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Dear Dr. Kurt Barbe,

Please find enclosed the revised version of the manuscript entitled “Models for Synchrophasor with Step Discontinuities in Magnitude and Phase: Estimation and Performance”, IM-18-18517, authored by Marcelo Britto Martins, Renata de Barros e Vasconcellos, and Paulo A. A. Esquef, which was first submitted to TIM in July 2018.

As requested by the Editor, we are sending attached to this file our response to the reviewers, where we addressed each of their concerns individually. The texts in red color refer to our answers. We would also like to thank the reviewers for their careful reading of our work, and for their comments.

Thank you for your consideration.

Best regards,

Marcelo Britto Martins

Renata de Barros e Vasconcellos

Paulo A. A. Esquef

Reviewer #1 (Required Remarks for the Author):

Authors are proposing models for synchrophasor with step discontinuities in magnitude and phase. The work provides a possible solution for calibration of PMUs under such transients by including data during the transient.

While the proposed parameters were estimated and results presented both from simulations and measured results, the proposed paper has the following major issues:

We would like to thank Reviewer #1 for taking the time to read carefully the manuscript and to provide valuable comments on the content of our work.

I. INTRODUCTION

UTC is Universal Time Coordinated and a time base could be synchronous with the UTC, not centered in.

Agreed. We changed the text as suggested.

II. MATHEMATICAL BACKGROUND

Equations (1) and (2) both define y(t), but they describe different models. Please use different designation for each model.

Thanks for pointing this out. We added a subscript modifier to distinguish the two models given in Eqs (1) and (2).

B. Reference phasor values

Here Ve is defined but its estimation performance is not reported elsewhere in the paper.

Following the changes in Eqs. (1) and (2), we have replaced V_e with $\hat{V}_{\mathrm{ref}}^{m}$ and $\hat{V}_{\mathrm{ref}}^{p}$ in (4) and (5) to discern between the models for the intermediate phasors in the cases of magnitude and phase steps, respectively. Moreover, we clarified in the text that (4) and (5) are our propositions for intermediate reference phasors, which can be computed either via prior knowledge of the parameters of (1) and (2) or their estimation via suitable methods. First, we proposed the method based on the Hilbert's instantaneous frequency, described in section II.C, for attaining estimates of τ. Then, for estimates of the remaining parameters, we followed the footsteps of Frigo [13] and employed the LM. In the new version of the paper, we call HLM4 the sequential use of these two estimators. The HLM4 allows estimating all parameters of (1) and (2), which are then fed to (4) and (5).

Table II shows the performance figures of the LM phasor estimator for the step in magnitude case. Table III shows the performance figures of the LM phasor estimator for the step in phase case. Please, note that these results refer to the computer-simulated tests. Moreover, following your suggestions (III.B below in this letter), we have added results for SNR=60dB, which is the measured SNR of the AWG we used in our laboratorial prototype system. In tables II and III, the row that reads "Intermediate Magnitude [$\mu V/V$]" refers to results for $\hat{V}_{\text{ref}}^{m}$, whereas the row that reads "Intermediate Phase [$m°$]" refers to results for $\hat{V}_{\text{ref}}^{p}$.

For the tests using our laboratorial prototype system, $\hat{V}_{\text{ref}}^{p}$ and $\hat{V}_{\text{ref}}^{m}$ are shown, respectively, in Figs. 9 and 10, as a function of the indicated τ values.

The only results are those presented in the Fig. 7 and 8, but not in the Fig. 11 and 12.

We partially answered this comment in the previous answer. Now we clarify that the results shown in Figs. 11 and 12. Figures 11 and 12 (now Figures 13 and 14) refer to **additional** tests in the laboratorial setup. In theory, in the test case of a step in magnitude (resp. phase), the phase (resp. magnitude) should remain unperturbed. However, in an actual laboratorial experimental setup, perturbations in phase (resp. magnitude) are produced when the AWG is forced to generate a step-like waveform in magnitude (resp. phase). We intent to quantify how well our AWG does its job in a challenging scenario of approximating a discontinuous signal in magnitude or phase. For example, during a phase step, the magnitude (which we expect to be constant) is not stable, but varies as shown in Fig. 11 (now Figure 13). Likewise, during a magnitude step, the phase (expected to be constant) varies as shown in Fig. 12 (now Figure 14). We modified the text in order to clarify this point.

It is not clear what is the purpose or the benefit of using these intermediate values. How do they add to the calibration of the PMU?

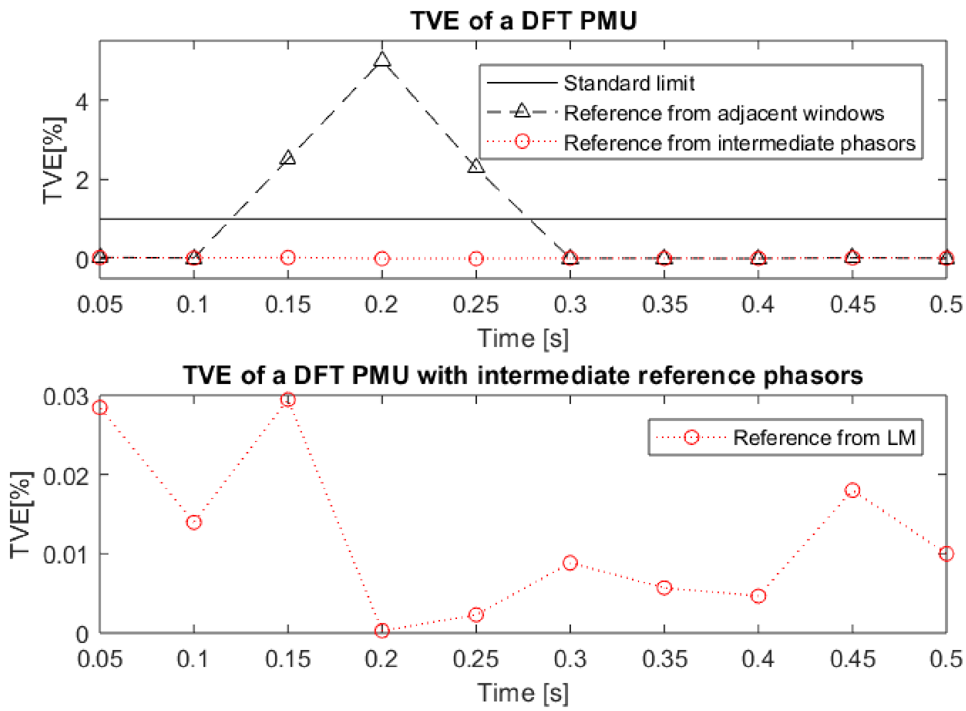
Reference phasors are undefined when the observed phasor waveform has steps in magnitude or phase. Our purpose is to propose sensible and well-defined reference phasors in such situations, which can be used in the calculation of TVE and other related indicators. In previous works, reference phasors are simply obtained from adjacent windows with steady state signals, taken before or after the step occurrence, depending on its time location. This procedure depends on detecting with good accuracy the instant of occurrence τ, and is based on the assumption that the phasor measurements taken from adjacent windows are suitable estimates of the phasor in the window with a step. It should be noted that methods that use adjacent windows in the phasor estimate can be easily adapted to employ the models (4) and (5) of the intermediate phasors. We exemplify this in Section III.C (see Fig. 5) of the revised paper.

The standard prescribes step tests to measure the time response (TR), which is the time during which the TVE, FE or RFE exceeds the defined limit values. The calibration of P-class PMUs shall provide a very short TR (of the order of a few cycles).

We now report, in Section III.D. (see Fig. 6), additional computational simulations to show how the proposed intermediate phasor values affect the TVE estimates of a DFT-based PMU. For that, we calculated TVE estimates with two different methods:

1) The reference phasors obtained from the nearest adjacent window of 500 samples, as related in reference [4], with a Steady State estimator (SS). The value of τ is known a priori.
2) The reference phasors estimated by feeding our intermediate reference phasor models with values obtained by an LM estimator, using 1000 samples. The value of τ is known a priori.

The simulated DFT-based PMU receives a signal containing a positive 10% magnitude step, SNR = 50dB. The PMU window takes 1000 samples, with reporting rate of 20 frames/s.



The upper graph shows the TVE response of the DFT-PMU calculated with method 1 (black line), and method 2 (red line). The lower plot shows the TVE calculated with method 2 alone.

If one takes the TR from the TVE calculated with the phasor reference of method 1, it lasts about 250 ms. On the other side, with TVE calculated with the reference of method 2, the DFT-PMU never passes the standard limit. In the first case, this PMU would be rejected as a P-class, but in the second case not. It is the same PMU, the only difference is the definition of reference values for TVE. As TR is defined in function of TVE, this difference can be significative for the already standardized P-class PMU tests, as well as possible more stringent TR tests for distribution PMUs in the future.

We believe method 1 offers a phasor reference based on an observation window that is delayed w.r.t. that (containing the step) the DFT-PMU uses to produce its phasor output. This may explain the large measured TVE. On the other hand, both method 2 and the DFT-PMU use the same window (containing the step) to attain, respectively, the reference phasor and the measured phasor. Moreover, the intermediate reference phasor takes into account (in a weighted manner) the phasor states before and after the step. This seems to be a sensible choice that also confers a more stable and smooth phasor reference along time, despite the step transient. This behavior of the intermediate reference phasor may help reducing undesirable false detections in protection systems, based on TVE measures. From the above rationale, we are confident that our proposed intermediate phasor reference may be potentially useful not only for PMU calibration tests, but also for applications to protection systems.

D. Model Parameters Estimation via Levenberg-Marquardt

Please define y(k) beforehand.

Thanks for pointing this out. We defined $y(k)$ beforehand as requested.

III. NUMERICAL SIMULATIONS

B. Parameter estimation with non-linear least squares

Here, the simulations were carried out using SNR of 90 dB, 93 dB and 97 dB. All these SNRs are too good for any realistic measurement setup concerning PMUs. Consequently, achieved standard deviations are very small, useless for any assessment of their influence in the final uncertainty budget. In previous paragraph (A), a SNR of 40 dB and 75 dB were used, which are more realistic. Consider using SNR as expected or measured with the sampling system and sampling parameters used (AWG + DSVM).

Yes, indeed. Thank you for raising this concern.

The high SNR levels we used are desirable levels for calibration systems, and considered in the setup used in Frigo et al. [13]. Although, in a simulated scenario, these high SNR values are useful to compare the performance of our method against alternative solutions, they are indeed unrealistic for the laboratorial setup we used to make measurements in this work.

The measured SNR with AWG + DSVM are estimated to be around 60 dB, according to the references [23], [24]. Considering SNR = 60 dB, we carried out simulations to assess a more realistic contribution of the parameter estimation in the final uncertainty. As mentioned before, we added the results related to the SNR=60 dB to the Tables II and III, in Section III.B of the revised paper.

IV. LABORATORY MEASUREMENTS

... Both are triggered with a 1 PPS (pulse per second) signal. Both goes for AWG and DSVM here, but only trigger to AWG is shown on Fig. 5.

Of course, the figure is corrected now. Thank you for pointing this out.

Also, if DSVM is triggered externally, there is a time delay and timing uncertainty (likely around 400 ns +- 100 ns) involved. How was this covered in the measured results? The DSVM trigger time delay is one component of the overall phase error (it is indeed one of the components of the absolute phase uncertainty, whose estimation is beyond the scope of this work). Therefore, phase uncertainty is part of the variations observed in the results. However, previous works [26] indicate time delay less than 50 ns and jitter less than 100 ps for the particular DSVM we used.

We now report the above information in Section IV, on the first paragraph.

V. CONCLUSION

The authors state: "The proposed approach tackles the estimation of the step discontinuities in the phasor signal observed within an analysis window, instead of dodging the problem." However, they do not give any further benefit of doing so, nor they provide any comparison to numerous previous results already published. This is the major issue of this paper - it should provide a clear comparison to the work already published and clearly depict benefits of the proposed method in comparison with previous work.

Thank you for calling our attention for this pertinent issue.

We believe we partially addressed, in Section II.B (above in this letter), the Reviewer's concern regarding offering a motivation to use the proposed intermediate phasors.

We now explain more clearly in the revised version of the paper that:

1) The proposed method is capable of detecting, without initial guessing, the instant of the transient with time resolution of the sampling interval Δt and uncertainty of a few units of Δt. The ability of estimating τ at about Δt sample resolution is an improvement in relation to window-based transient detectors, whose time resolution is on the order of a few 60Hz cycles.
2) We propose, as an extension of the 3-parameter models used in Frigo et al. [13], to incorporate the depth of the step in the LM estimator, to evaluate its performance with 4 parameters, along with the τ estimation based on the instantaneous frequency of the analytical signal (via Hilbert's method). This can be considered a hybrid estimator, which we now call HLM4.
3) Our choice for employing the LM estimator follows the footsteps and findings of Frigo et al. [13], who provide a very detailed comparison that shows that the accuracy of an LM estimator (incorporating a model for the transient) is higher than other representative estimators (IP-DFT and CS-TFM). Therefore, in this regard, it is implicit we are counting on reliable information previously published.
4) Now we include a comparison in section III.C, Table IV, where the performance of the hybrid estimator (HLM4) is compared to the one (LM3), previously published by Frigo et al. [13]. The results show that the HLM4 outperforms the LM3, but with various levels of reductions in the estimation errors (from about 1% to 45%), depending on the quantity at hand.

In summary, for the assessment of PMU calibration systems, the proposed method that can bring more information about the system components, especially for the cases when one needs to investigate the behavior of the measurements during a few cycles.

Also, what would be the deficit of the measurement if the 5th window shown in Fig. 6 would be excluded from the analysis, related to the calibration outcome of the PMU involved?

We answered this question in Section II.B (of this letter). In Section III.D (see Fig. 6) of the revised paper, we now report additional computational simulations to show how the TVE of phasor estimates of a simulated DFT-based PMU are affected depending on two ways to estimate the reference phasor. We compare our proposition, which looks into an analysis window that contains the step, vs a usual procedure that relocate the analysis window in time to skip the step.

In addition, the paper need a thorough proofreading

We did our best to proofread and correct the errors found in the paper.

Reviewer #2 (Required Remarks for the Author):

The language is quite ok.

The mathematics and explanations of the mathematics and tests are quite ok.

The conclusions are also good.

The problems lay in the problem definition, and reasons for the work.

We would like to thank Reviewer #2 for taking the time to read carefully the manuscript and to provide valuable comments on the content of our work.

The proposed tests are for signals for which a PMUs response is undefined and as such a real calibration can not be done, since there are no requirements set in the PMU standard for these kinds of signals. In which situation/for what purpose do they propose/anticipate it to be used?

Actually, the standard [1] requires the step tests described (section 5.3.3), based in the metric Total Vector Error (TVE), well defined for steady-state conditions. These tests are performed taking a series of observation windows, some of them containing the fast transition. For the specific case of these windows containing magnitude or phase steps, the definition for the reference phasor for the TVE calculation is not provided by the standard, so previous works usually take the nearest steady state phasor as a reference phasor.

We are proposing an intermediate reference phasor that takes into account (in a weighted manner) the phasor states before and after the step discontinuity, along with related model-based estimation methods. In Section III.D of the revised paper, we now report additional computational simulations to show how the TVE of phasor estimates of a simulated DFT-based PMU are affected depending on two ways to estimate the reference phasor. We compare our proposition (method 2, in Section III.D), which looks into an analysis window that contains the step, vs a usual procedure (method 1, Section III.D) that relocate the analysis window in time to skip the step. The latter phasor references yield TVEs way larger than our intermediate reference phasor (see Fig. 6 in the revised paper).

We believe method 1 offers a phasor reference based on an observation window that is delayed w.r.t. that (containing the step) the DFT-PMU uses to produce its phasor output. This may explain the large measured TVE. On the other hand, both method 2 (ours) and the DFT-PMU use the same window (containing the step) to attain, respectively, the reference phasor and the measured phasor. Moreover, the intermediate reference phasor takes into account (in a weighted manner) the phasor states before and after the step. This seems to be a sensible choice that also confers a more stable and smooth phasor reference along time, despite the step transient. This behavior of the intermediate reference phasor may help reducing undesirable false detections in protection systems, based on TVE measures. From the above rationale, we are confident that our proposed intermediate phasor reference may be potentially useful not only for PMU calibration tests, but also for applications to protection systems.

A test can still be valuable but not for calibration purposes, this should be reflected in the first section where reasons for the work is described.

We do not feel comfortable in making such a hard statement in the Introduction because it is our hope that the proposed intermediate reference phasors may set a more solid ground for PMU calibration purposes and beyond. We are not the first ones to propose modeling step-like transients in the context of phasor estimation. See for instance the work of Frigo et al. [13], which we extended to account for the estimation of the step location and depth. It is our understanding that moving toward a more detailed characterization of the phasor states in step-like transient situation is the proper way to go, instead of relying on phasor estimators based on relocated analysis windows that skip the transient.

Further, the benefits of such a test is not very well described in the first section (while it is in the conclusion)

In summary the first section lacks in clarity regarding the reason for and the practical use of the method proposed.

In the Introduction of the revised paper, we state:

1) "In the specific case of an observed phasor disturbed by a step discontinuity in magnitude or phase, the estimation using an underlying steady state model does not guarantee convergence nor accuracy [11], [12]. Besides, **one lacks a definition of what the reference phasor should be." So, we are proposing a definition for the phasor reference.**
2) "...the method used in [4] adjusts the timestamp and position of the analysis window to skip the discontinuity and sets the phasor estimates where the discontinuity occurs as those obtained from the previous or following window." and that this kind of solution "may be not accurate enough to evaluate the performance of calibration systems." And because of that, "**Methods for a more detailed analysis of calibration systems** under step conditions are proposed by Frigo et al. [13], where the authors used an underlying mathematical model for the transient and a non-linear least squares method estimator, which showed to outperform stateof-the-art methods (the enhanced interpolated DFT (IP-DFT) [14], and the compressive sensing-based Taylor Fourier model [15]) when submitted to the IEEE standard tests [1]."
3) We then we say that we are contributing:
    a. "Models that **extend those used in Frigo et al. [13]** in order to account for the time location and height of the step discontinuities in magnitude or phase, incorporating representations of both types of transients and the underlying stationary phasor."
    b. **and in addition to [13]** a "Proposition of model-based single phasor estimates for step discontinuity situations, which can be used as reference values for PMU calibrations and easily implemented in the existing systems, in place of traditional estimation schemes. "

It is our understanding that the above line of argumentation makes it clear what the reasons behind our propositions are and that we are moving to the same direction of [13] to bring more information about the phasor states, especially for the cases when one needs to measure its behavior during a few cycles.

In the revised version of the paper, we now briefly anticipate in the Introduction some of our findings that may be beneficial toward our propositions. We write, w.r.t. the list of contributions given in the Introduction:

"As regards item 1, we will show in Section III.B that our proposed models offer phasor-related estimates with lower errors than those reported in [13]. Moreover, concerning item 3, we show in Section III.D that a simulated DFT-based PMU yields way lower TVEs w.r.t. our proposed intermediate reference phasors than w.r.t. usual phasor references based on time relocated analysis windows."

Apart from the Introduction, we now explain more clearly in the revised version of the paper that:

1) The proposed method is capable of detecting, without initial guessing, the instant of the transient with time resolution of the sampling interval Δt and uncertainty of a few units of Δt. The ability of estimating τ at about Δt sample resolution is an improvement in relation to window-based transient detectors, whose time resolution is on the order of a few 60Hz cycles.
2) We propose, as an extension of the 3-parameter models used in Frigo et al. [13], to incorporate the depth of the step in the LM estimator, to evaluate its performance with 4 parameters, along with the τ estimation based on the instantaneous frequency of the analytical signal (via Hilbert's method). This can be considered a hybrid estimator, which we now call HLM4.
3) Our choice for employing the LM estimator follows the footsteps and findings of Frigo et al. [13], who provide a very detailed comparison that shows that the accuracy of an LM estimator (incorporating a model for the transient) is higher than other representative estimators (IP-DFT and CS-TFM). Therefore, in this regard, it is implicit we are counting on reliable information previously published.
4) Now we include a comparison in section III.C, Table IV, where the performance of the hybrid estimator (HLM4) is compared to the one (LM3), previously published by Frigo et al. [13]. The results show that the HLM4 outperforms the LM3, but with various levels of reductions in the estimation errors (from about 1% to 45%), depending on the quantity at hand.
5) With our intermediate reference phasor, the TVEs of simulated DFT-based PMU get way smaller than with reference phasors estimated from analysis window relocated in time to skip the step (see Section III.D). And that result may be potentially useful not only for PMU calibration tests, but also for applications to protection systems.

Reviewer #3 (Required Remarks for the Author):

(Note, due to the limitations in text formatting, mathematical symbols in this review are written in LaTex)

Overview: Calibration of PMUs and PMU calibration systems is a very important topic and improvements in analysis techniques are essential for the technology to move forward since future requirements for PMU performance are expected to be more stringent than they are in the present standard. This paper is timely and important and it must be clear about what it can and cannot provide to the community.

In the first paragraph of the introduction states: "Recent developments towards the calibration of PMUs for distribution grids demand lower uncertainty levels than the current systems, which were designed for the context of transmission grids [3]" This statement implies that the proposed method will provide higher uncertainty levels than existing methods. The statement must be substantiated or else state that future work is needed to determine if this method is more accurate. Accuracy is especially important in the determination of signal phase, which is assumed to be crucial parameter for distribution PMUs.

We would like to thank Reviewer #3 for taking the time to read carefully the manuscript and to provide valuable comments on the content of our work.

We shall emphasize that the statement we have made cites a reference. Nowhere in the paper we have claimed that our proposition meets the demands reported in [3] or outperform other methods available in the literature. As pointed out by Reviewer #1, we did not even run comparative performance tests against other solutions and just reported the performance of our package of methods. In the conclusions we stated “Within the limits reported, the proposed method can give reliable and accurate results to assess PMU calibration systems.” We did not use any comparative or superlative clauses that could possibly suggest the implication aforementioned by Reviewer #2.

Anyhow, by understanding the importance of comparing the performance of our proposition against well-stablished solutions available in the literature, we now report in the paper results of additional computational simulations:

1) Now we include a comparison in section III.C, Table IV, where the performance of our proposed hybrid estimator (HLM4) is compared to the one (LM3), previously published by Frigo et al. [13]. The results show that the HLM4 outperforms the LM3, but with various levels of reductions in the estimation errors (from about 1% to 45%), depending on the quantity at hand.
2) Now we report in section III.D that with our intermediate reference phasor, the TVEs of simulated DFT-based PMU get way smaller than with reference phasors estimated from analysis window relocated in time to skip the step (see Section III.D). And that result may be potentially useful not only for PMU calibration tests, but also for applications to protection systems.

In the forth paragraph: "...and sets the phasor estimates where the discontinuity occurs as those of obtained from the previous or following window." change: "those of obtained" to "those obtained"

Agreed. We changed the text as suggested.

Equation number 4 is skipped, equation 3 is followed by equation 5. Equation 4 appears on page 3 in section D and should be equation 14 once the numbering is corrected.

Thanks for pointing this out. We made a general revision on cross-references.

Following Figure 1, it is unclear what the author means by "intermediate phasor estimates". I think this refers to the phasor values during the rise time of the step itself. the step generally rises faster than the sampling rate so (5) and (6) can be used to find intermediate values between two samples. This is important to know as a reference value if the step occurs exactly coincident with a synchrophasor report but not exactly coincident with a sampled value. The equations work, however "T" and \tau are not the correct values to use. "T" should be "dt" and another symbol should replace "\tau" to denote the length of time following the sample time at which we are trying to interpolate the value. For example, if the sampling period "dt" is 1/5000 s and the step occurs half way between two samples then "\tau" is 1/10,000 s. "T" is used elsewhere in the paper to represent the total duration of the sampled window and \tau is the time from the beginning of the window until the step. Using these values in (5) and (6) would basically mean that the step rise time is the duration of the window. Using those values, (5) and (6) would only provide some kind of average value of amplitude or phase over the entire sampling window, which I fail to see as a useful metric. I recommend changing "T" to "dt" and providing a new symbol to represent the distance between the samples where the step actually occurred.

The reference phasor values are those given by equations (4) and (5), whose parameters can be estimated by several means or known a priori. In our case, we have chosen to employ the models (1) and (2), sampled at $t = k\Delta t$, in conjunction with the LM method to estimate the needed parameters, over window of 1000 samples inside which the step happens. The value of τ is estimated by a detector based on the instantaneous frequency of the Hilbert's analytical signal related to (1) and (2). Therefore, the intermediate reference phasor values given by (4) or (5) hold for the whole analysis window, including the rise time of the step itself. However, nothing prevents a more detailed view of the phasor estimates within the window, since the transient location can be accurately determined (at time resolution of few units of Δt), along with the phasor parameters before and after the short transient.

In the context of PMU evaluation via TVE, in which both the phasor reference and measured phasor refer to the phasor state over a whole analysis window, our proposed method estimates the intermediate phasor reference from the window that contains the step, instead of from a window that is time-relocated to exclude the step. We show in Section IV.D that our proposed intermediate phasor references not only are compatible with TVE calculation, but also yield smaller TVEs in tests involving steps in magnitude and phase.

Equation 4 is mis-numbered (should be 14),

Thanks for pointing this out. We made a general revision on cross-references.

Top of page 5: The PMU standard does not state that synchrophasors must be obtained relative to the center of an analysis window. Synchrophasors may be obtained in any manner as long as the performance meets the requirements of the standard.

Agreed. Our particular choice was taking the synchrophasors related to the center of the window. We changed the text accordingly.

Conclusion: Recommend mentioning that Levenburg-Marquadt initial parameter sensitivity should be studied in future work. When calibrating PMU calibration systems, actual parameters are not available to the calibrator calibration system. Some anecdotal testing has shown that due to local minima or possibly phase wrap issues, Lebenburg-Marquadt is sensitive to errors in initial phase error as small as 3 degrees: estimated parameters with a negative magnitude and phase error of pi resulted (which actually provides the same signal). Also recommend that future work be suggested to test sensitivity to \tau estimation when \tau of a magnitude step near or coincident with a zero crossing. The PMU standard says nothing about the required phase at which the steps may or may not occur but this and previous methods may not work when the step occurs at or near particular points in the phase, such as zero crossings.

We agree that this study should be extended to assess the behavior of the estimator when subjected to large errors in the initial guessing.

The sensitivity of τ estimation in special situations can be high with lower SNR and vary depending on the initial phase and the location of τ inside the window. However, one can design a more elaborated detector to deal with these cases. For example, we have already run computational simulations that show that it is feasible to attain reliable τ estimates in a scenario where a magnitude step occurs near or coincident with a zero crossing, for SNR as low as 50 dB, by using a detector based on the instantaneous magnitude of the Hilbert's analytical signal. Similarly, phase steps that occur near a local maximum (peak) or minimum (valley) of the waveform can be reliably detected using a detector based on a suitable combination of the instantaneous magnitude and phase of the Hilbert's analytical signal.

In the conclusions of the revised paper we comment on the above issue and say we will leave for a future work reporting the investigation of these challenging cases.