Response to Reviewer 4 Comments

Point 1: (Line 6) Why are you using just a real number for the "normal gasoline" permittivity?
Response 1: In this paper, we have used real number for normal gasoline because the gasoline samples used in our experiments are high driveablity index (HiDI) samples with average permittivity value of 2.16 and the permittivity of normal gasoline used in the design of this sensor is 2.15, which is similar to the average permittivity of HiDI gasoline.

-Revised paper: Line (135)

1. Selection of permittivity (ε): First, we selected the permittivity of gasoline for simulating the sensor model. The gasoline samples used in our experiments are high driveablity index (HiDI) samples with average permittivity value of 2.16 and the permittivity of normal gasoline used in the design of this sensor is 2.15, which is similar to the average permittivity of HiDI gasoline

Point 2: (Line 8) The radius is 19.235mm. Is this level of precision required for acceptable performance?
Response 2: The theoretical value was calculated and written down with this precision. Otherwise, the precision up to 19.2mm is enough. This change is also mentioned in the manuscript.
-Revised paper: Table 2 Design parameters of the proposed sensor
19.235 => 19.2

Point 3: (Line 22) Should the word "sum" really be "function"?
Response 3: The word “sum” here is used to describe driveability index relationship with ethanol. Driveability index (DI) is a measure of a gasoline's performance across a number of operating conditions, covering cold start and warmed up operations. It incorporates elements of the distillation profile for the gasoline (temperatures for evaporation percentages, such as T50) as well as ethanol content.
The driveability index is calculated as:

$$\mathbf{DI}\ (℃) = \mathbf{1.5} \times \mathbf{T10} + \mathbf{3.0} \times \mathbf{T50} + \mathbf{T90} + \mathbf{1.33} \times (\mathbf{Vol\%ethanol})$$

In the revised version, we have replaced the word “sum” with “function”.

Point 4: (Line 57) The claim that this is a novel sensor is not credible. Any novelty here lies in the Application.
Response 4: We have considered the suggestion and removed the word ‘novel’ from the updated manuscript.

Point 5: (Line 59) Is the 0.04 and 0.15 for the "minor" difference 4% and 15%? Where do these figures come from?
Response 5: These numbers are the differences in the permittivity values. To clear this ambiguity, the permittivity values of different gasoline samples are mentioned in the following Table 1. Observing these values, one can see that these are very close to each other. The minimum difference lies between Tier2 and Cold CO, which is equal to 0.04 and the maximum difference lies between Euro4 and Tier3, which is equal to 0.15 approximately.

The purpose of mentioning this difference is to highlight the requirement for the proposed sensor to have high sensitivity to distinguish between various gasoline samples with such close permittivity values.

Table 1. Real permittivities and measured complex permittivities for different gasoline samples

Gasoline Sample	Permittivity Real (ε)	Permittivity Complex (ε'')
Tier2	2.018	0.0764
Cold CO	2.072	0.073
Euro4	2.134	0.066
Tier3	2.289	0.0087
LEV3	2.324	0.0385

Point 6: (Line 96) It would be useful to include the safety measures used for handing gasoline in these experiments.

Response 6: Thank you for this advice. Gasoline is generally dangerous when exposed to heat or fire. In our experiments, we used the gasoline samples contained in glass tubes and the environment of lab does not contain any fire causing equipment. To incorporate this advice, we have checked few of the papers on the relative topic and neither of these technical papers added any safety measures. That is why we did not include any precautions or safety measures in our experimental setup.

Point 7: (Line 154) What complex permittivity values were used for this simulation?

Point 8: The missing information regarding loss tangent values and the temperature effects on permittivity, that would be required to perform a simulation, are major concerns.

Response 7&8: We are thankful to the reviewer for this technical suggestion; we have added the following Table in the updated version of manuscript (as Table 5), which contains the complex and real part of permittivities used in these simulations. The permittivity values were measured using N1501A permittivity measuring kit. Since loss-tangent is the ratio of complex permittivity ε" and real permittivity ε, it is calculated using Table 2 and plotted in Figure 1.

Table 2. Real permittivities and measured complex permittivities for different gasoline samples

Gasoline Sample	Permittivity Real (ε)	Permittivity Complex (ε'')
Tier2	2.018	0.0764
Cold CO	2.072	0.073
Euro4	2.134	0.066
Tier3	2.289	0.0087
LEV3	2.324	0.0385

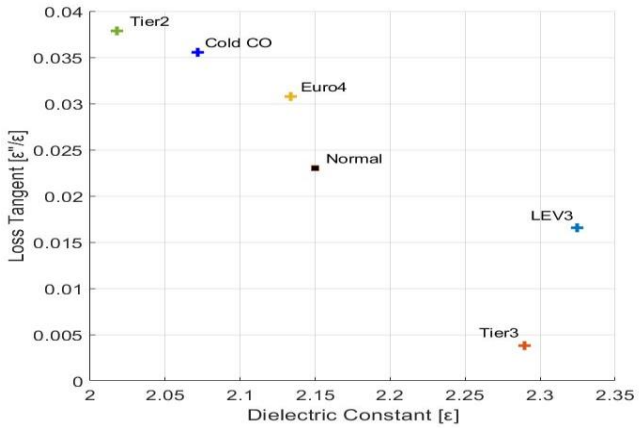

Figure 1. Variation of loss-tangent with permittivity for different gasoline samples

Point 9: (Line 159) Where does the permittivity data come from for Table 4. There are no axes labels for Figure 5.

Response 9: The permittivity data is taken from the material referenced in the caption of following Table 3. It is also updated in the revised version of the manuscript. The said figure is replaced with the corrected Figure 2 with labels.

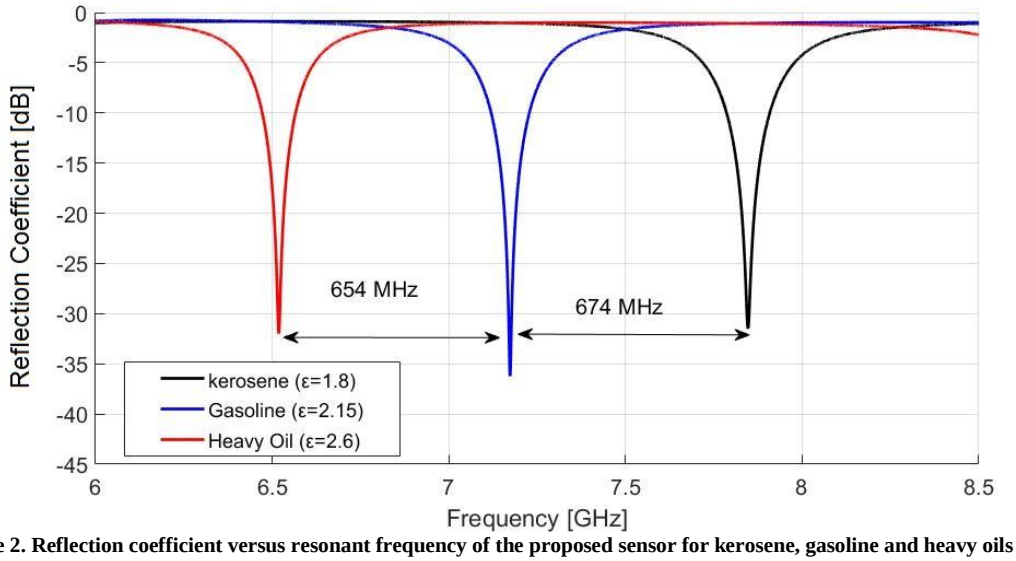

Figure 2. Reflection coefficient versus resonant frequency of the proposed sensor for kerosene, gasoline and heavy oils at room temperature (20°C)

Table 3. Simulation results of proposed sensor showing resonant frequency, reflection coefficients and permittivity for kerosene, gasoline and heavy oils [26] at 20°C

	Kerosene	Gasoline	Heavy oil
f_r (GHz)	7.847	7.173	6.519
Γ (dB)	-31.5	-36.2	-32.0
ϵ	1.8	2.15	2.6

Point 10: (Line 200) How was HFSS used to simulate different temperatures?

Response 9: To answer this question, the HFSS is not used for analyzing temperature effects. Referring to the following Figure 3, which is also present in the manuscript as Figure 10. The response of the sensor is analyzed to check the ability of proposed sensor to distinguish various gasoline samples under different temperature conditions by inducing temperature

variations with the help of thermostatic bath. It is also explained in the paragraph of the revised manuscript where the figure is referenced.

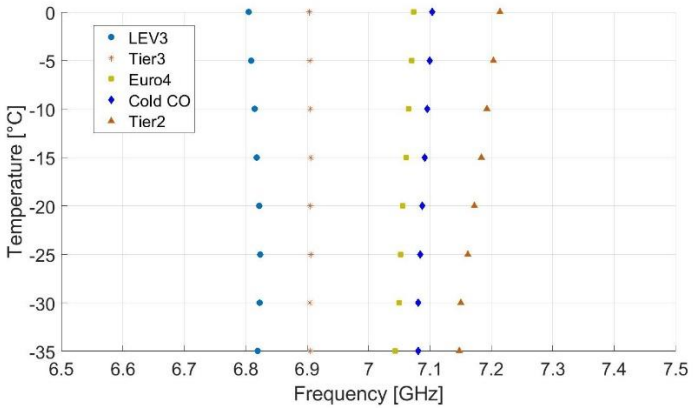

Figure 3. Experimental results of resonant frequency of the proposed sensor at different temperatures for various gasoline samples

Point 11: (Line 203) What are the extra modes in Figure 10?
Response 11: The extra modes in the following Figure 4 and Figure 5 are TM111 mode.

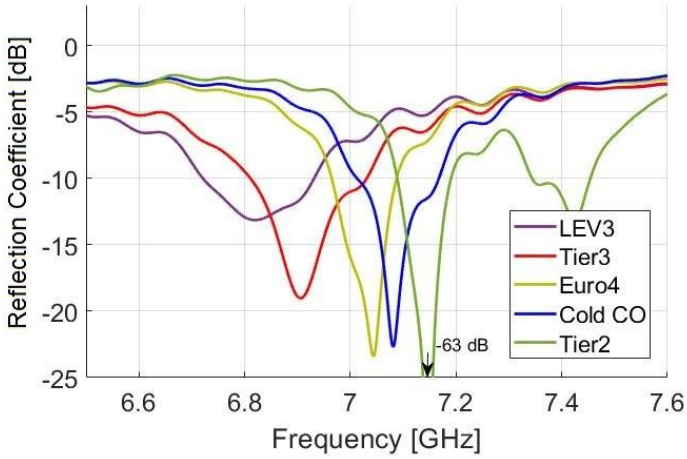

Figure 4. Reflection coefficient analysis of the proposed sensor at temperature -35°C

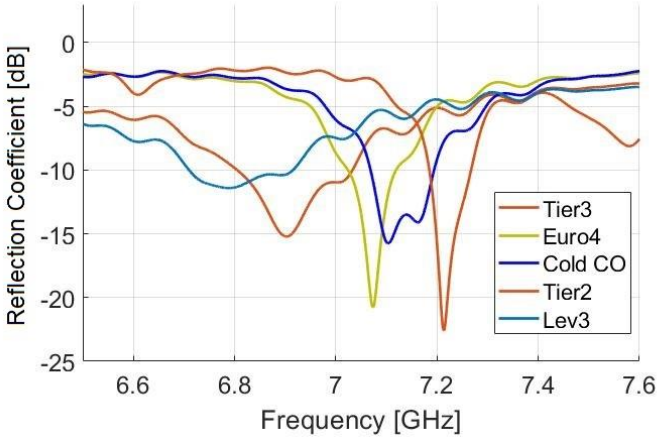

Figure 5. Reflection coefficient analysis of the proposed sensor at temperature 0°C

Point 12: (Line 220) Equation 3 is too basic to include.
Response 12: The equation is indeed simple. It is added for the purpose of clarity.

Point 13: You need to explain why the capacitor method (reference 5) is not a better approach than the one proposed.
Response 13: The techniques proposed to measure the driveability index (DI) of gasoline are by Lambert et. al. [5] and Ferguson et. al. [6]. In research [5], DI of the sample is estimated by heating fuel sample placed between two narrow parallel plates of a capacitor and then measuring the change in capacitance of the sensing element as a function of time and temperature. The other technique presented in [6] utilized platinum resistance temperature detectors (RTDs) to compare the engine exhaust gas temperatures during cold starts to actual engine exhaust air/fuel ratios using low and high DI fuels to detect the cold start volatility characteristic of the fuel.
To address this suggestion, we have explicitly mentioned that the techniques [5] and [6] both requires the sample to be heated for a substantial amount of time before the sensor becomes effective for control following a cold start. Our technique is better as compared to both since it does not require the sample to be heated so the quick measurements are possible. Moreover, we have analyzed the sensor response for different temperature variations, which also shows its robustness.

-Previous paper: Line (32~35)
However, such sensors generally need to be heated for a substantial amount of time before the sensor becomes effective for control following a cold start. Furthermore, these techniques works for a certain temperature and the performance is uncertain under temperature variations.

-Revised paper: Line (32)
This limitation to this technique is that it can only detect the presence of HiDI fuel and can not differentiate between various HiDI. Moreover, both of the techniques mentioned above generally require the sample to be heated for a substantial amount of time before the sensor becomes effective for control following a cold start. On the contrary RF techniques does not require the sample to be heated so the quick measurements are possible.

Point 14: (Line1) There is a “1”
Point 15: (Line 8) The cavity is not limited to a single resonant frequency. You should include the mode if you are going to specify a frequency.
Point 16: (Line 28) It would read better if you included the authors' names for reference [5].
Point 17: (Line 31) You do not need the word "sensors".
Point 18: (Line 31) The use of both "out" and "exhaust" seems unnecessary. Exhaust would be preferable in both instances.
Point 19: (Line 36) Reconsider the word "strong"
Point 20: (Line 37) "In peculiar" is not correct. You may have intended to write "In particular", but that does not follow from the previous sentence, and it would be better to delete it.
Point 21: (Line 39) The permittivity does not change, the speed of light in the sample volume changes.

Point 22: (Line 41) Change "resonance frequency" to "resonant frequency" throughout the paper.
Point 23: (Line 43) Change "perform distinction of" to "distinguish between".
Point 24: (Line 52) See comment for line 28**.**
Point 25: (Line 61) "out" should be deleted.
Point 26: (Line 68) This sentence should be rewritten. "??" should be "4".
Point 27: (Line 69) Remove "At the end".
Point 28: (Line 74) "shortening" should be "shorting".
Point 29: (Line 76) Use the multiplication symbol (×) not the letter x. There are several other instances.
Point 30: (Line 77) Use "external interaction" rather than "interaction from outside"
Point 31: (Line 85) Remove the sentence, "The length …"
Point 32: (Line 86- 89) Merge into one sentence.
Point 33: (Line 92) "of the loop"?
Point 34: (Line 92) The last sentence in this paragraph is not needed.
Point 35: (Line 102) The brackets should also enclose TE11**.**
Point 36: (Line 107) "operation frequency of the cylindrical cavity resonator" should be changed to "resonant frequency of the TMnmt mode".
Point 37: (Line 110) remove "for the TE or TM modes of the cavity resonator". The roots of the Bessel function (and its derivative) are independent of their application.
Point 38: (Line 116) Refer to the equation as Equation 2.
Point 39: (Line 116- 117) The claim that the cavity volume is inversely proportional to the square of the resonant frequency is wrong. The same volume can give different frequencies.
Point 40: (Line 116- 117) The claim that the pnm and t are directly proportional to the square of the resonant frequency is wrong. Also changing Pnm to a different root would change the mode.
Point 41: (Line 137) The 7.124GHz is the calculated value for TM012 if c = 300 000 000m/s. The exact value of c is 299 792 458m/s which gives a frequency of 7.119GHz.
Point 42: (Line 140) Providing the circumference serves no purpose, and if it were required it would be rounded up to 120.86mm
Point 43: (Line 142) Not "TM" but "TM012".
Point 44: (Line 152) nitrogen oxides (NOx)
Point 45: (Line 154) "sweeping" not "swiping".
Point 46: (Line 155) No full stop.
Point 47: (Line 175) Finish the sentence after "cavity sensor".
Point 48: (Line 181) Change "is" to "represents".
Point 49: (Line 183) Power propagating in a conductor?
Point 50: (Line 190) The sentence beginning, "This analysis.." should be removed.
Point 51: (Line 199) remove ×10 from Figures 9 and 10. The units are GHz.
Point 52: (Line 203) Remove the sentence, "It can be …"
Point 53: (Line 207) "dip point"?

Response 14~53: We thank the reviewer for such detailed review of our paper. All the above mentioned corrections are made in the revised manuscript. The revised version has been thoroughly checked; writing errors and inappropriate expression have been corrected where found.

Point 54: There are a lot of missing "a"s and "the"s.`
Response 54: We have proof read the paper again to remove such mistakes.