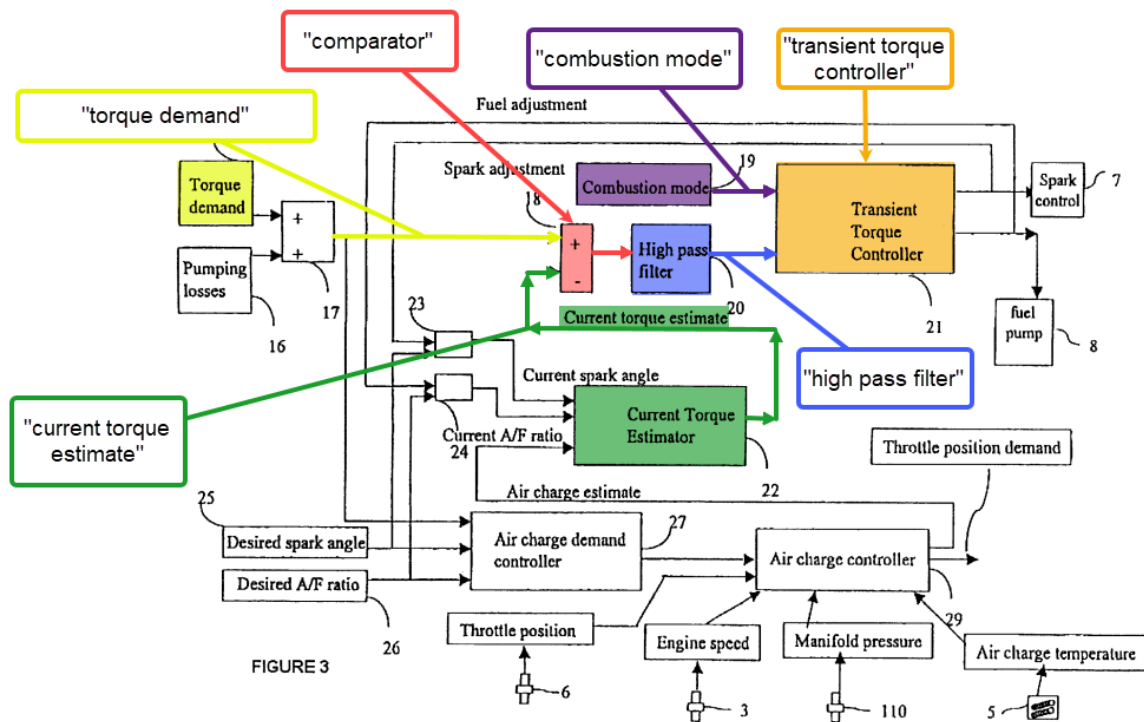
42. The claims further recite a “comparator” that compares the estimated torque demand and estimated current torque and determines the difference between the two. *Id.* at 3:34-39.

43. The difference value calculated by the comparator is then filtered via a “high pass filter” to remove low frequency components of the signal isolating just the transient component of the signal, as shown in annotated Figure 3 below (*id.* at 3:34-39):



Id. at FIG. 3 (annotated).

44. After the low frequency signal component is removed, the '565 patent's system adjusts the engine operation uses based on the torque difference value to achieve the desired torque. A "transient torque controller" receives the filtered torque difference signal and "generate[s] signals for temporarily adjusting the torque produced by the engine 100." *Id.* at 2:57-59, 3:29-339. This transient torque controller is shown in annotated Figure 3 below:



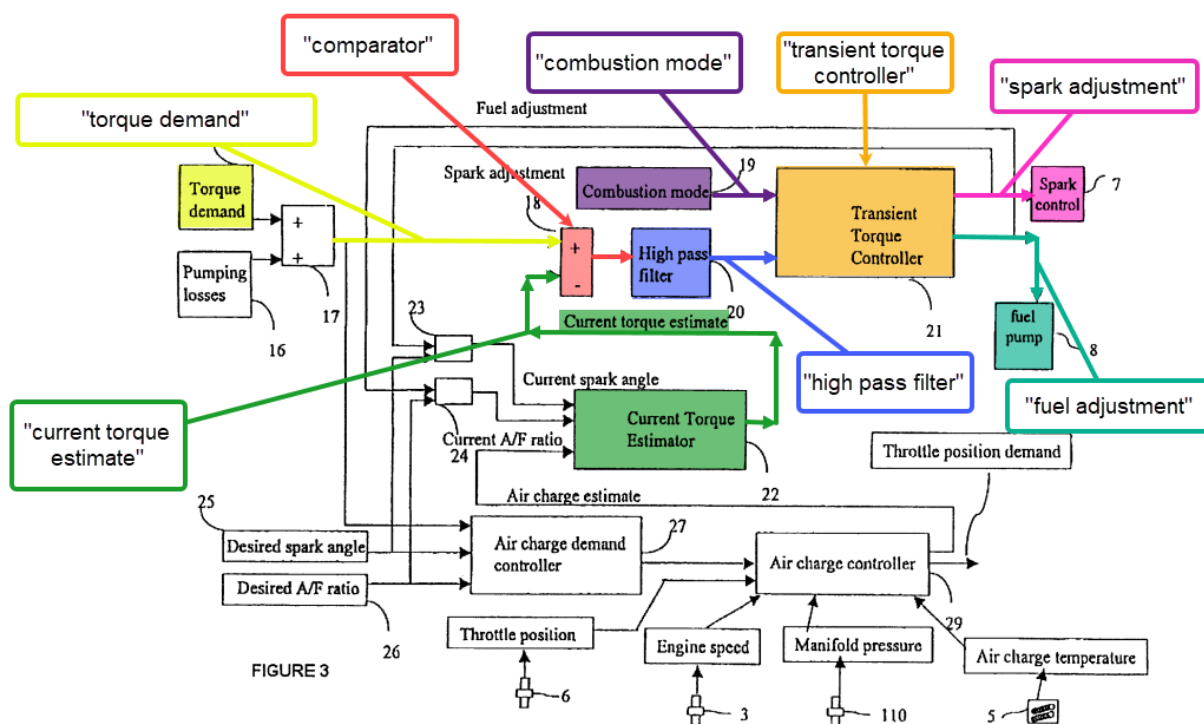
Id. at FIG. 3 (annotated).

45. The “transient torque controller” receives a “combustion mode signal 19” “indicat[ing] whether the engine 100 is operating in a stratified mode or in a homogeneous mode.” *Id.* at 3:40-43.

46. The ’565 patent explains: “If the engine 100 is operating in the stratified mode then a fuel adjustment signal is generated and sent to the fuel pump 8 in order to adjust the amount of fuel which is injected into the combustion chamber 108 by the fuel injector 130” to adjust engine torque. *Id.* at 3:43-47 (emphasis added). The patent further explains if “the engine 100 is operating in the homogenous mode then a spark adjustment signal is generated and sent to the spark control unit 7 to

adjust the timing of the ignition spark generated by the spark plug 106” to adjust engine torque. *Id.* at 3:47-50.

47. Accordingly, the alleged invention of the '565 patent is a feedback loop that makes either a spark adjustment or fuel adjustment based on the difference between the demanded torque and an estimate of the current torque. The spark and fuel adjustment signals are shown below in annotated Figure 3:



Id. at FIG. 3 (annotated).

48. The '565 patent's dependent claims add other well-known components and steps that are disclosed in the prior art.

D. Prosecution History

49. I have reviewed the prosecution history of the '565 patent (Ex. 1001). Based on my review, it appears that the Examiner did not render any rejections based on any substantive consideration of prior art.

50. Based on my review of the first page of the '565 patent prosecution history, I see the patent issued from US Patent Application 10/191,641 ("641 application"), which was filed on July 9, 2002. Ex. 1001. I understand the '565 patent claims priority to European Patent Application EP01306301, filed July 23, 2001.

51. Based on my review of the prosecution history, I understand that prior art references Suzuki, Cullen, and Takahashi were not considered by the Examiner during prosecution. Ex. 1002. I also understand the Scherer reference was listed as prior art in the prosecution history, but it was never expressly considered by the Examiner. *Id.*

VIII. CHALLENGED CLAIMS

52. I have analyzed claims 1-7 of the '565 patent in connection with MBUSA's petition for *inter partes* review that accompanies this Declaration. I understand MBUSA is challenging the validity of all 7 claims ("Challenged Claims"). The Challenged Claims are reproduced below for reference.

Claim 1	
1[pre]	A device for controlling a torque output of an engine, the device comprising:
1[a]	a torque demand controller for generating a torque demand signal; and
1[b]	a torque producer which receives the torque demand signal, the torque producer includes:
1[c]	an estimator which receives as inputs a current spark angle signal, a current air/fuel ratio signal and an estimated air charge signal and outputs an estimated torque signal;
1[d]	a comparator which receives as inputs the estimated torque signal and a desired torque signal and outputs a difference signal;
1[e]	a high pass filter which receives as an input the difference signal and outputs a filtered difference signal in which low frequency components are absent; and
1[f]	a transient torque controller which receives as an input the filtered difference signal and outputs a fuel adjustment signal and a spark adjustment signal.

Claim 2	
2	The device in claim 1, wherein the estimated air charge signal is produced by an air charge controller which receives as inputs an air charge demand signal, a throttle position signal, an engine speed signal, a manifold pressure signal and an air charge temperature signal

Claim 3	
3	The device in claim 2, wherein the air charge demand signal is produced by an air charge demand controller which receives as inputs

	the desired torque signal, a desired spark angle signal and a desired air/fuel.
--	---

Claim 4	
4[a]	The device of claim 1, in which the engine is a direct injection spark ignition engine, wherein the transient torque controller is arranged to receive a combustion mode signal indicating whether the engine is operating in a stratified mode or a homogeneous mode, and
4[b]	wherein the transient torque controller is arranged to control the fuel adjustment signal when the combustion mode signal indicates that the engine is operating in the stratified mode, and
4[c]	wherein the transient torque controller is arranged to control the spark adjustment signal when the combustion mode signal indicates that the engine is operating in the homogeneous mode.

Claim 5	
5	The device in claim 4, wherein the estimated air charge signal is produced by an air charge controller which receives as inputs an air charge demand signal, a throttle position signal, an engine speed signal, a manifold pressure signal and an air charge temperature signal

Claim 6	
6	The device in claim 5, wherein the air charge demand signal is produced by an air charge demand controller which receives as inputs the desired torque signal, a desired spark angle signal and a desired air/fuel.

Claim 7	
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7[pre]	A method for controlling a torque output of an engine, the method comprising:
7[a]	estimating a current torque signal from a received current spark angle signal, a received current air/fuel ratio signal and a received estimated air charge signal;
7[b]	comparing the estimated current torque signal with a desired torque signal to output a difference signal;
7[c]	filtering out a plurality of low frequency components from the difference signal; and
7[d]	controlling a fuel adjustment signal and a spark adjustment signal in dependence upon a filtered difference signal.

IX. CLAIM CONSTRUCTION

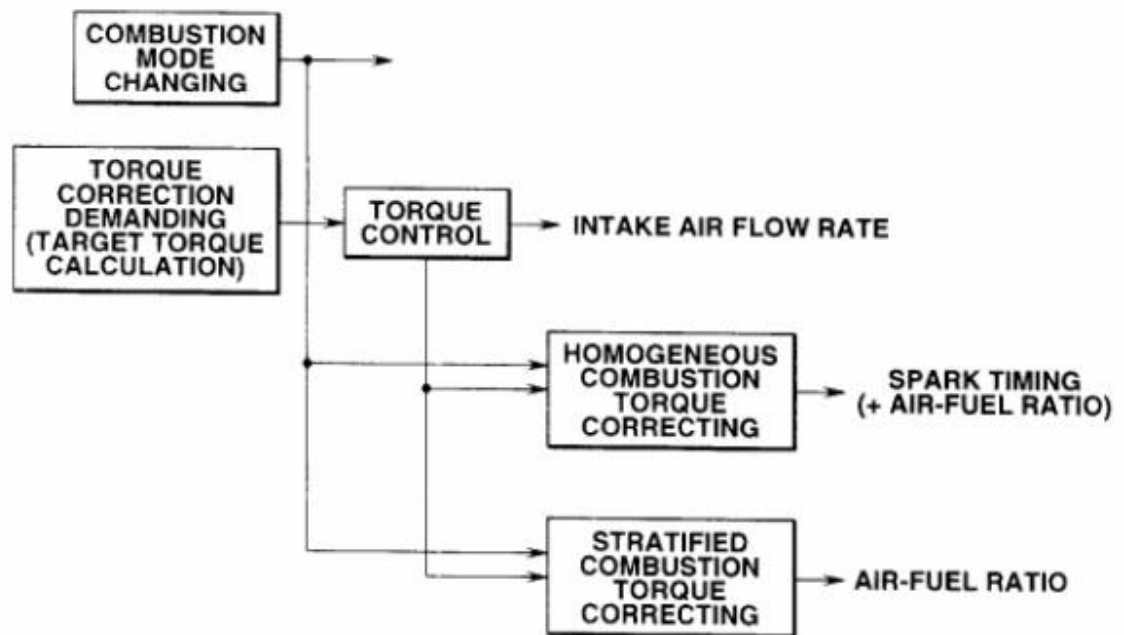
53. It is my understanding that the challenged claims of the '565 patent are to be given their ordinary and customary meaning as understood by one of ordinary skill in the art at the time of the alleged invention in light of the specification and the prosecution history pertaining to the patent. Therefore, for the purposes of this Declaration, all claim terms are given their plain and ordinary meaning.

X. SUMMARY OF PRIOR ART

A. Suzuki

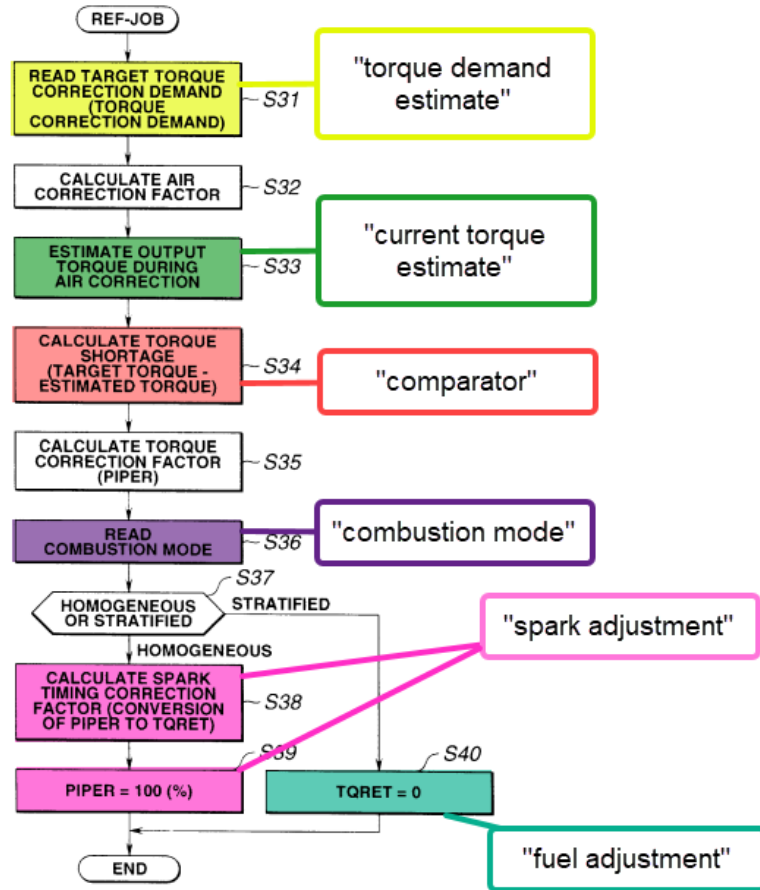
54. Suzuki, like the '565 patent, is directed to controlling the output torque of a direct injection spark ignition ("DISI") engine. Suzuki discloses a "torque correction during both homogeneous combustion and stratified combustion" where "[t]orque correction is made in response to a torque correction demand . . . by

correcting the spark timing . . . during homogeneous combustion and by correcting the air-fuel ratio during stratified combustion.” Ex. 1005 at Abstract. Figure 1B below shows Suzuki’s feedback control loop:



Id. at FIG. 1B.

55. Annotated Figure 6 from Suzuki below demonstrates that Suzuki’s feedback loop parallel the ’565 patent’s recited claim steps:



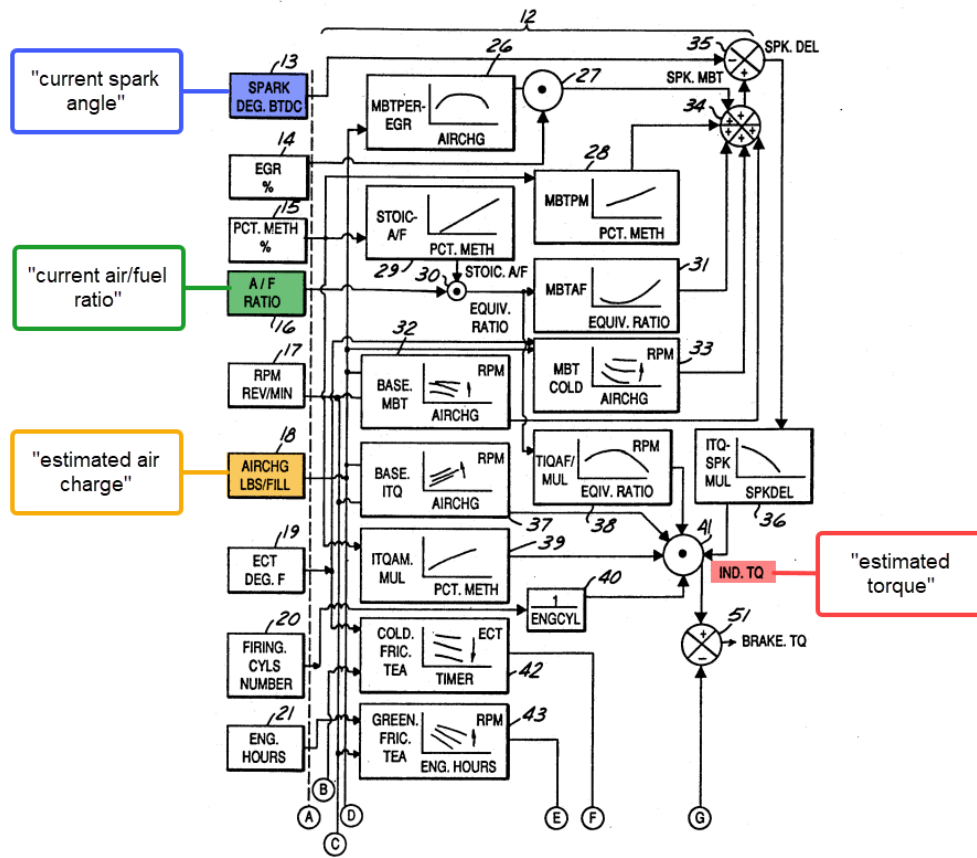
Id. at FIG. 6 (annotated).

56. Also like the '565 patent, Suzuki discloses a controller and method for controlling output torque by comparing a torque demand signal to a signal representing the engine's current torque and adjusting the engine's torque output based on the difference. Suzuki teaches calculating a target torque based on a torque demand control. *Id.* at 7:14-16, FIG. 6 (S31). Suzuki discloses calculating the difference between the demanded torque demand and the current estimated torque by subtracting the estimated torque from the torque demand. *Id.* at 7:33-39, FIG. 6 (S33). Suzuki's method and controller then determine whether the engine

is operating in stratified or homogeneous mode. *Id.* at FIG. 6 (S36)-(S37). Based on the combustion mode, Suzuki discloses adjusting either spark timing (*id.* at FIG. 6 (S38)-(S39)) or air/fuel ratio to control the engine's output torque (*id.* at FIG. 6 (S34)). *Id.* at 7:45-64.

B. Cullen

57. Like the '565 patent and Suzuki, Cullen is directed to an engine controller for “inferring and predicting engine torque [as] a function of . . . speed . . . air/fuel ratio and spark advance.” Ex. 1006 at Abstract. Cullen's engine controller estimates the engine's current torque based on a current spark timing angle 13, a current air/fuel ratio 16, and an estimated air charge 18, and other engine parameters. *Id.* at 4:5-14, 5:35-50, 5:60-6:2. Annotated Figure 3 of Cullen below shows the various inputs Cullen uses to estimate current engine torque:

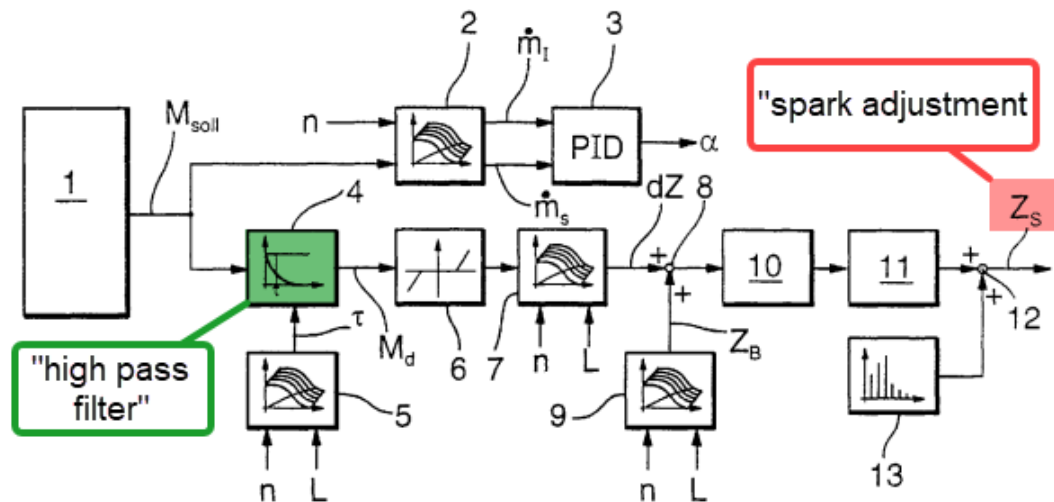


Ex. 1006 at FIG. 3 (annotated).

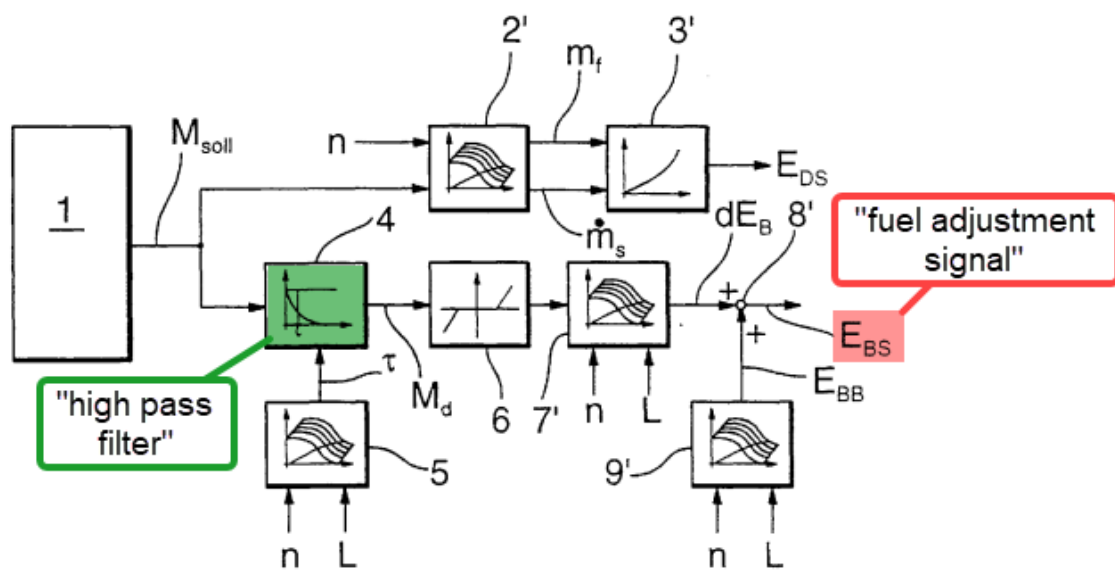
C. Scherer

58. Scherer, like Suzuki, Cullen, and the '565 patent, is directed to “a process and an apparatus for controlling the engine torque of an internal-combustion engine.” Ex. 1007 at Abstract. Scherer’s controller adjusts torque output adjusting “the ignition point . . . of the injection start,” (*i.e.*, spark adjustments), “adjust[ing] . . . the air flow rate,” or adjusting “the fuel injection duration.” *Id.* Scherer also discloses using a high pass filter to filter an input to a torque controller that adjusts torque output through correcting spark timing for homogeneous engine operation or fuel delivery for heterogeneous (*i.e.*, stratified-charged) engine

operation. *Id.* at 2:51-55, 3:49-67, 5:35-55. Annotated Figures 1 and 2 below demonstrate Scherer's high pass filters and spark and fuel adjustment signals:



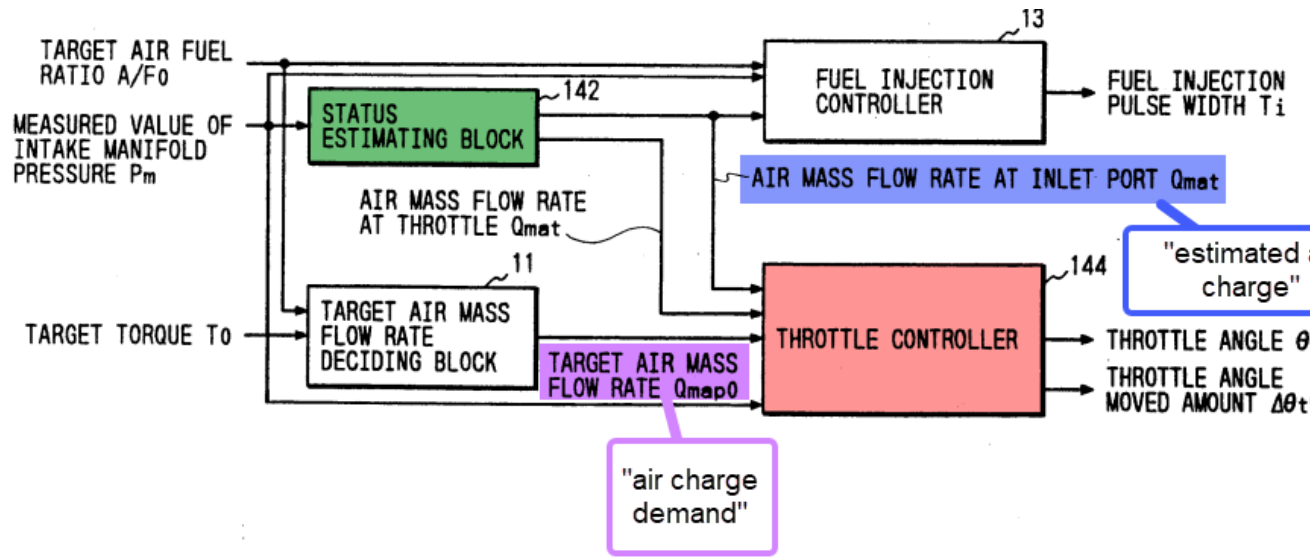
Id. at FIG. 1 (annotated).



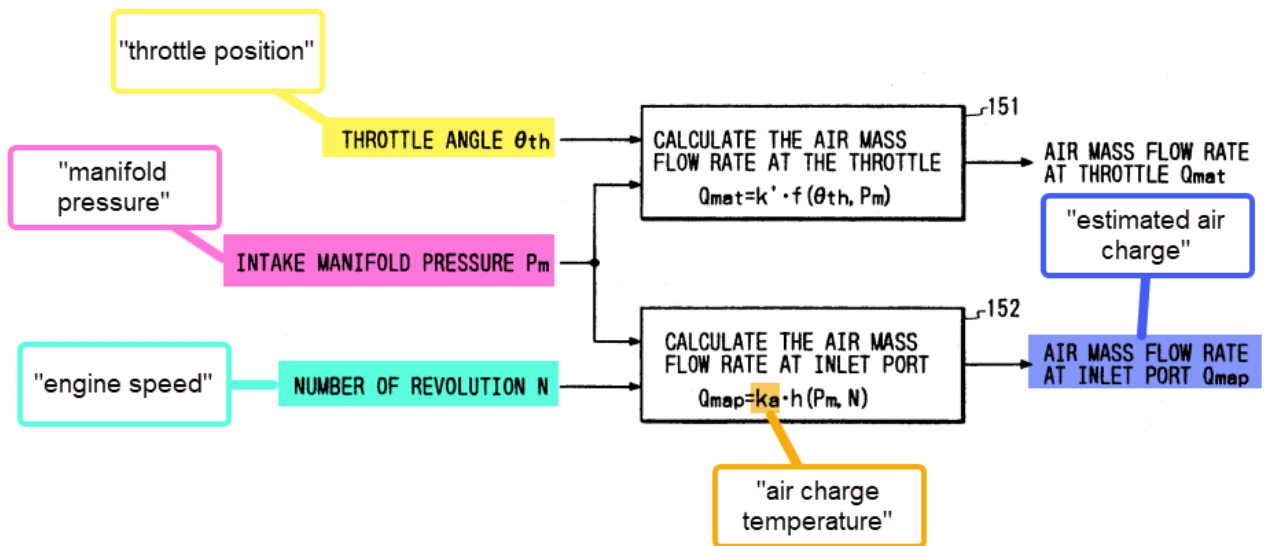
Id. at FIG. 2 (annotated).

D. Takahashi

59. Takahashi, like Suzuki, Cullen, Scherer, and the '565 patent, discloses a method and controller for “control of the engine generated torque.” Ex. 1008 at Abstract. The system taught by Takahashi “control[s] . . . the throttle valve and fuel injection to ensure that the torque and air fuel ratio of the . . . engine will reach target values.” *Id.* at 1:5-9. Takahashi’s controller “comprises [a] status estimating block [142], target air mass flow rate deciding block [11], fuel injection control block 13, and throttle control block [144].” *Id.* at 3:16-24. The controller “determines the throttle angle and the throttle angle moved amount, which achieve the target air mass flow rate.” *Id.* at 6:13-17. Together, the status estimating block and the throttle controller comprise an air charge controller that “achieves the target air mass flow rate” (*i.e.*, air demand air charge) based on current air mass flow rate (*i.e.*, estimated air charge), intake manifold pressure, temperature, throttle angle, and number of engine revolutions (*i.e.*, engine speed). *Id.* at 6:13-17, 10:50-11:21.



Id. at FIG. 14 (annotated).



Id. at FIG. 16 (annotated).

XI. GROUND 1: SUZUKI, CULLEN, AND SC HERER RENDER OBVIOUS CLAIMS 1, 4, AND 7.

60. In my opinion, a POSITA at the time of the alleged invention would have found claims 1, 4, and 7 obvious over Suzuki in view of Cullen and Scherer.

A. Motivation to Combine Suzuki with Cullen and Scherer

61. In my opinion, a POSITA in possession of Suzuki's torque control system would have been motivated to modify the system to include an estimator and high pass filter as claimed in claim 1 of the '565 patent based on Cullen and Scherer's teachings, respectively.

1. Combining Suzuki and Cullen

62. Suzuki discloses a torque estimator. See claim 1[c], *infra*. Similarly, Cullen discloses a torque estimator and additional explanation regarding the inputs its estimator receives—including a current spark angle signal, a current air/fuel ratio signal and an estimated air charge signal—and its estimated torque output signal. In my opinion, a POSITA would have been motivated to modify Suzuki's system to use an estimator with spark and fuel inputs as taught by Cullen because Suzuki already discloses adjusting spark timing (Ex. 1005 at FIG. 6 (S38)-(S39)) or air/fuel ratio (*id.* at FIG. 6 (S34)) to adjust the engine's output torque. In my opinion, a POSITA would understand that modifying Suzuki's estimator to include spark and fuel as taught by Cullen would improve Suzuki's method of calculating spark and fuel adjustment.

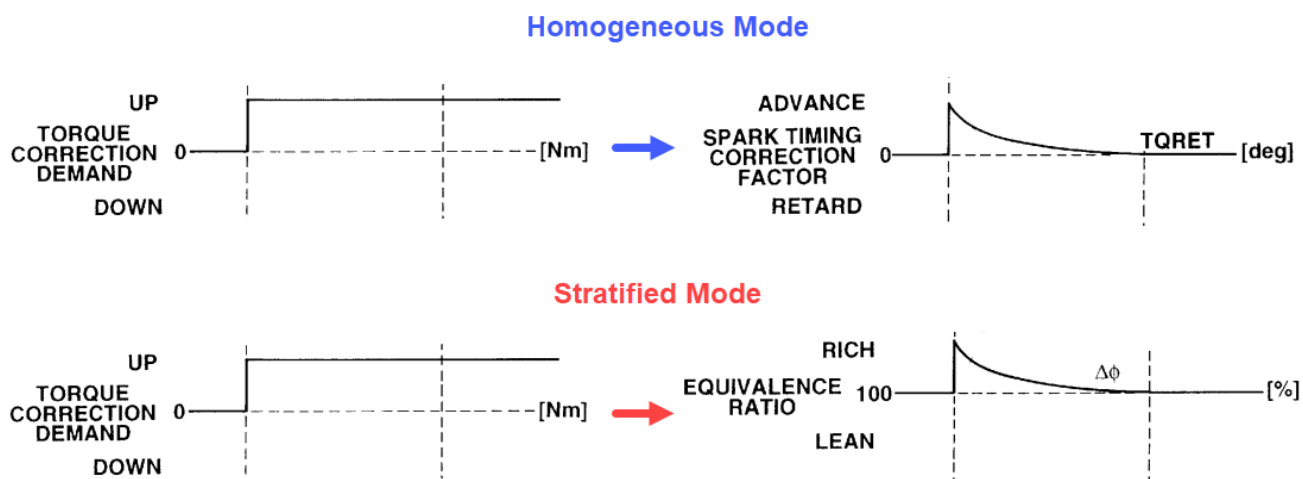
63. Moreover, in my opinion a POSITA would have been motivated to modify Suzuki's system to use an estimator with spark and fuel inputs as taught by Cullen because, as Cullen describes, doing so makes a system's torque estimation

more accurate. Cullen discloses that its torque estimation makes “predicted torque calculation . . . more accurate.” Ex. 1006 at 2:32-40.

64. In addition, in my opinion a POSITA would be motivated to modify Suzuki based on the teachings of Cullen because both references are in the same field of endeavor as the '565 patent: predicting and controlling engine torque. Ex. 1001 at Abstract; Ex. 1005 at Abstract; Ex. 1006 at Abstract. In my opinion, Suzuki and Cullen both also use similar techniques to solve the same problem as the '565 patent. For example, as described herein, Suzuki discloses nearly all of the limitations of the '565 patent's claims 1, 4, and 7, and Cullen discloses claim 1's estimator that takes spark and fuel inputs. In my opinion, a POSITA also would have had a reasonable expectation of success of modifying Suzuki's torque estimator based on the teachings of Cullen because Suzuki already teaches using a microcomputer in its control unit to estimate current torque, and because the inputs taught by Cullen are used in a similar engine. In my opinion, a POSITA would understand that the software running on Suzuki's microcomputer that implements the torque estimation could easily be modified based on the teachings of Cullen to improve the estimation's accuracy by implementing Cullen's method of torque estimation.

2. Combining Scherer with Suzuki and Cullen

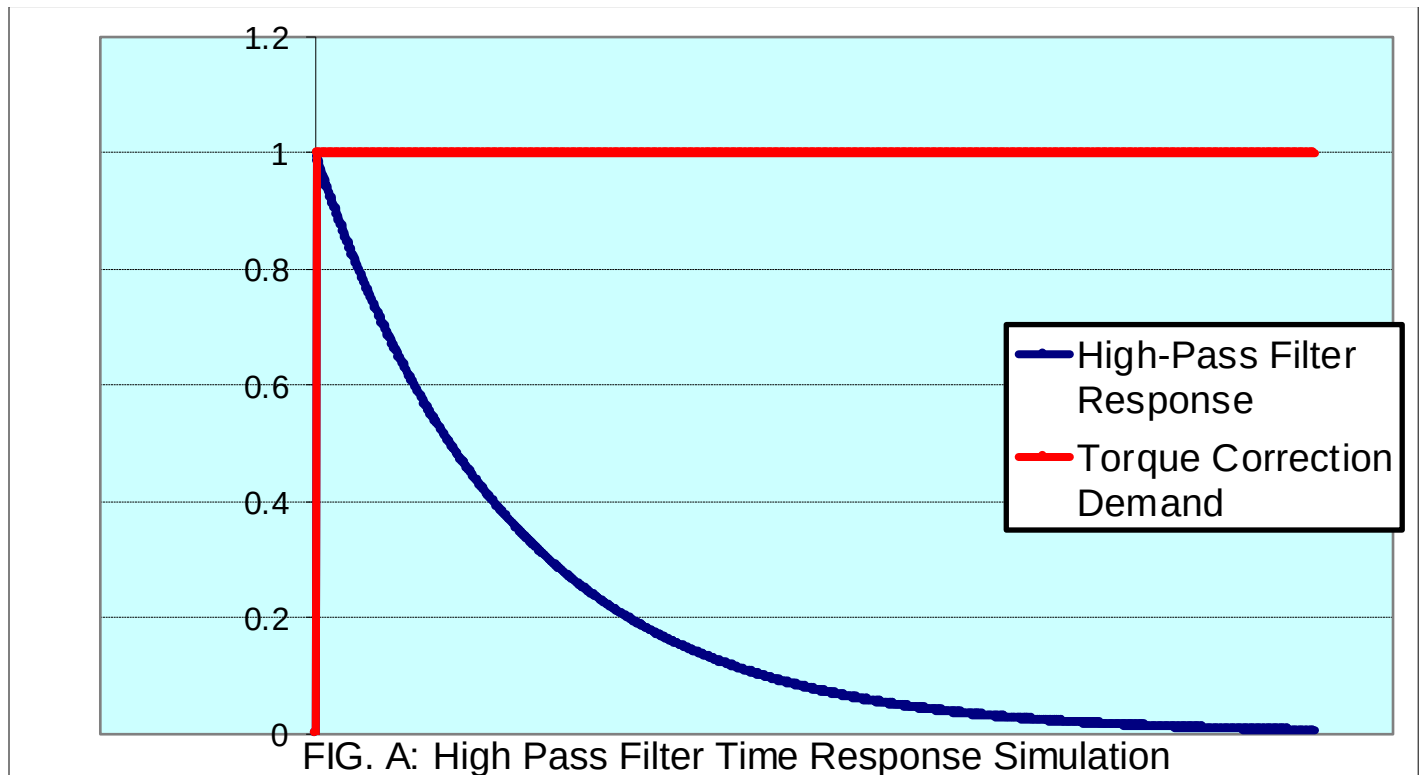
65. In my opinion, even if it was not completely clear that Suzuki did in fact include a high-pass filter to isolate rapid torque transients, a POSITA would have been motivated to modify Suzuki's torque controller to include a high pass filter based on the teachings of Scherer. In my opinion, a POSITA would understand that Suzuki's system already discloses high pass filtering. As shown in excerpted and annotated Figure 13 below, Suzuki's processes its torque correction demand signal into either a spark timing correction signal or an air/fuel ratio adjustment signal, where the processing generates an exponential decay curve.



Ex. 1005 at FIG. 13 (annotated).

66. As demonstrated by Figure A below, the exponential decay curves disclosed in Suzuki's Figure 13 match a high pass filter's response to the torque correction demand signal. Figure A includes two signals: the torque correction demand signal from Suzuki's Figure 13, and the output of a simulated high pass filter

that has the torque correction demand signal as an input. As demonstrated by the high pass filtering simulation in Figure A, the exponential decay curves in Figure 13 match a high pass filter's response to Suzuki's torque correction demand signal.



67. Because Suzuki's spark timing and air/fuel ratio signals match a high pass filter response to Suzuki's torque correction demand signal, in my opinion a POSITA would understand that Suzuki's system generates its spark timing and air/fuel ratio adjustment signals using a high pass filter.

68. Further, in my opinion a POSITA would have been motivated to include a high pass filter in Suzuki's system because it would enable the system to adjust for dynamic changes in torque values more accurately. Scherer describes that its high pass filtering would allow Suzuki's torque controller to "react very

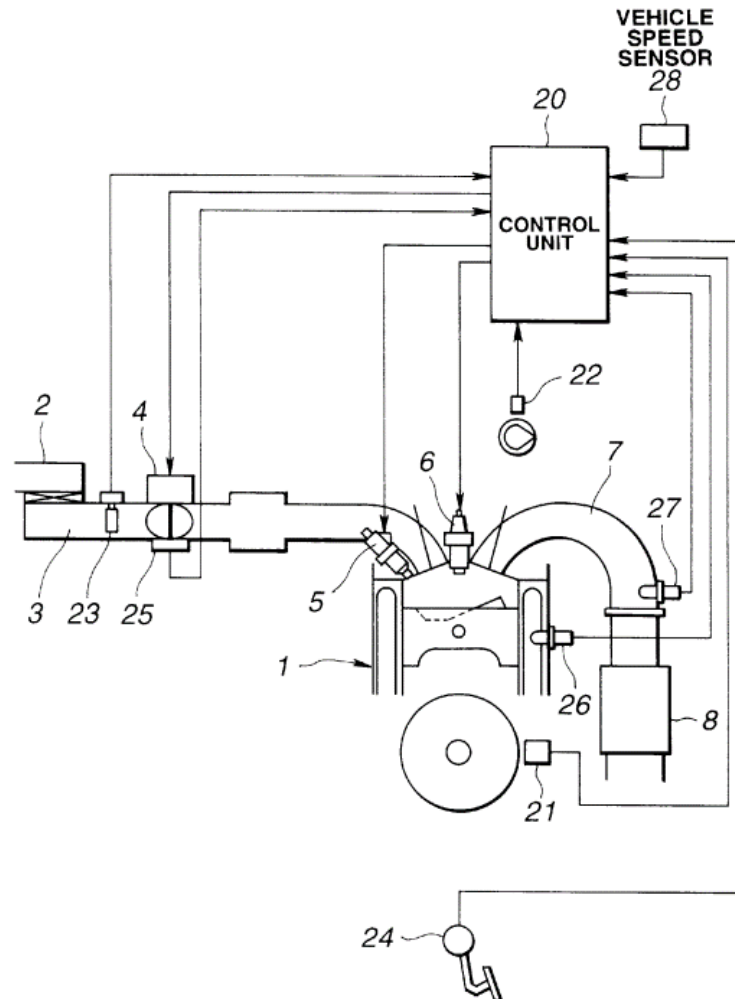
rapidly to sudden changes of the engine torque” arising during transient engine operations. Ex. 1007 at 4:20-25, 4:40-45, 5:10-15.

69. In addition, in my opinion a POSITA would be motivated to modify the combination of Suzuki and Cullen based on the teachings of Scherer because they are all in the same field of endeavor as the '565 patent: predicting and controlling engine torque. Ex. 1001 at Abstract; Ex. 1005 at Abstract; Ex. 1006 at Abstract; Ex. 1008 at Abstract. In my opinion, Suzuki, Cullen, and Scherer all use similar techniques to solve the same problem as the '565 patent. For example, as described herein, Suzuki discloses nearly all of the limitations of the '565 patent's claims 1, 4, and 7, Cullen discloses claim 1's estimator that takes spark and fuel inputs, and Scherer discloses the high pass filter disclosed in claim 1. In my opinion, a POSITA also would have had a reasonable expectation of success of modifying Suzuki's torque control system to include high pass filtering based on the teachings of Scherer at least because Suzuki already teaches high pass filtering, as described above. Further, in my opinion a POSITA would have recognized that the code stored in Suzuki's control unit 20 could be modified to apply a high pass filter to Suzuki's torque difference signal before outputting the difference signal to the rest of the system.

B. Claim 1

1. 1[pre] “A device for controlling a torque output of an engine, the device comprising”

70. In my opinion, Suzuki discloses a device for controlling an engine’s torque output. As further discussed with respect to elements 1[a]-[f], Suzuki discloses a system “for correcting engine torque,” *i.e.*, controlling a torque output of an engine. *Id.* at 1:5-7. For example, Suzuki teaches “torque correction during both homogeneous combustion and stratified combustion” where “[t]orque correction is made in response to a torque correction demand . . . by correcting the spark timing . . . during homogeneous combustion and by correcting the air-fuel ratio during stratified combustion.” Ex. 1005 at Abstract. As shown in Suzuki’s Figure 2 below, Suzuki teaches a “direct-injection spark-ignition engine” 1 connected to a “control unit 20 that receives . . . signals from . . . various sensors,” including crank- or camshaft “angle sensors 21 and 22,” “an airflow meter 23,” “an accelerator sensor 24,” “a throttle valve sensor 25,” and “an O₂ sensor 27.” Ex. 1005 at 3:23-24, 4:6-32. Suzuki’s control unit 20 comprises a microcomputer that performs calculations based on the sensor input “to control the degree of opening of the electronic controlled throttle valve 4, the amount of fuel injected to the engine by the fuel injector 5, and the spark timing of the spark plug 6.” *Id.* at 4:33-38.



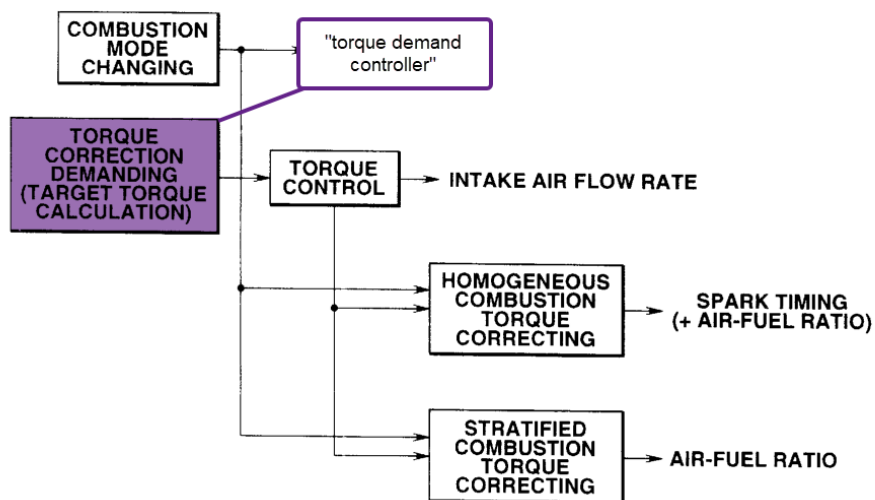
Id. at FIG. 1.

71. Accordingly, in my opinion, Suzuki discloses the preamble of claim 1.

2. 1[a] “a torque demand controller for generating a torque demand signal”

72. In my opinion, Suzuki discloses a torque demand controller for generating a torque demand signal. Suzuki teaches a “torque correction demanding section” (*i.e.*, the claimed “torque demand controller”) that “produces a torque correction demand based on engine operating conditions.” Ex. 1005 at 3:10-12.

For example, the “torque demand control” disclosed by Suzuki comprises “[a] torque calculation section” that “outputs a driver demand torque,” *i.e.*, generates a torque demand signal. *Id.* at 8:7-11.



Id. at FIG. 1B (annotated).

73. Suzuki’s “torque correction demanding” section teaches the claimed “torque demand controller” because it “produces a torque correction demand” indicating a “a demand for increasing or decreasing the torque” and “a target torque” that the system uses to control torque output. *Id.* at 3:10-12; 7:11-19.

74. Further, Suzuki’s torque correction demanding section performs the same functions in the same way as ’565 patent’s torque demand controller. The ’565 patent’s teaches that its “torque demand controller 11 calculates a required output torque signal” based on throttle position and engine operating conditions. Ex. 1001 at 2:57-67. Suzuki teaches a “torque demand control” that calculates “a

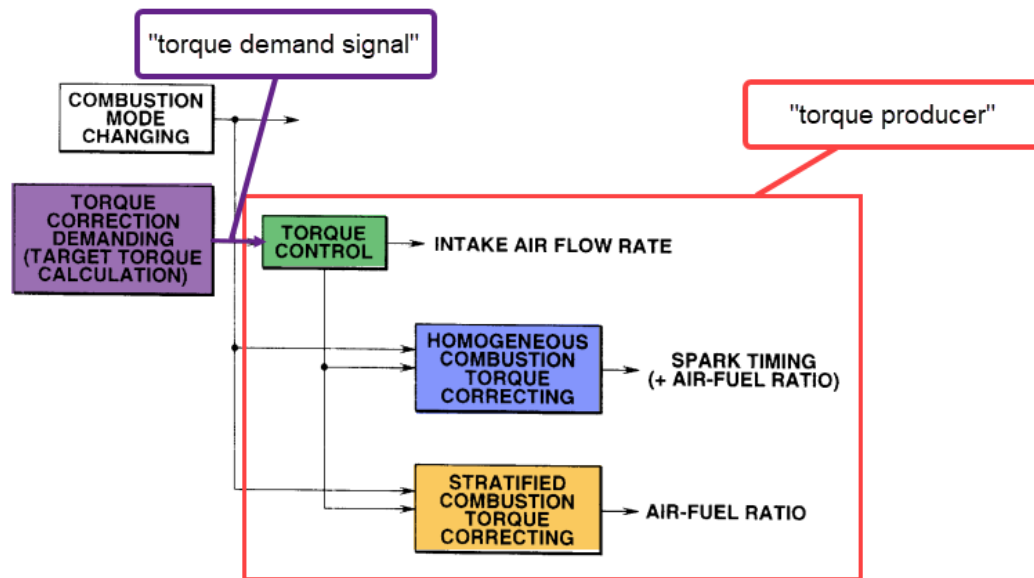
target torque,” *i.e.*, a required output torque signal, that the system uses to control torque output after a change in engine operation. Ex. 1005 at 7:11-17.

75. Accordingly, in my opinion Suzuki discloses claim limitation 1[a].

3. 1[b]: “a torque producer which receives the torque demand signal, the torque producer includes:”

76. In my opinion, Suzuki discloses a torque producer which receives the torque demand signal. Suzuki discloses that its control unit 20 comprises “a torque correction section . . . which receives a torque correction demand and produces a torque correction output in response to the torque correction demand.” Ex. 1005 at claim 1.

77. As shown in the annotated version of Suzuki’s Figure 1B below, Suzuki’s “torque control section is responsive to the torque correction demand” and comprises “a homogeneous combustion torque correcting section [that] corrects at least the spark timing” and “[a] stratified combustion torque correcting section [that] corrects at least the air-fuel ratio.” *Id.* at 3:10-22.



Id. at FIG. 1B (annotated).

78. In my opinion, Suzuki's torque control section, homogeneous combustion torque correction section, and stratified combustion torque correction section disclose claim 1's torque producer.

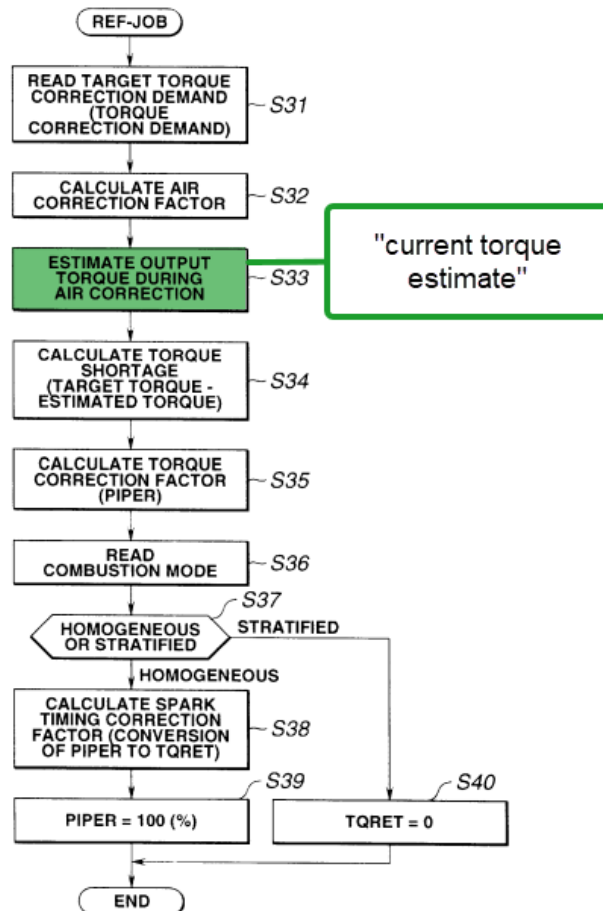
79. Accordingly, in my opinion Suzuki discloses claim limitation 1[b].

4. **1[c]: “an estimator which receives as inputs a current spark angle signal, a current air/fuel ratio signal and an estimated air charge signal and outputs an estimated torque signal;”**

80. In my opinion, Suzuki in view of Cullen renders a torque estimator which receives as inputs a current spark angle signal, a current air/fuel ratio signal, and an estimated air charge signal and outputs an estimated torque signal obvious.

81. Suzuki teaches a controller for a direct injection spark ignition engine that adjusts torque based on the engine's operating conditions by controlling the air-fuel ratio and spark timing. Ex. 1005 at 1:4-7, 1:44-48. Suzuki's control unit 20

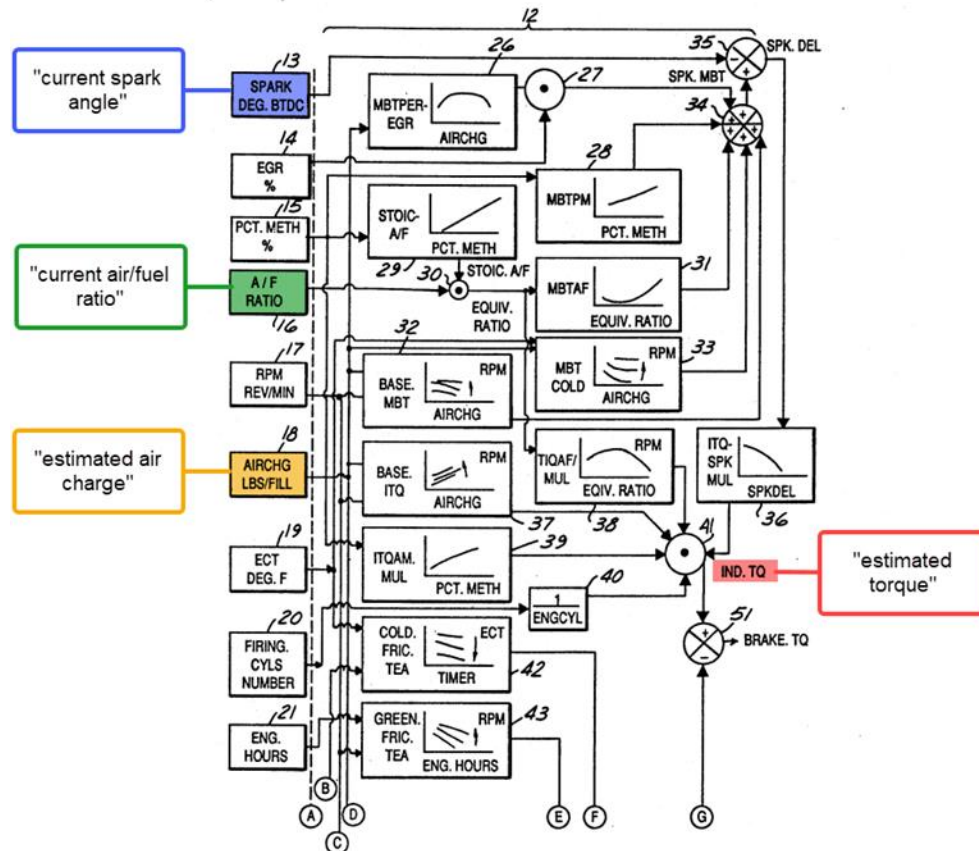
includes an estimator that estimates current torque output, as shown in annotated Figure 6 below. *Id.* at 7:33-34, FIGS. 4-6.



82. Ex. 1005 at FIG. 6 (annotated).

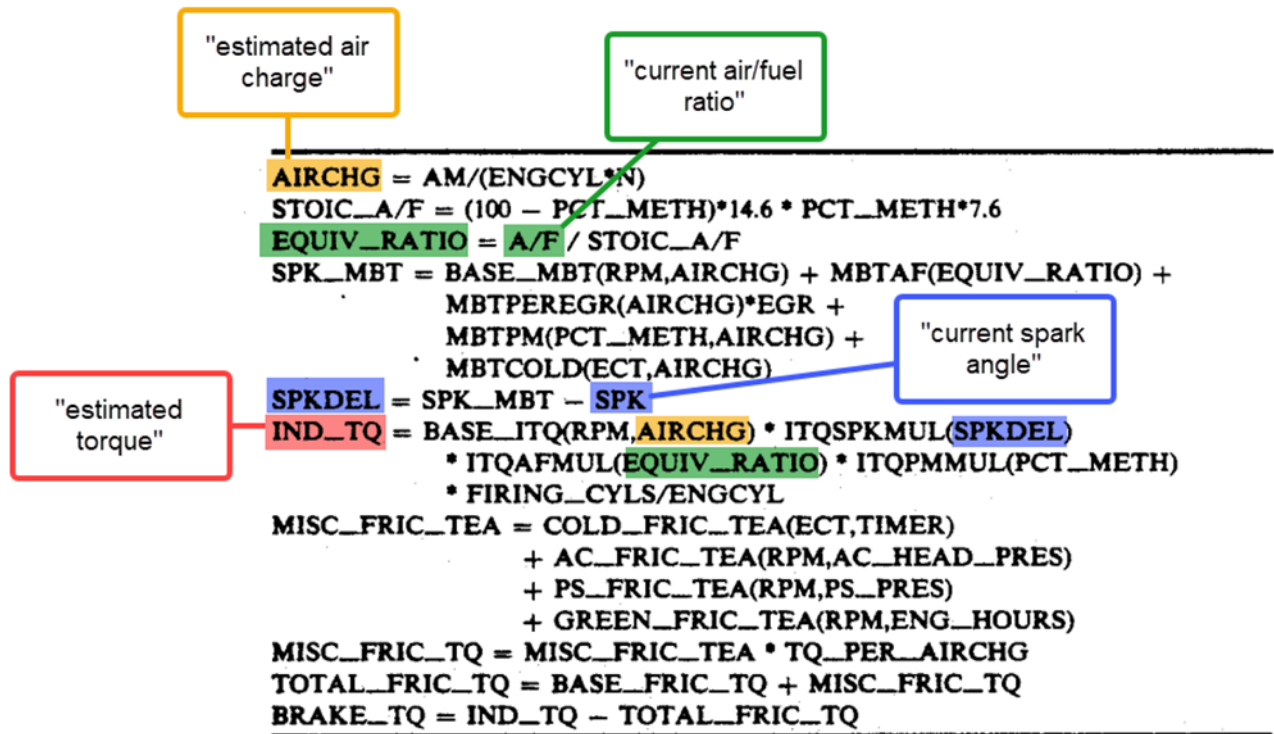
83. Further, Cullen teaches specific implementation details for torque estimation, including an estimator that receives a current spark angle signal, a current air/fuel ratio signal, and an estimated air charge signal as inputs. Cullen's teachings regarding its estimator would have been readily applicable to Suzuki's torque controller. Cullen discloses "an electronic engine control module 12 which includes various algorithms for processing a spark timing input 13 . . . an air/fuel

ratio input 16 . . . [and] an engine air charge input 18” “to provide indicated torque,”
i.e., estimated torque. Ex. 1006 at 5:59-6:2, 6:67-7:2.



Id. at FIG. 3 (annotated).

84. Moreover, Cullen teaches functions that calculate an estimated torque IND_TQ based on an estimated air charge AIRCHG, a current air/fuel ratio A/F, and a current spark angle SPKDEL or SPK. *Id.* at 4:5-15; 5:33-6:2, 6:67-7:2.



Id. at 5:33-53 (annotated).

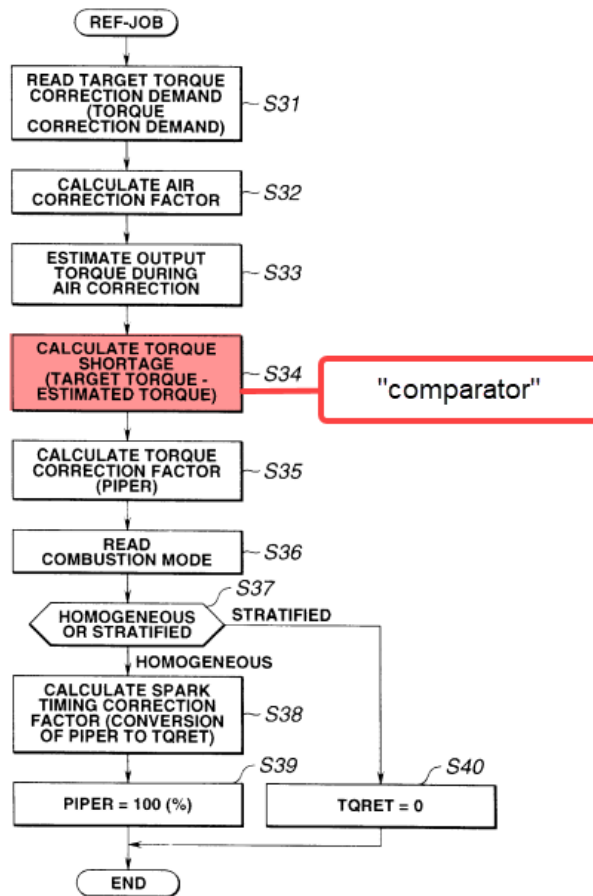
85. In my opinion, a POSITA would have been motivated to modify Suzuki's system to use an estimator with spark and fuel inputs as taught by Cullen because, as Cullen describes, doing so makes a system's torque estimation more accurate. Ex. 1006 at 2:32-40.

86. Additionally, in my opinion a POSITA would understand that the software running on Suzuki's microcomputer that implements the torque estimation could easily be modified based on the teachings of Cullen to improve the estimation's accuracy by implementing Cullen's method of torque estimation.

87. Accordingly, in my opinion Suzuki in view of Cullen renders obvious claim limitation 1[c].

5. **1[d]: “a comparator which receives as inputs the estimated torque signal and a desired torque signal and outputs a difference signal;”**

88. In my opinion, Suzuki clearly discloses a comparator which receives as inputs the estimated torque signal and a desired torque signal and outputs a difference signal. As shown in Suzuki’s Figure 6 below, Suzuki teaches a torque correction section that calculates the difference between estimated torque and target torque to calculate a torque shortage signal (S34). Ex. 1005 at 7:35-39 (“In step S34, the estimated torque is subtracted from the target torque...to calculate the torque shortage”).



Id. at FIG. 6 (annotated).

89. In my opinion, Suzuki's torque correction section discloses a comparator which receives as inputs the estimated torque signal and a desired torque signal and outputs a difference signal.

90. Additionally, Suzuki's torque correction section at S34 performs the same function in the same way as the comparator disclosed in the '565 patent. The '565 patent teaches that its comparator subtracts the current torque estimate from the demanded torque to calculate a torque error signal. Ex. 1001 at 3:34-39, FIG. 3. Suzuki also discloses a torque correction section that subtracts estimated

torque from target torque to calculate a torque shortage. Ex. 1005 at 7:35-39, FIG. 6.

91. Suzuki's further teaches that its calculated torque shortage is a difference signal. Suzuki discloses that "the estimated torque is subtracted from the target torque . . . to calculate the torque shortage," *i.e.*, the difference between the target and estimated torque. *Id.* at 7:35-39.

92. Accordingly, in my opinion, Suzuki discloses claim limitation 1[d].

6. 1[e]: "a high pass filter which receives as an input the difference signal and outputs a filtered difference signal in which low frequency components are absent; and"

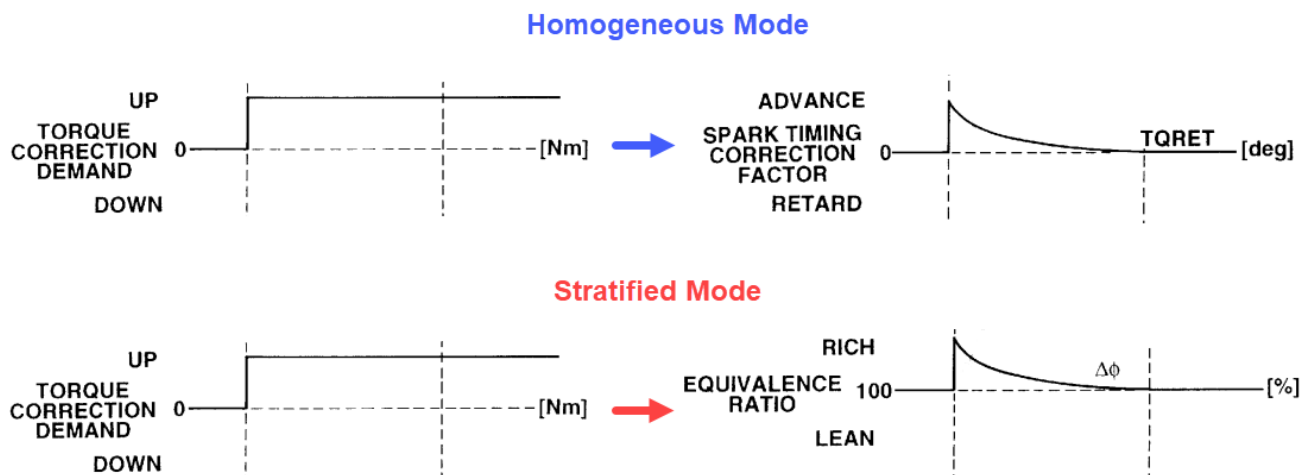
93. In my opinion, Suzuki in view of Scherer renders obvious a high pass filter which receives as an input the difference signal and outputs a filtered difference signal in which low frequency components are absent.

94. Suzuki teaches a controller for a direct injection spark ignition engine that adjusts torque based on engine operating conditions by adjusting the air-fuel ratio and spark timing. Ex. 1005 at 1:4-7, 1:44-48. As explained in Section XI.B.5 above, Suzuki discloses calculating a difference signal, which Suzuki calls a torque shortage.

95. In my opinion, a POSITA would have understood that the correction factor response curves disclosed in Suzuki's Figures 12-15 disclose high pass filtering. As shown in Suzuki's Figure 13 below, Suzuki teaches a torque

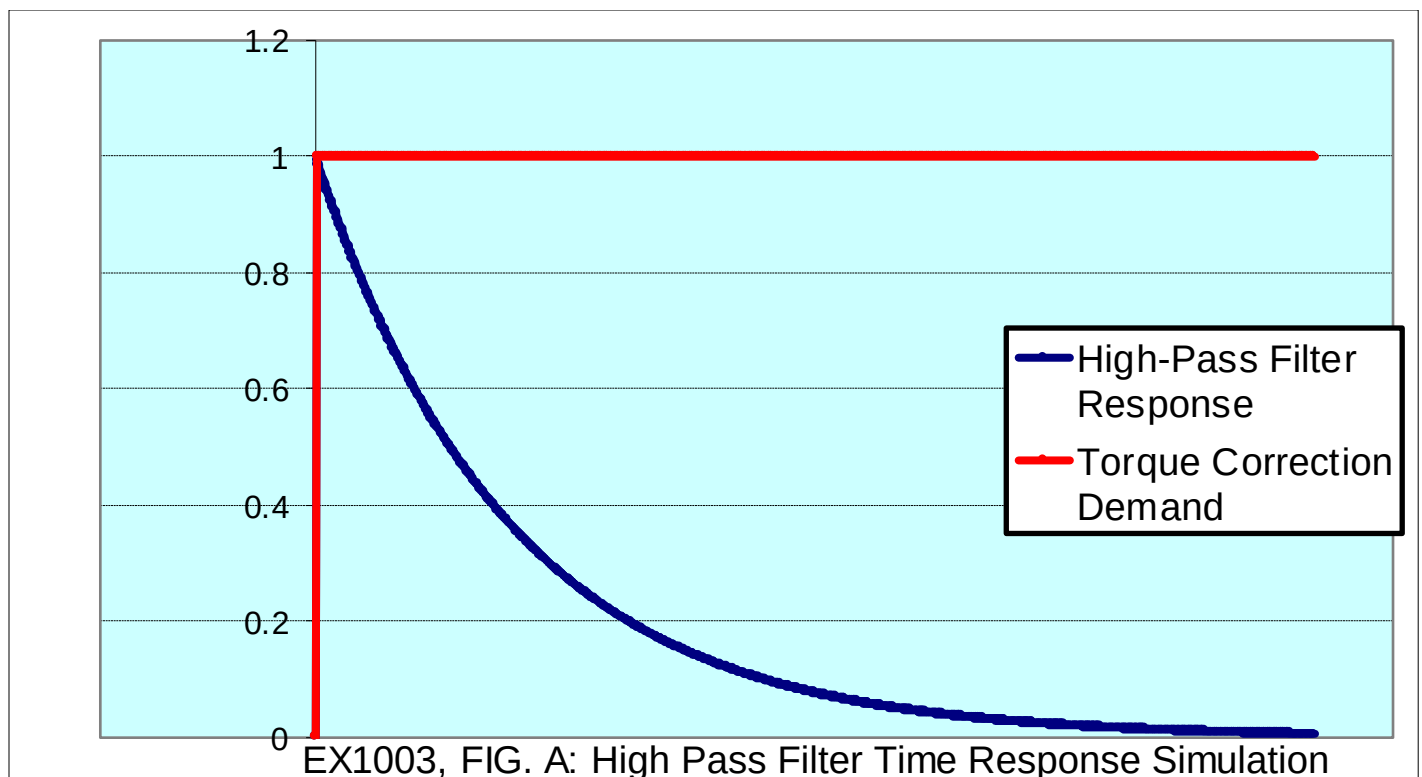
correction demand signal wave that steps from zero up to some positive value. Ex. 1005 at FIG. 13.

96. When Suzuki's engine is operating in the homogeneous combustion mode, Suzuki teaches processing the torque correction demand signal through the torque correction routine shown in Figures 4 and 6 to generate a spark timing correction factor signal. Ex. 1005 at 7:51-58, 8:1-2. When Suzuki's engine is operating in the stratified combustion mode, Suzuki teaches processing the torque correction demand signal through the torque correction routine shown in Figures 5 and 6 to generate a signal representing an air/fuel ratio adjustment signal from . *Id.* at 7:60-64, 8:2-4. As shown in excerpted and annotated Figure 13 below, Suzuki's processing of the torque correction demand signal in either combustion mode generates a signal with an exponential decay curve:



Ex. 1005 at FIG. 13 (annotated).

97. As demonstrated by Figure A below, the exponential decay curves disclosed in Suzuki's Figure 13 match a high pass filter's response to the torque correction demand signal. Figure A includes two signals: the torque correction demand signal from Suzuki's Figure 13, and the output of a simulated high pass filter that has the torque correction demand signal as an input. As demonstrated by the high pass filtering simulation in Figure A, the exponential decay curves in Figure 13 match a high pass filter's response to Suzuki's torque correction demand signal.



98. Because Suzuki's spark timing and air/fuel ratio signals match a high pass filter response to Suzuki's torque correction demand signal, in my opinion a POSITA would understand that Suzuki's system generates its spark timing and air/fuel ratio adjustment signals using a high pass filter.

99. Further, in my opinion Scherer clearly discloses using a high pass filter to filter a signal related to torque demand. Scherer teaches a “high pass filter stage, which precisely determines [a] dynamic desired torque component” from “a signal indicative . . . of the desired engine torque.” Ex. 1007 at 3:59-63; 4:31-38. As shown in Scherer’s Figures 1 and 2 below, Scherer’s system generates spark timing or fuel injection timing signals based on a high-pass filtered torque demand signal.

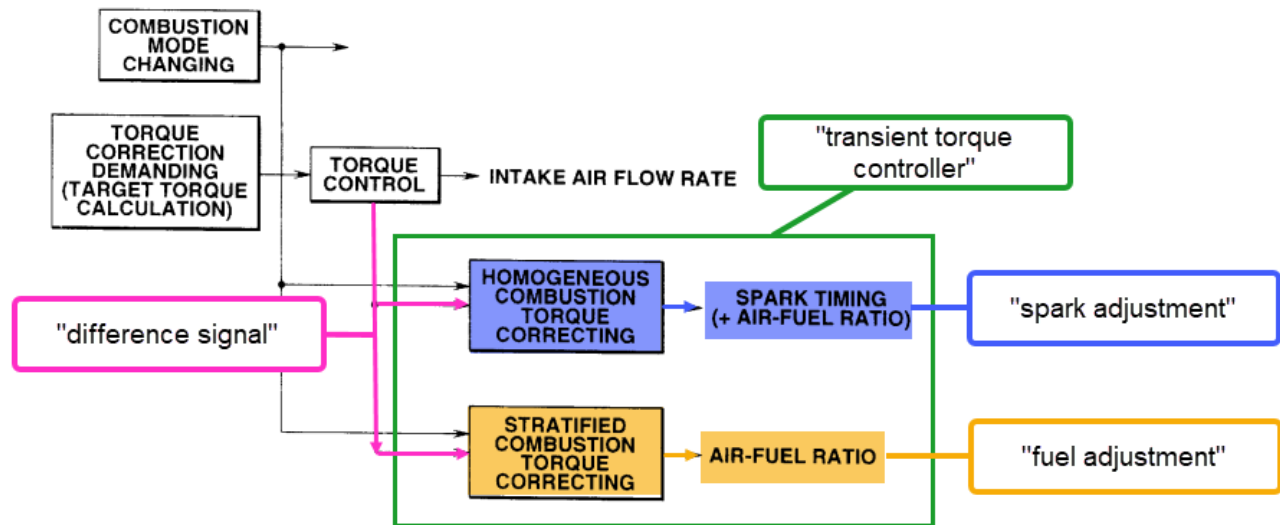
Id. at FIG. 1 (annotated).

102. Accordingly, in my opinion, Suzuki in view of Scherer renders obvious claim limitation 1[e].

7. **1[f]: “a transient torque controller which receives as an input the filtered difference signal and outputs a fuel adjustment signal and a spark adjustment signal.”**

103. In my opinion, Suzuki in view of Scherer renders obvious a transient torque controller which receives as an input the filtered difference signal and outputs a fuel adjustment signal and a spark adjustment signal.

104. As shown in Suzuki’s Figure 1B below, Suzuki’s torque control section includes both “a homogeneous combustion torque correcting section [that] corrects at least the spark timing” and “[a] stratified combustion torque correcting section [that] corrects at least the air-fuel ratio,” and “is responsive to the torque correction demand.” Ex. 1005 at 3:10-22. Therefore, Suzuki’s torque correction section is able to adjust torque “regardless of combustion mode . . . with a fast response to a torque correction demand . . . over the entire range of engine speed,” *i.e.* during transient engine operation *Id.* at 1:44-64.

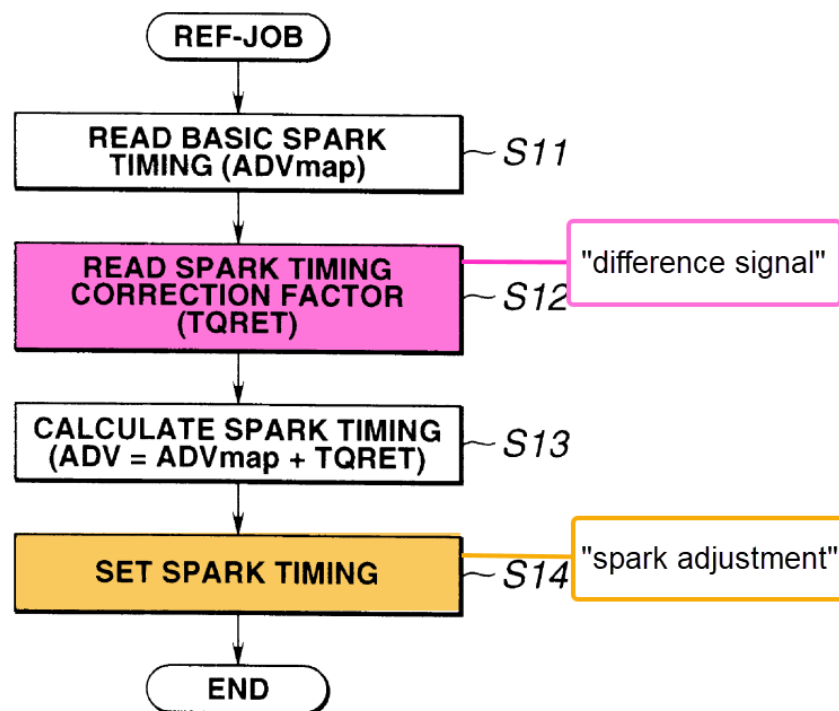


Ex. 1005 at FIG. 1B (annotated).

105. Suzuki discloses that the homogenous combustion torque correcting section generates a “spark timing correction factor” from the torque correction factor, which is itself based on the torque shortage signal (*i.e.*, the “torque difference signal”). *Id.* at 7:51-59. Similarly, Suzuki’s teaches that the stratified combustion torque correcting section generates a “fuel deliver requirement” used to determine a fuel “injection pulse” from the torque correction factor, which is itself based on the torque shortage signal (*i.e.*, the “torque difference signal”). Ex. 1005 at 6:50-57.

106. As shown in Suzuki’s Figure 4 below, Suzuki’s homogenous combustion torque correcting method teaches a “spark timing calculating routine.” Ex. 1005 at 5:41-43. Suzuki teaches reading “the spark timing correction factor TQRET,” which is calculated from a “torque correction factor PIPER” that is based

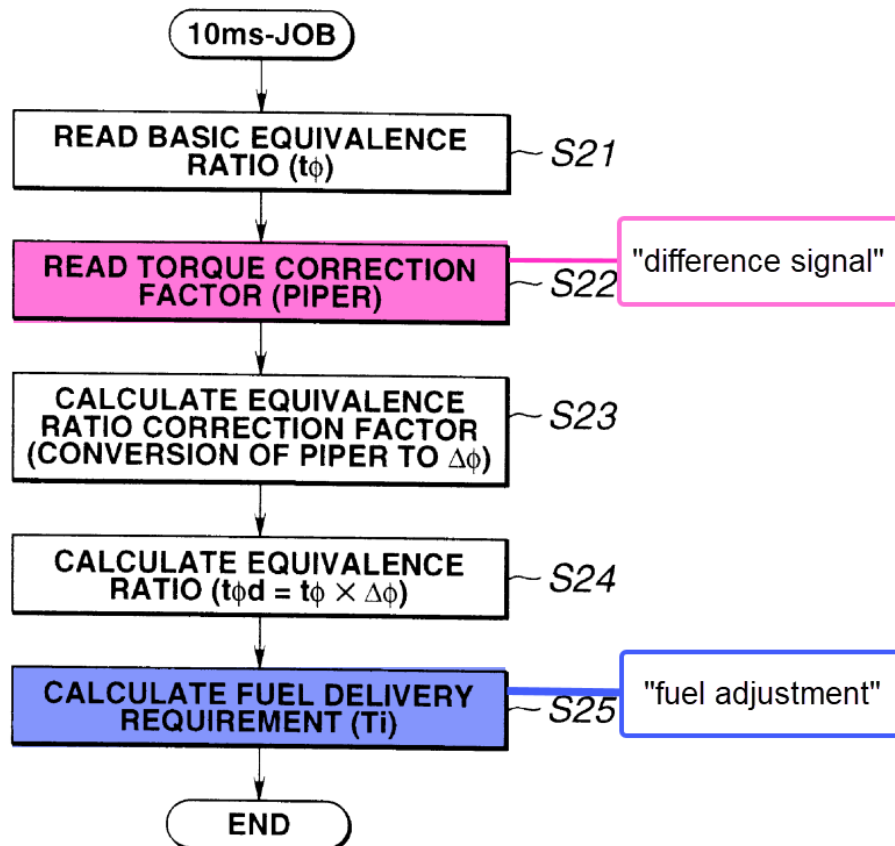
on an input torque shortage, *i.e.*, the difference signal. *Id.* at 5:21-26, 5:41-43, 7:40-44 (“a torque correction factor PIPER . . . is calculated in accordance with the torque shortage”). Suzuki’s method generates an output spark timing change, *i.e.*, a “spark adjustment signal,” in process block S12 with output labeled TQRET. *Ex.* 1005 at 5:59-64.



Id. at FIG. 4 (annotated).

107. As shown in Suzuki’s Figure 5 below, Suzuki’s stratified combustion torque correcting method teaches a “fuel delivery requirement calculating routine.” *Ex.* 1005 at 6:10-12. Suzuki teaches reading “the torque correction factor PIPER” that is calculated from an input torque shortage *i.e.*, a difference signal. *Id.* at 6:20, 5:41-43, 7:40-44 (“a torque correction factor PIPER . . . is calculated in accordance

with the torque shortage”). Suzuki’s method generates a fuel deliver requirement T_i , which determines the fuel injector’s injection pulse, *i.e.*, a “fuel adjustment signal,” by processing the torque correction factor. Ex. 1005 at 6:10-57.



Id. at FIG. 5 (annotated).

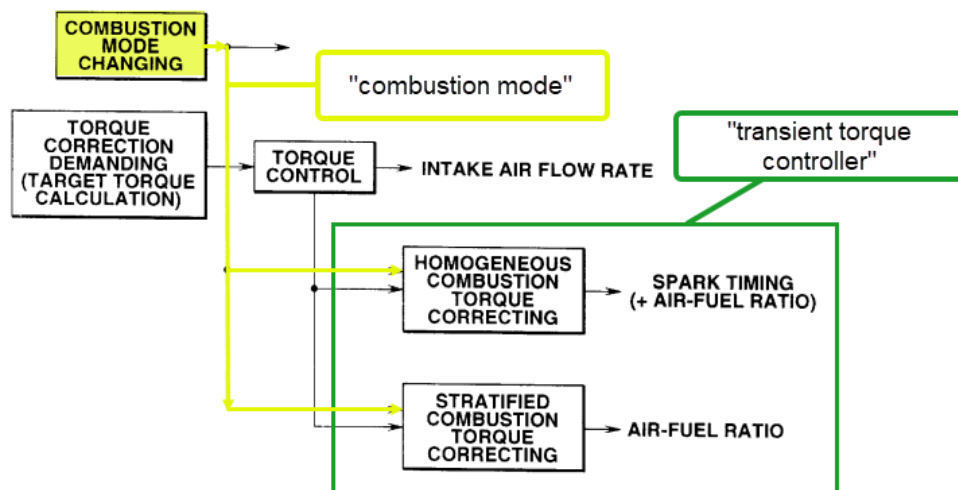
108. Accordingly, in my opinion, Suzuki discloses a transient torque controller which receives as an input a torque difference signal and outputs a fuel adjustment signal and a spark adjustment signal. Additionally, as described above in Section XI.B.6, Suzuki in view of Scherer renders obvious filtering the torque difference signal using a high pass filter.

109. Accordingly, in my opinion, Suzuki in view of Scherer renders obvious claim limitation 1[f].

C. Claim 4:

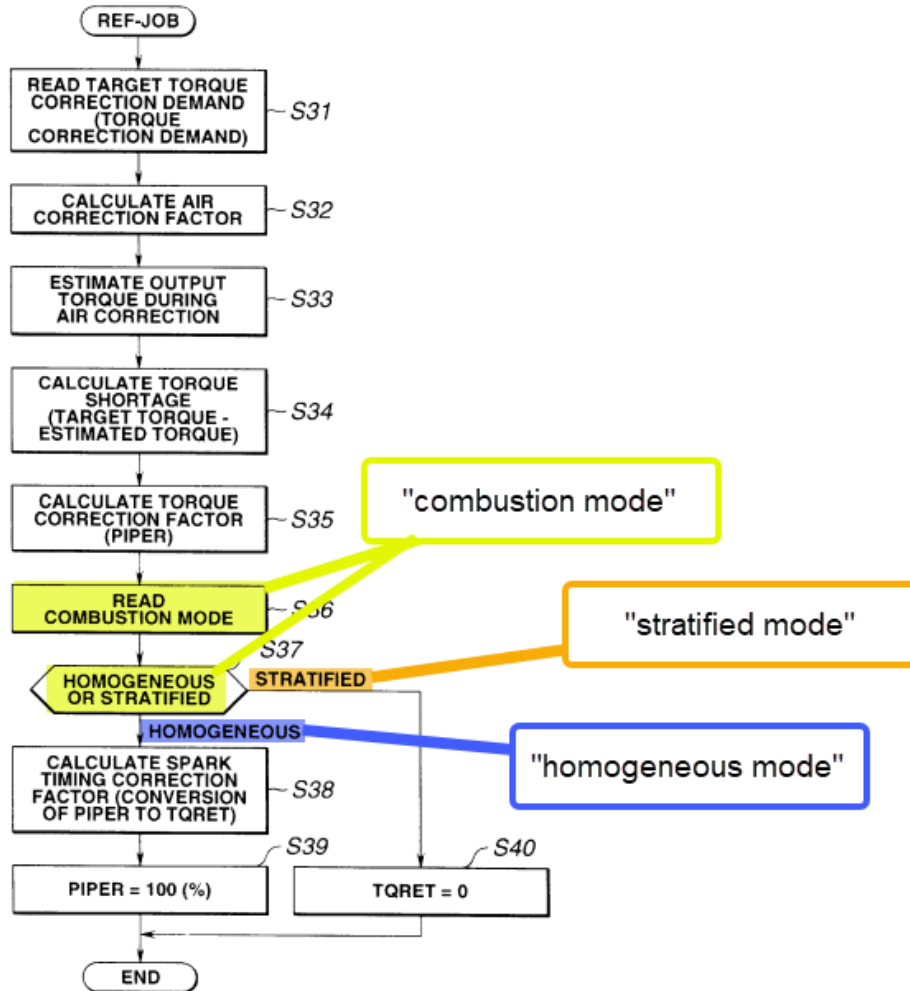
- 1. 4[a]: “The device of claim 1, in which the engine is a direct injection spark ignition engine, wherein the transient torque controller is arranged to receive a combustion mode signal indicating whether the engine is operating in a stratified mode or a homogeneous mode, and”**

110. In my opinion, Suzuki discloses a direct injection spark ignition engine and a transient torque controller wherein the transient torque controller is arranged to receive a combustion mode signal indicating whether the engine is operating in a stratified mode or a homogeneous mode. Suzuki teaches a “controller for a direct-injection spark-ignition type engine.” Ex. 1005 at 3:6-7. Suzuki’s controller comprises “a combustion mode changing section for making a combustion mode change between homogenous combustion and stratified combustion.” *Id.* at 3:7-10. As shown in Suzuki’s Figure 1B below, Suzuki’s homogeneous and stratified torque correction sections receive a combustion mode signal from Suzuki’s combustion mode changing section. Ex. 1005 at 7:45-8:4.



Id. at FIG. 1B (annotated).

111. As shown in Suzuki's Figure 6 below, the signal output from Suzuki's combustion mode changing section into Suzuki's transient torque controller indicates whether the engine is operating in homogeneous or stratified combustion mode. *Id.* at 7:45-50 ("In step S36, the combustion mode is read. In step S37, a determination is made as to whether the combustion mode is homogeneous . . . or stratified.")



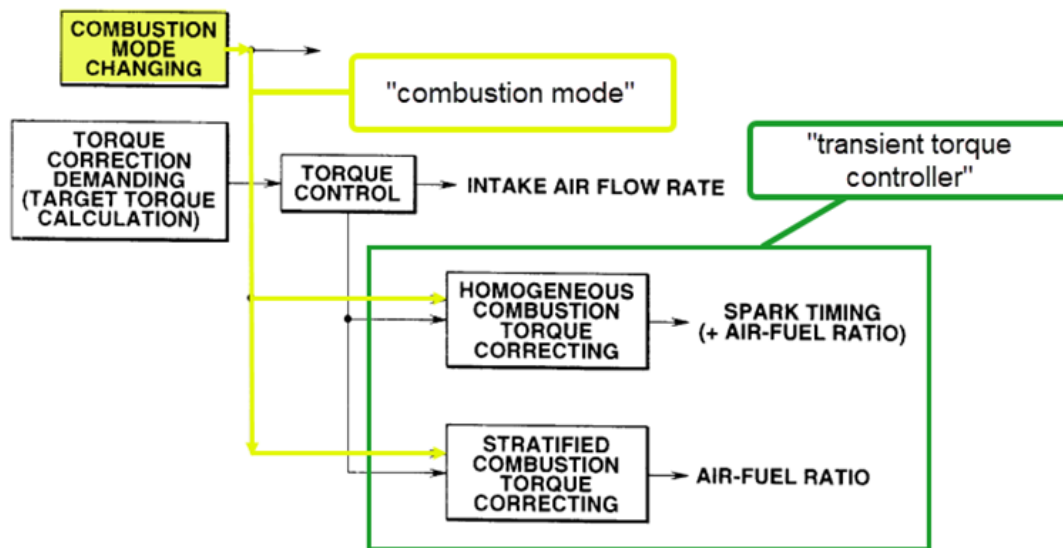
Id. at FIG. 6 (annotated).

112. Accordingly, in my opinion, Suzuki discloses claim limitation 4[a].

2. **4[b]: “wherein the transient torque controller is arranged to control the fuel adjustment signal when the combustion mode signal indicates that the engine is operating in the stratified mode, and”**

113. In my opinion, Suzuki discloses a transient torque controller arranged to control the fuel adjustment signal when the combustion mode signal indicates the engine is operating in the stratified mode. As described in my analysis regarding

claim 1 above, Suzuki's homogeneous and stratified torque correction sections disclose a "transient torque controller."



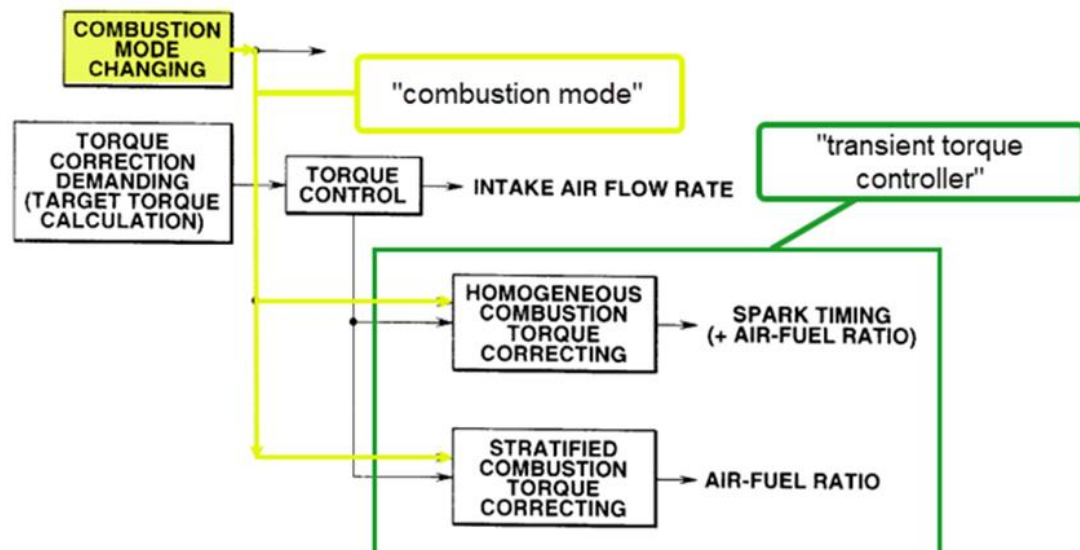
Ex. 1005 at FIG. 1B (annotated).

114. Suzuki discloses that the "stratified combustion torque correcting section corrects at least the air-fuel ratio to make torque correction during stratified combustion." *Id.* at 3:10-22. Suzuki's stratified combustion torque correction section performs a method for calculating a fuel delivery requirement that generates a fuel deliver requirement T_i that is used to adjust the fuel injection pulse signal (*i.e.*, a fuel adjustment signal). *Id.* at 6:10-12; 6:50-57. Suzuki discloses that, using the combustion mode signal, "a determination is made as to whether the combustion mode is . . . stratified." *Id.* at 7:44-50. When Suzuki's system determines the engine is in the stratified combustion mode "control is made according to . . . the fuel delivery requirement calculation routine." *Id.* at 7:65-67.

115. Accordingly, Suzuki discloses claim limitation 4[b].

3. **4[c]: “wherein the transient torque controller is arranged to control the spark adjustment signal when the combustion mode signal indicates that the engine is operating in the homogeneous mode.”**

116. In my opinion, Suzuki discloses a transient torque controller arranged to control the spark adjustment signal when the combustion mode signal indicates the engine is operating in the homogeneous mode. As described in my analysis regarding claim 1 above, Suzuki’s homogeneous and stratified torque correction sections include a “transient torque controller.”



Ex. 1005 at FIG. 1B (annotated).

117. Suzuki discloses that the “homogenous combustion torque correcting section corrects at least the spark timing in order to make a torque correction with a fast response . . . during homogeneous combustion.” *Id.* at 3:10-22. Suzuki’s homogeneous combustion torque correction section performs the calculation of

spark timing adjustment (*i.e.*, a spark adjustment signal). *Id.* at 5:41-6:6. Suzuki discloses that based upon the combustion mode signal, “a determination is made as to whether the combustion mode is homogeneous.” *Id.* at 7:44-50. When the engine is operating in homogeneous combustion mode, “control is made according to the spark timing calculation routine.” 7:65-67.

118. Accordingly, in my opinion, Suzuki discloses claim limitation 4[c].

D. Claim 7:

1. 7[pre]: A method for controlling a torque output of an engine, the method comprising:

119. As shown below, claim 7 recites a method that corresponds to the apparatus of claim 1:

Claim 7	Claim 1
7[pre]: A method for controlling a torque output of an engine, the method comprising:	1[pre]: A device for controlling a torque output of an engine, the device comprising:
7[a]: estimating a current torque signal from a received current spark angle signal, a received current air/fuel ratio signal and a received estimated air charge signal;	1[c]: an estimator which receives as inputs a current spark angle signal, a current air/fuel ratio signal and an estimated air charge signal and outputs an estimated torque signal;
7[b]: comparing the estimated current torque signal with a desired torque signal to output a difference signal;	1[d]: a comparator which receives as inputs the estimated torque signal and a desired torque signal and outputs a difference signal;
7[c]: filtering out a plurality of low frequency components from the difference signal; and	1[e]: a high pass filter which receives as an input the difference signal and outputs a filtered difference signal in which low frequency components are absent; and

7[d]: controlling a fuel adjustment signal and a spark adjustment signal in dependence upon a filtered difference signal.	1[f]: a transient torque controller which receives as an input the filtered difference signal and outputs a fuel adjustment signal and a spark adjustment signal.
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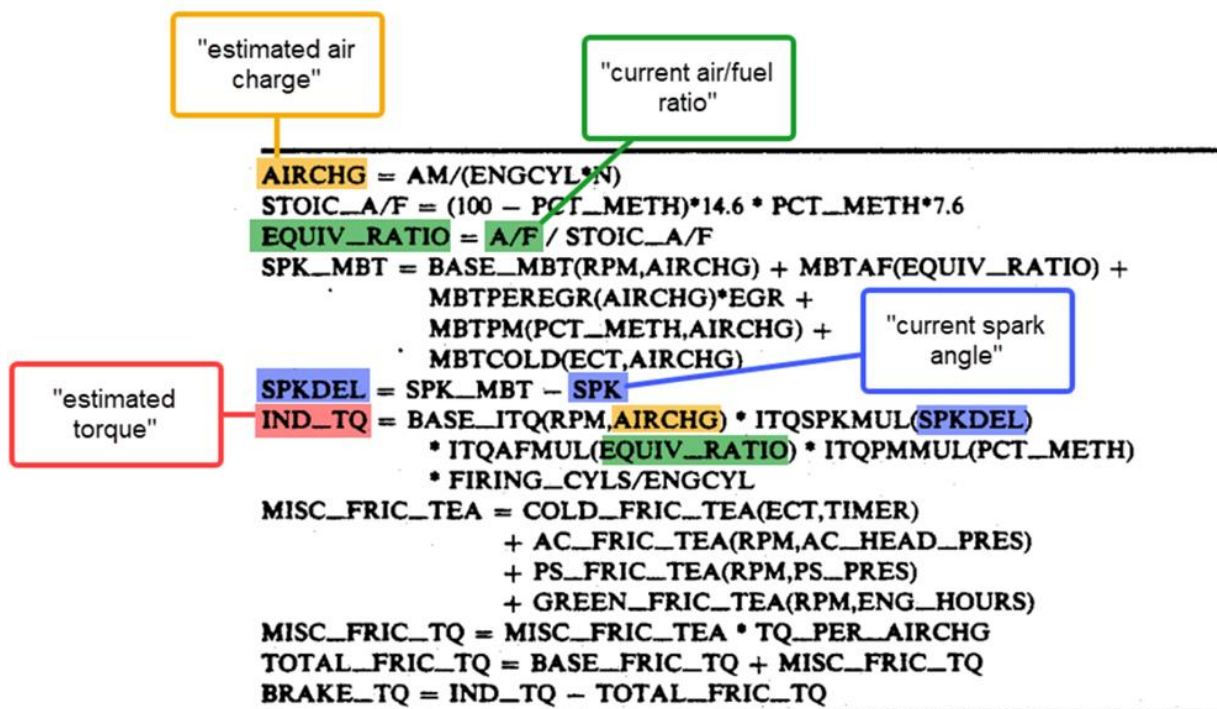
120. In my opinion, Suzuki discloses a method for controlling a torque output of an engine. 7[pre] is a method claim preamble that corresponds to the device claim preamble 1[pre], which, as explained in Section XI.B.1 above, is disclosed by Suzuki. Suzuki's Figure 6 teaches "a torque correcting routine" that corrects engine torque based on "a torque increase demand" or "torque decrease demand," *i.e.*, a method for controlling a torque output of an engine. Suzuki, 7:10-44.

121. Accordingly, in my opinion Suzuki discloses claim limitation 7[pre], including for at least the same reasons as 1[pre].

2. 7[a]: estimating a current torque signal from a received current spark angle signal, a received current air/fuel ratio signal and a received estimated air charge signal;

122. In my opinion, Suzuki in view of Cullen renders obvious estimating a current torque signal from a received current spark angle signal, a received current air/fuel ratio signal and a received estimated air charge signal. 7[a] is a method claim limitation that corresponds to the device claim limitation 1[c], which, as explained in Section XI.B.4 above, is rendered obvious by Suzuki in view of Cullen. Suzuki teaches "the output torque during intake air correction is estimated." Ex. 1005 at 7:33-34.

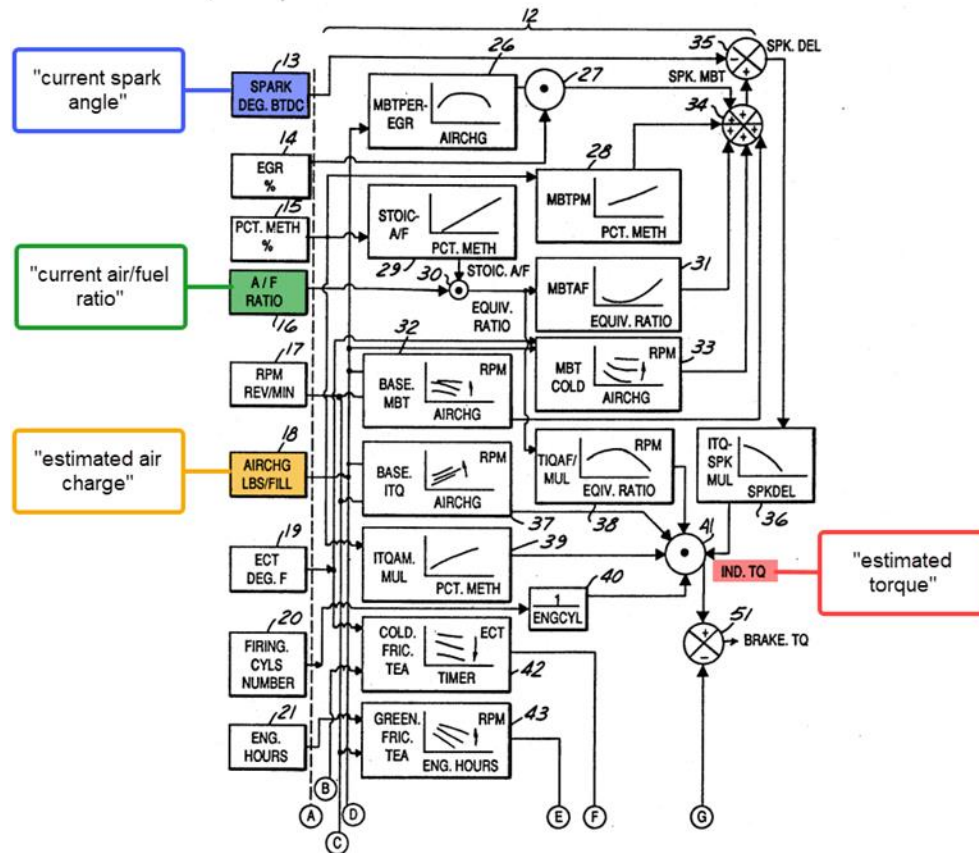
123. Cullen discloses specific implementation details for torque estimation, including an estimator that receives a current spark angle signal, a current air/fuel ratio signal, and an estimated air charge signal as inputs. Cullen's teachings regarding its estimator would have been readily applicable to Suzuki's torque controller. Cullen discloses "an electronic engine control module 12 which includes various algorithms for processing a spark timing input 13 . . . an air/fuel ratio input 16 . . . [and] an engine air charge input 18" "to provide indicated torque," i.e., a calculated torque estimate. Ex. 1006 at 5:59-6:2, 6:67-7:2.



Id. at 5:33-53 (annotated).

124. Moreover, as shown below in Figure 3, Cullen discloses "an electronic engine control module 12 which includes various algorithms for processing a spark

timing input 13 . . . an air/fuel ratio input 16 . . . [and] an engine air charge input 18”
 “to provide indicated torque,” i.e., estimated torque. Ex. 1006 at 5:59-6:2, 6:67-7:2.



Id. at FIG. 3 (annotated).

125. Accordingly, in my opinion Suzuki in view of Cullen renders obvious claim limitation 7[a], including for at least the same reasons as claim limitation 1[c].

3. 7[b]: comparing the estimated current torque signal with a desired torque signal to output a difference signal;

126. In my opinion, Suzuki discloses comparing the estimated current torque signal with a desired torque signal to output a difference signal. 7[b] is a method

claim limitation that corresponds to the device limitation 1[d], which, as explained in Section XI.B.5 above, is disclosed by Suzuki. Suzuki teaches a torque correction section that calculates the difference between estimated torque and target torque to calculate a torque shortage signal (S34). Ex. 1005 at 7:35-39 (“In step S34, the estimated torque is subtracted from the target torque...to calculate the torque shortage”).

127. Accordingly, in my opinion Suzuki discloses claim limitation 7[b], including for at least the same reasons as claim limitation 1[d].

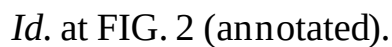
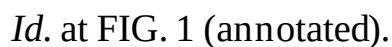
4. 7[c]: filtering out a plurality of low frequency components from the difference signal; and

128. In my opinion, Suzuki and Cullen in view of Scherer disclose filtering out a plurality of low frequency components from the difference signal. 7[c] is a method claim limitation that corresponds to the device limitation 1[e], which, as explained in Section XI.B.6 above, is rendered obvious by Suzuki and Cullen in view of Scherer.

129. 91. As explained with regard to claim limitation 1[e] above, in my opinion a POSITA would have understood that the correction factor response curves disclosed in Suzuki’s Figures 12-15 disclose high pass filtering.

130. Further, in my opinion Scherer specifically discloses using a high pass filter to process a signal related to torque demand. Scherer teaches a “high pass filter stage, which precisely determines [a] dynamic desired torque component” (the

Ex. 1007 at 3:59-63; 4:31-38. As shown in Scherer's Figures 1 and 2 below, Scherer's system generates spark timing or fuel injection timing signals based on a high-pass filtered torque demand signal.



131. As explained above with regard to limitation 1[e], in my opinion it would have been obvious to a POSITA to modify Suzuki to use high pass filtering on use Suzuki's torque shortage, (*i.e.*, "the difference signal"), based on the teachings of Scherer because such modifications would enable Suzuki's torque controller to "react very rapidly to sudden changes of the engine torque," arising during transient engine operations. Ex. 1007 at 4:20-25, 4:40-45, 5:10-15.

132. Accordingly, in my opinion, Suzuki and Cullen in view of Scherer render claim limitation 7[c] obvious, including for at least the same reasons as limitation 1[e].

5. 7[d]: controlling a fuel adjustment signal and a spark adjustment signal in dependence upon a filtered difference signal.

133. In my opinion, Suzuki and Cullen in view of Scherer render obvious controlling a fuel adjustment signal and a spark adjustment signal in dependence upon a filtered difference signal. 7[d] is a method claim limitation that corresponds to the device limitation 1[f], which, as explained in Section XI.B.7 above, is rendered obvious by Suzuki and Cullen in view of Scherer.

134. Suzuki discloses that the homogenous combustion torque correcting section generates a "spark timing correction factor" from the torque correction factor, which is itself based on the torque shortage signal (*i.e.*, the "torque difference signal"). Id. at 7:51-59. Similarly, Suzuki's teaches that the stratified

combustion torque correcting section generates a “fuel deliver requirement” used to determine a fuel “injection pulse” from the torque correction factor, which is itself based on the torque shortage signal (i.e., the “torque difference signal”). Ex. 1005 at 6:50-57. Moreover, Suzuki teaches that its spark timing adjustments and air-fuel ratio adjustments are made based on processing of a torque shortage (difference) signal (i.e., the “torque difference signal”). Suzuki, 6:50-57, 7:51-59.

135. As described above with regard to limitation 7[c], Suzuki in view of Scherer renders filtering the low frequency components of the torque difference signal obvious.

136. Accordingly, in my opinion Suzuki and Cullen in view of Scherer discloses claim limitation 7[d], including for at least the same reasons as limitation 1[f].

XII. GROUND 2: THE COMBINATION OF SUZUKI, CULLEN, SCHERER, AND TAKAHASHI RENDERS OBVIOUS CLAIMS 2, 3, 5, AND 6.

137. In my opinion, a POSITA at the time of the alleged invention would have found claims 2, 3, 5, and 6 obvious over Suzuki in view of Cullen, Scherer, and Takahashi.

A. Motivation to Combine Suzuki, Cullen, Scherer, and Takahashi

138. In my opinion, a POSITA would have been motivated to modify the combination of Suzuki, Cullen, and Scherer I described in Section XI.A to include

an air charge controller and air charge demand controller based on the teachings of Takahashi.

139. In my opinion, a POSITA would have been motivated to modify Suzuki's air charge controller and air charge demand controller to the methods for calculating air charge estimate and air charge demand as taught by Takahashi because Takahashi's methods "ensure a high precision control of the torque to reach a target value." Ex. 1008 at 1:43-48. As discussed below with regard to claims 2, 3, 5, and 6, Suzuki discloses an air charge controller and an air charge demand controller. Similarly, Takahashi teaches an air charge controller that receives an air charge demand signal, a throttle position signal, an engine speed signal, a manifold pressure signal, and an air charge temperature signal as inputs, and generates estimated air charge output signal. *Id.* Takahashi further teaches an air charge demand controller that receives a desired torque signal, a desired air/fuel ratio signal, and a desired spark angle signal as inputs, and generates an air charge demand output signal. *Id.*

140. Takahashi teaches that its air charge demand generating and its air charge estimating methods "ensure a high precision control of the torque to reach a target value." Ex. 1008 at 1:43-48. Accordingly, in my opinion, a POSITA would have been motivated to use an air charge controller and air charge demand controller that receive the inputs taught by Takahashi because doing so would

“ensure a high precision control of the torque to reach a target value.” Ex. 1008 at 1:43-48. Modifying Suzuki’s based on Takahashi’s teachings to ensure high precision control of torque would further support Suzuki’s goal of “ensur[ing] optimum torque correction.” Ex. 1005 at 139-43.

141. Further, in my opinion a POSITA would understand it would have been trivial to modify Suzuki’s control unit 20 based on Takahashi’s teachings. A POSITA would have understood that Suzuki’s control unit 20 could be modified to receive the input signals described in Takahashi, including the air charge demand signal Q_{map0} , the throttle position signal θ_{th} , the intake manifold pressure signal P_m , the engine speed signal N , and an air charge temperature signal. Moreover, a POSITA would recognize that the code stored in Suzuki’s control unit 20 could be easily modified to implement the air charge estimation functions taught by Takahashi.

142. Additionally, a POSITA would be motivated to combine the teachings of Suzuki, Cullen, Scherer, and Takahashi because they are all in the same field of endeavor as the ’565 patent: predicting and controlling engine torque. Ex. 1001 at Abstract; Ex. 1005 at Abstract; Ex. 1006 at Abstract; Ex. 1007 at Abstract; Ex. 1008 at Abstract. As discussed herein, Suzuki, Cullen, Scherer, and Takahashi all use similar techniques to solve the same problem as the ’565 patent. Suzuki discloses the majority of the limitations of claims 1, 4, and 7 of the ’565 patent. Cullen

discloses claim 1's estimator. Scherer discloses claim 1's high pass filtering. Finally, Takahashi discloses the air charge controller and air charge demand controller claimed by claims 2, 3, 5, and 6. Moreover, in my opinion a POSITA would have had a reasonable expectation of success of modifying Suzuki's torque control system based on Takahashi's teachings regarding its air charge controller and air charge demand controller because Suzuki already teaches using a microcomputer to calculate an air correction factor, which would include calculating an estimated air charge and an air charge demand. In my opinion, a POSITA would have recognized Suzuki's torque estimation code could be modified to implement a method of calculating an estimated air charge and a demanded air charge as taught by Takahashi to improve accuracy.

B. Claims 2 and 5: “The device in claim 1/4, wherein the estimated air charge signal is produced by an air charge controller which receives as inputs an air charge demand signal, a throttle position signal, an engine speed signal, a manifold pressure signal, and an air charge temperature signal”

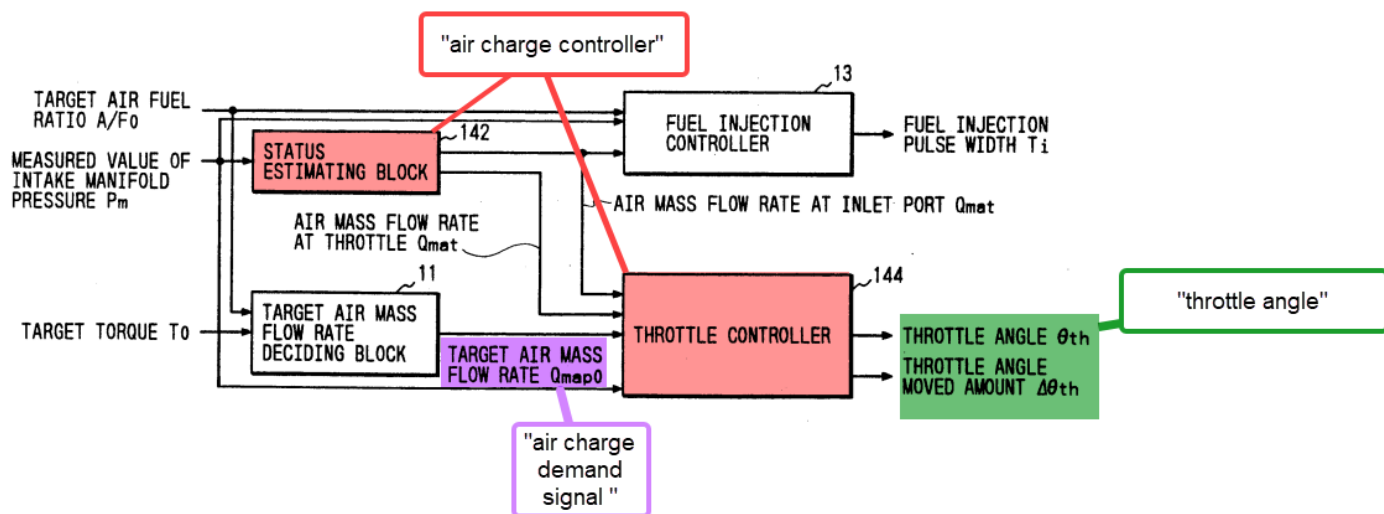
143. In my opinion, Suzuki in view of Cullen, Scherer, and Takahashi renders obvious claims 2 and 5. Claims 2 and 5 depend from claims 1 and 4, respectively, and recite “wherein the estimated air charge signal is produced by an air charge controller which receives as inputs an air charge demand signal, a throttle position signal, an engine speed signal, a manifold pressure signal and an air charge

temperature signal.” Ex. 1001 at claim 2, claim 5. As explained herein, Suzuki in view of Cullen and Schererrender claims 1 and 4 obvious.

144. Further, a POSITA would have understood the plain and ordinary meaning of the term “air charge” is the quantity of air mass that is drawn into the engine cylinder. Ex. 1009 at 176. A POSITA would also recognize that air charge cannot be measured directly, and thus it is estimated from air mass flow rate at the engine intake. Ex. 1009 at 176 (defining “air charge” as “the mass of air that is drawn into the cylinder” and explaining “[t]here is no practically feasible way of measuring [air charge] directly” but “the air charge can be determined from the mass flow rate of air into the engine intake”).

145. In my opinion, Suzuki discloses an air charge controller as claimed in claims 2 and 5. As shown in Suzuki’s Figure 1B below, Suzuki discloses a torque control section that “controls the amount of air permitted to enter the engine” by “control[ing] the degree of opening of the electronic controlled throttle valve.” Ex. 1005 at 3:12-15, 4:33-38.

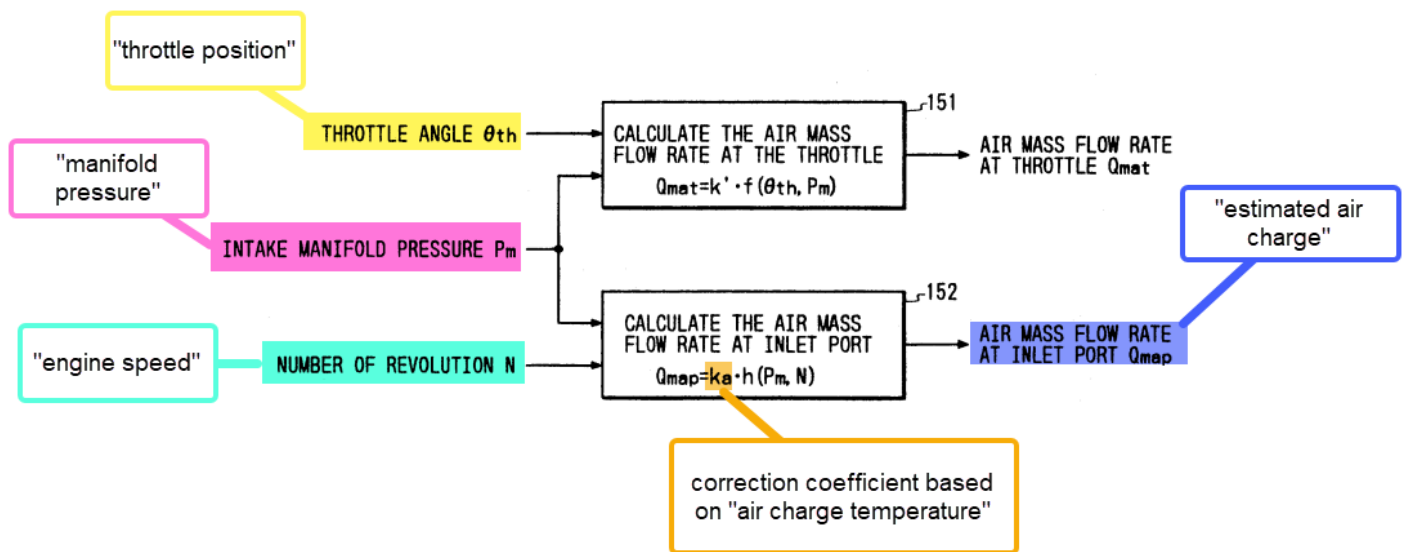
148. Further, in my opinion Takahashi discloses an air charge controller that receives an air charge demand signal, a throttle position signal, an engine speed signal, a manifold pressure signal, and an air charge temperature signal as inputs. Takahashi discloses a “status estimating block 142” and “throttle controller 144” that collectively calculate the throttle angle required to achieve the desired quantity of air mass entering the engine cylinder—*i.e.*, desired air charge. Ex. 1008 at 6:13-17. Accordingly, as shown in Takahashi’s Figure 14 below, Takahashi’s status estimating block and throttle controller collectively operate as an air charge controller.



Ex. 1008 at FIG. 14 (annotated).

149. Takahashi’s throttle controller 144 receives an target air mass flow rate Q_{map0} , *i.e.*, air charge demand signal, as an input. *Id.* at 3:28-30, FIG. 14. Moreover, as shown in Takahashi’s Figure 15 below, Takahashi’s status-estimating block 142 receives the other claimed inputs, including:

- A current throttle angle signal θ_{th} , *i.e.*, a throttle position signal (Ex. 1008 at 3:36-37);
- An intake manifold pressure signal P_m , *i.e.*, a manifold pressure signal (Ex. 1008 at 3:36-37);
- An engine speed signal N (Ex. 1008 at 3:36-37); and
- A correction coefficient ka that is “calculated according to the output of the intake air temperature sensor,” *i.e.*, an air charge temperature signal. Ex. 1008 at 10:54-66.



Ex. 1008 at FIG. 15 (annotated)

150. Moreover, Takahashi's status estimating block generates an estimated air mass flow rate at the inlet port, *i.e.*, an estimated air charge. Ex. 1008 at 10:54-66. Accordingly, Takahashi's throttle controller and status estimating block collectively disclose an air charge controller that receives an air charge demand signal, a throttle position signal, an engine speed signal, a manifold pressure signal, and an air charge temperature signal as inputs, and produces an estimated air charge signal. *Id.* at 3:36-37, 6:13-17, 10:54-66.

151. Moreover, Takahashi teaches that air charge demand generating and its air charge estimating methods “ensure a high precision control of the torque to reach a target value.” Ex. 1008 at 1:43-48. Accordingly, in my opinion, a POSITA would have been motivated to use an air charge controller and air charge demand controller that receive the inputs taught by Takahashi because doing so would “ensure a high precision control of the torque to reach a target value.” Ex. 1008 at 1:43-48. Modifying Suzuki’s based on Takahashi’s teachings to ensure high precision control of torque would further support Suzuki’s goal of “ensur[ing] optimum torque correction.” Ex. 1005 at 139-43.

152. Further, in my opinion a POSITA would understand it would have been trivial to modify Suzuki’s control unit 20 based on Takahashi’s teachings. A POSITA would have understood that Suzuki’s control unit 20 could be modified to receive the input signals described in Takahashi, including the air charge demand signal Q_{map0} , the throttle position signal θ_{th} , the intake manifold pressure signal P_m , the engine speed signal N , and an air charge temperature signal. Moreover, a POSITA would recognize that the code stored in Suzuki’s control unit 20 could be easily modified to implement the air charge estimation functions taught by Takahashi.

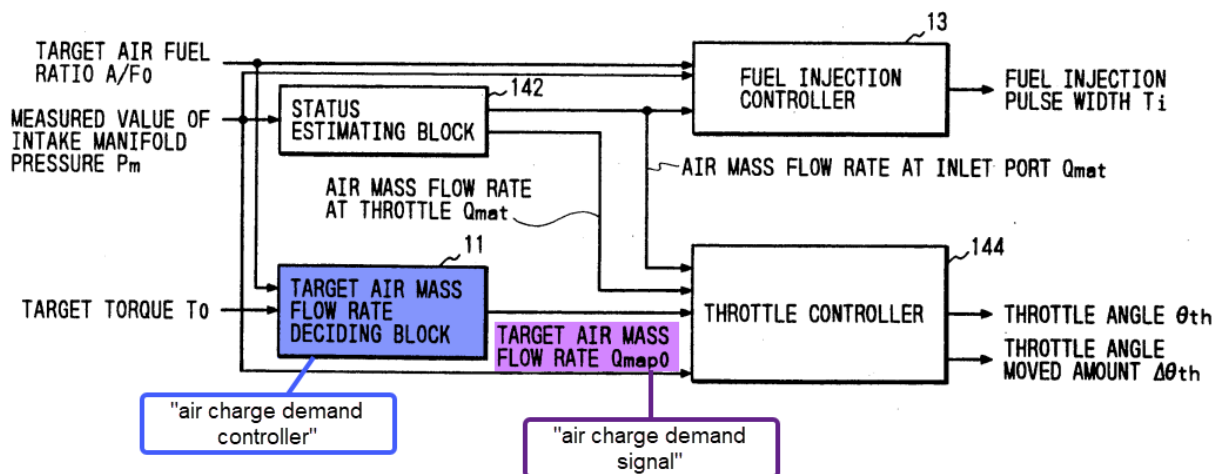
153. Accordingly, in my opinion Suzuki, Cullen, and Scherer in view of Takahashi renders obvious claims 2 and 5.

C. **Claim 3 and 6: “The device in claim 2/5, wherein the air charge demand signal is produced by an air charge demand controller which receives as inputs the desired torque signal, a desired spark angle signal and a desired air/fuel.”**

154. In my opinion, Suzuki in view of Cullen, Scherer, and Takahashi renders obvious claims 3 and 6. Claims 3 and 6 depend from claims 2 and 5, respectively, and recite “wherein the air charge demand signal is produced by an air charge demand controller which receives as inputs the desired torque signal, a desired spark angle signal and a desired air/fuel.” Ex. 1001 at claim 3, claim 6.

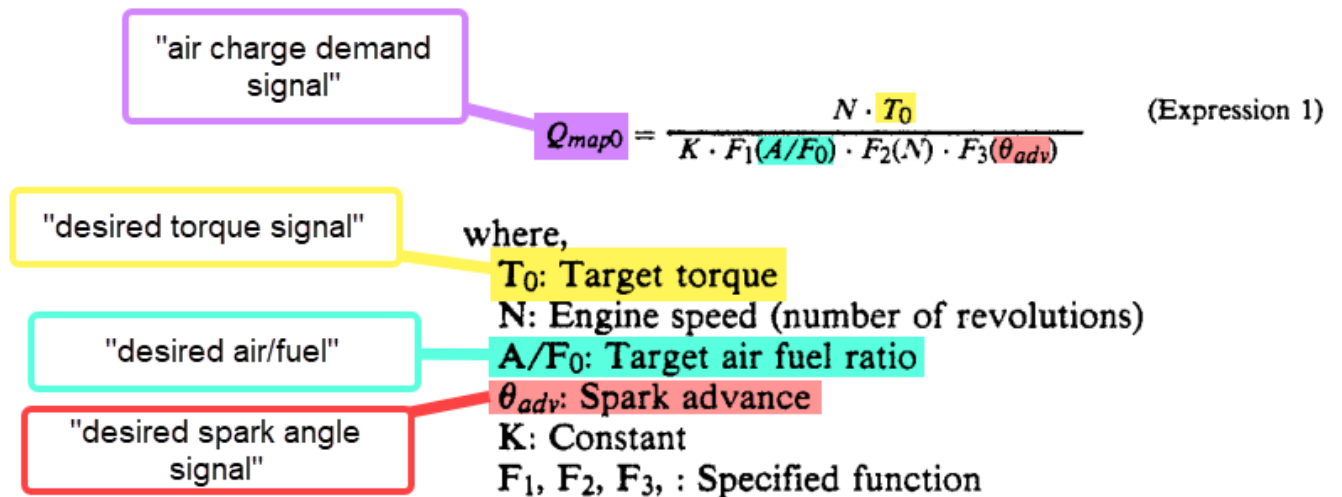
155. As explained above in Section XII.B, Suzuki in view of Cullen, Scherer, and Takahashi render claims 2 and 5 obvious. Ex. 1008 at 3:28-29, 10:42-50, FIG. 14.

156. Takahashi further discloses a target air mass flow rate deciding block (i.e., an air charge demand controller) that produces a target air mass flow rate signal Q_{map0} (i.e., an air charge demand signal), as shown in Takahashi’s Figure 15 below.



Id. at FIG. 15 (annotated).

157. Takahashi also teaches functions that calculate the target mass flow rate Q_{map0} (*i.e.*, an air charge demand signal) based on a target torque signal T_0 (*i.e.*, a desired torque signal), a target air/fuel ratio signal A/F_0 (*i.e.*, a desired air/fuel), and a spark advance signal θ_{adv} (*i.e.*, a desired spark angle signal) using the target air mass flow rate deciding block 11. Ex. 1008 at 3:28-51.



"air charge demand signal"

$$Q_{map0} = \frac{N \cdot T_0}{K \cdot F_1(A/F_0) \cdot F_2(N) \cdot F_3(\theta_{adv})} \quad (\text{Expression 1})$$

"desired torque signal"

where,

T_0 : Target torque

N : Engine speed (number of revolutions)

"desired air/fuel"

A/F_0 : Target air fuel ratio

"desired spark angle signal"

θ_{adv} : Spark advance

K : Constant

F_1, F_2, F_3 : Specified function

Ex. 1008 at Expression 1 (annotated).

158. Further, Takahashi's target air mass flow rate deciding block 11 and air charge demand controller 27 disclosed by the '565 patent function in the same way. Both components "receive[]" as inputs the desired torque signal, a desired spark angle signal 25 and a desired air fuel ratio signal 26" and "generate[]" an air charge demand signal." Ex. 1001 at 3:6-12.

159. Moreover, Takahashi teaches that determining the target air mass flow rate based on the target torque, target air/fuel ratio, and spark advance "ensures a

high precision estimation of the air flow status,” “high-precision control of the air mass flow rate at the inlet port,” and “a high-precision maintenance of the engine-generated torque.” Ex. 1008 at 1:49-57, 2:17-23, 3:24-51. Accordingly, in my opinion, a POSITA would have been motivated to modify Suzuki based on Takahashi’s teachings to more precisely estimate target air flow and ultimately more precisely control engine torque. *Id.*

160. Further, in my opinion a POSITA would understand it would have been trivial to modify the application instructions stored in the microcomputer of Suzuki’s control unit 20 based on Takahashi’s teachings such that Suzuki’s estimator section received the desired torque signal, a desired spark angle signal and a desired air/fuel signal as inputs and output an air charge demand signal.

161. Accordingly, in my opinion, Suzuki, Cullen, Scherer, in view of Takahashi render obvious claims 3 and 6.

XIII. SECONDARY CONSIDERATIONS

162. I understand that “secondary considerations” may be relevant to an obviousness analysis. If MMT presents such evidence, I will consider it; however, I do not believe that any commercial success of the claimed invention or other objective evidence would be attributable to the merits of the claimed invention given my analysis of the lack of novelty and the obviousness of the ’565 patent.

XIV. CONCLUSION

163. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

164. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on the information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

June 6, 2023



C. Arthur MacCarley, Ph.D., P.E.