WHITEPAPER

Optimizing Masimo SET® SpO_2 Alarm Settings on Select GE Monitors

Summary

- Masimo SET pulse oximetry in GE patient monitors has different alarm configuration settings compared to standalone Masimo SET pulse oximeters.
- These differences in alarm configuration settings will lead to differences in alarm behavior.
- GE offers different alarm configuration choices depending on model.
- Alarm occurrences can be significantly reduced by extending alarm delays so only persistent alarms are annunciated, lowering alarm thresholds according to patient condition, and/or extending averaging times.
- Lowering SpO_2 low-alarm limits to 88% with a 10 second delay may reduce alarms by 78% or more depending on the patient population and care setting.

INTRODUCTION

According to the ECRI Institute[1], alarms are one of the top technology hazards in hospitals today. While responding to actionable alarms is critical to prevent patient injury or death, the frequency of false and nuisance alarms can increase workload and desensitize clinicians to all alarms, putting patients at risk.

Alarms can be placed into three categories:

- True alarms – alarms that require clinician notification and potential intervention;
- False alarms – alarms that occur due to incorrect SpO_2 or pulse rate values;
- Nuisance alarms – true alarms that do not require clinician notification and intervention

Pulse oximeters alarm as implemented on a host monitor are based on three primary factors:

- The displayed SpO_2 and pulse rate value;
- The user-defined alarm threshold and alarm notification delay;
- Alarm averaging

This means that two pulse oximeters can display the same value but one can audibly alarm while the other does not if it has different alarm settings.

GE monitors implement Masimo SET technology, but alarm behavior is determined by the GE monitor, which is different than what is available in Masimo devices. Table 1 gives a subset of Masimo features implemented in select GE products. The option and selection of features determined by the GE monitor can have a dramatic effect on the frequency of alarm occurrence. In the case of GE devices illustrated in Table 1, alarm occurrence can be significantly reduced, in order of impact by the following:

- Extending alarm delays so only persistent alarms are annunciated
- Modestly lowering alarm thresholds according to patient condition
- Extending averaging times

Masimo®

Table 1. Masimo alarm features in select GE Monitors.

GE Alarm Configurations for Masimo SET					
	GE Tram (851 only)	GE Dash 3000, 4000, 5000	GE Carescape® PDM	GE Carescape	Masimo Standalone Monitors
Alarm Delay	None	None (v6.5), 5-15 seconds selectable in one second increments (v6.6)	None	10 seconds fixed in "Escalation" setting	0, 5, 10, 15 seconds
Averaging Times	2-16 seconds	2-16 seconds	2-16 seconds	2-16 seconds	2-16 seconds

SUPERIOR TRUE ALARM DETECTION AND FALSE ALARM PREVENTION

Most pulse oximeters perform well with patients with good peripheral perfusion and who are not moving, but during motion and/or low perfusion, conventional pulse oximetry can freeze, zero out, or falsely alarm. Freezing or zeroing out can delay the notification of true alarms when the patient may require intervention. False alarms due to motion and/or low perfusion can significantly increase the total number of alarms so that clinicians become desensitized to true alarms when they occur.

Masimo SET Measure-Through Motion and Low Perfusion pulse oximetry is a breakthrough technology that significantly improves true alarm detection and false alarm prevention compared to conventional pulse oximetry. More than 100 independent studies have established Masimo SET as the gold standard for pulse oximetry. As shown in Figure 1, in one study[2] Masimo SET was shown to prevent 95% false alarms while detecting 97% of true alarms.

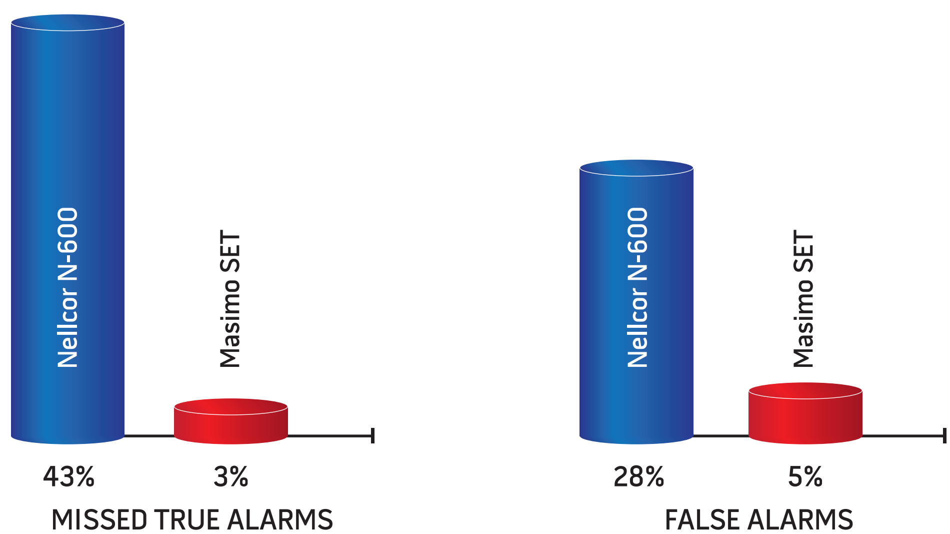


Figure 1. *The occurrence rate of missed true alarms during 40 low saturation events and false alarms during 120 fully oxygenated periods, both during conditions of motion. Pulse oximeters were set with no alarm delay.*

EVIDENCE-BASED ALARM MANAGEMENT

Since Masimo SET's sensitivity and specificity allow for the detection of more true events than any other technology, there will be instances where alarm thresholds are crossed for clinically insignificant periods of time. This can require alarm management strategies that provide clinician-controlled notification delays. Patients in acute care settings can have desaturation events that fall below the traditional alarm threshold of 90% but recover within a few seconds without the need for therapeutic interventions. Figure 2 shows a distribution of Masimo SET SpO_2 values in post-surgical patients on a 36-bed floor over an 11 month period.[3] SpO_2 values less than 90%, the most common alarm threshold setting, occurred 4.4% of the entire monitoring time. This equates to an average of 63 minutes per patient per day during which SpO_2 values were below an alarm threshold of 90% SpO_2. Assuming an average desaturation event of 20 seconds, the 63 minutes of alarm condition could result in 190 separate alarms, the vast majority of which would be non-actionable.

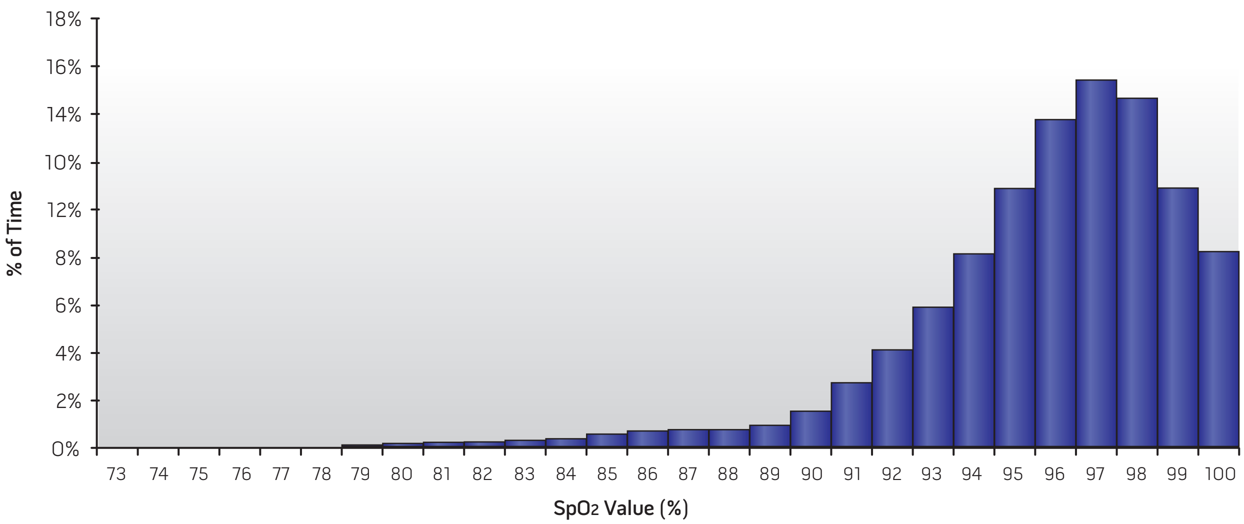


Figure 2. *Frequency of SpO_2 values in post-surgical patients using Masimo SET. SpO_2 values under 90% occurred 4.4% of the time – approximately 1 hour per day. However, very few of these alarms below 90% were actionable.*

Analysis of the Impact of Various Alarm Settings on Alarm Frequency

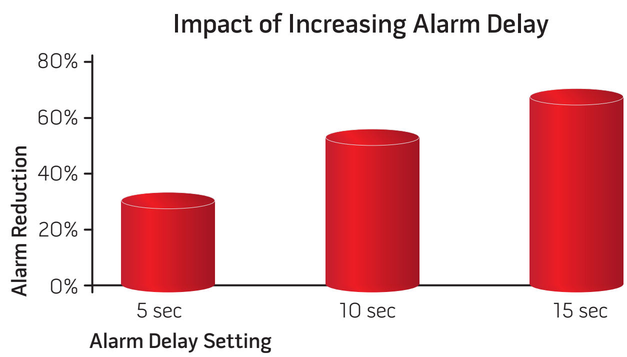
To help clinicians make evidence-based decisions on alarm parameters, Masimo performed a comprehensive analysis of 32 million SpO_2 data points from 10 hospital care areas. Each hospital was equipped with a Masimo Patient SafetyNet Remote Monitoring and Clinician Notification System, which continuously captures and stores time-stamped SpO_2 data. A retrospective analysis was conducted to determine the incidence of alarms at various alarm threshold and delay settings.

A separate analysis was conducted to determine how alarm frequency at various low SpO_2 threshold and delay settings compares to the alarm frequency of the same data run through the Nellcor "SatSeconds" alarm calculation. Based on publicly available information, SatSeconds works by multiplying the percent of the desaturation below the alarm threshold by the number of seconds the value remains below the alarm threshold. For example, a 10% drop below a 90% alarm threshold for 10 seconds would equal 100 SatSeconds.

While it is helpful for comparison purposes, this analysis is expected to significantly underestimate the frequency of alarms with SatSeconds. This is because Masimo SET Measure-Through Motion and Low Perfusion SpO_2 values are being used in the SatSeconds calculation, while in a clinical setting, Nellcor technology calculated SpO_2 values would be used. Nellcor pulse oximetry has been proven in multiple studies to have increased false alarms during motion and low perfusion.

Results of Alarm Delay Settings on Alarm Frequency

Alarm delays are the single most influential factor to reduce alarm frequency. Separation of events between short-duration and longer-duration alarms can be realized by modest alarm delays. Most desaturations below 90% recover within a short period of time. These self-correcting desaturations represent the vast majority of alarms, which in the vast majority of patients do not require clinical intervention. Setting an alarm delay of 5 seconds, as offered in select Dash GE monitors, can reduce alarms by 32%. The most recent GE Carescape monitor has an alarm "Escalation" feature that provides a fixed 10 second delay before visual and audio alarms are activated. Implementing this feature at a threshold setting of 90% may reduce alarms by 57%. Longer delays of 15 seconds, as found in Masimo monitors as well as the GE Dash (v6.6), can reduce alarms by 71%. Figure 3 shows the impact of 5, 10, and 15 second delays on the number of alarms at a low SpO_2 threshold setting of 90%. An alarm delay of 15 seconds reduces alarm frequency by 70%.

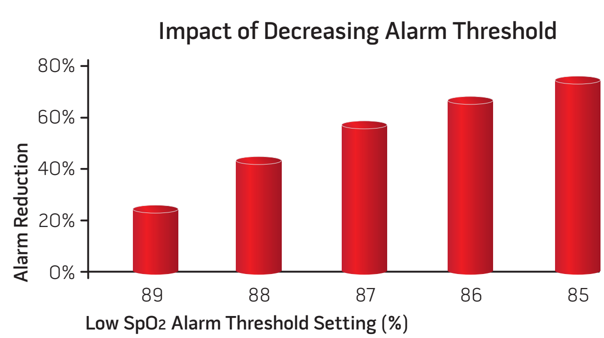


Increasing alarm delays from 5 to 15 seconds can decrease alarms by 70%.

Figure 3. *Longer alarm delays have a profound reduction on nuisance alarms, assuming such short duration events are clinically non-actionable.*

Results of Alarm Threshold Settings on Alarm Frequency

The low SpO_2 alarm threshold can also have a significant effect on the number of alarms generated. Ideally, alarm thresholds should be set to the individual patient condition. Modest lowering of the alarm threshold in the absence of any alarm delay can help reduce the total number of alarms generated. Figure 4 shows that lowering the low SpO_2 alarm threshold from 90% to 88% reduces alarms by 45%. Further reducing the low SpO_2 alarm threshold from 90% to 85% decreases alarms by 75%.



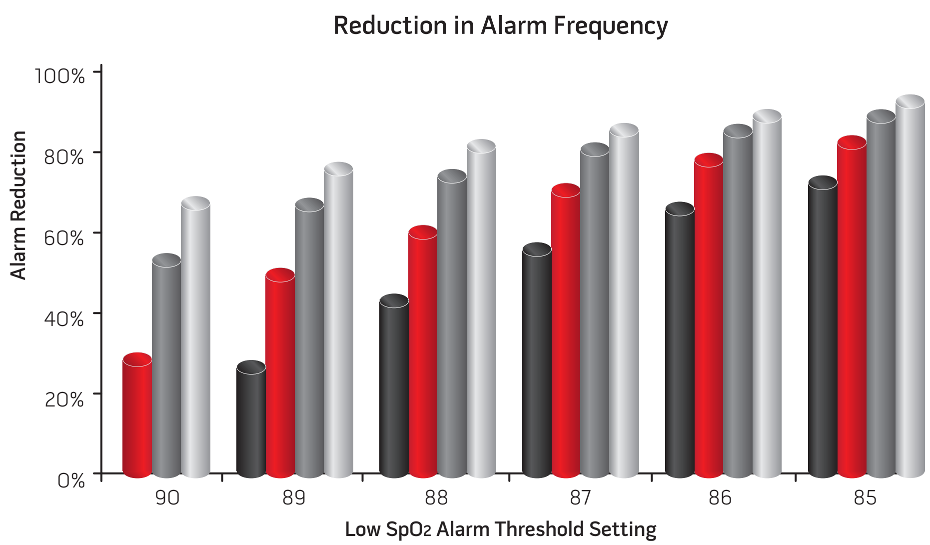
Decreasing alarm thresholds from 90% to 88% decreases alarms by 45%.

Figure 4. *Lower alarm thresholds significantly reduce the occurrence of alarms and should be set according to the severity and risk of the patient population.*

The significant alarm reduction demonstrated in this analysis by decreasing the alarm threshold was also shown by clinicians at a major academic hospital. In their analysis, reducing low SpO_2 threshold to 88% from 90% led to an even greater reduction in alarm frequency of 65%, and led them to change their default alarm threshold.[4]

Results of Combining Alarm Delay and Threshold Settings on Alarm Frequency

Combining both an alarm delay and a lower threshold produces the greatest reduction in alarms, as shown in Figure 5. Lowering alarm limits to 88% with a 15 second delay, as available in the GE Dash (v6.6), reduces alarms by over 85%. These two settings offer significant alarm reduction while preserving actionable alarms. Using the previous example from Figure 2 of 190 alarms per day, setting the low SpO_2 threshold to 88% with a 15 second delay would reduce alarm frequency to 28 alarms per patient per day. Lowering the low SpO_2 alarm threshold to 85% with a 15 second delay would reduce the alarms even further to 17 alarms per patient per day.



Lowering low SpO_2 alarm thresholds from 90% to 88% and setting a 15 second alarm delay can reduce the number of alarms by 85%.

Figure 5. *The combined effects of alarm delay and lower alarm thresholds significantly reduce nuisance alarms.*

For reference purposes, Table 2 shows the full range of alarm reductions possible by lowering alarm thresholds and increasing alarm delays, compared to a 90% low SpO_2 threshold at a zero second delay.

Table 2. Percent reduction in alarms at various low SpO_2 alarm thresholds and alarm notification delays, compared to a 90% low SpO_2 threshold at a zero second delay.

Reduction in Alarm Frequency				
	Alarm Delay			
Low SpO_2 Alarm Threshold (%)	**0 sec**	**5 sec**	**10 sec**	**15 sec**
90	Reference	32%	57%	70%
89	27%	51%	69%	79%
88	45%	64%	78%	85%
87	58%	74%	84%	89%
86	68%	80%	87%	91%
85	75%	85%	87%	91%
84	80%	89%	93%	95%
83	84%	91%	95%	97%
82	87%	93%	96%	97%
81	89%	95%	97%	98%
80	90%	96%	97%	98%

ALARM AVERAGING EFFECTS

Modest changes in SpO_2 averaging times have a small impact compared to alarm thresholds and alarm delays at reducing alarm frequency. Modest extensions in averaging times (e.g., from 8 to 16 seconds) can filter out short duration saturation dips that rebound in a few seconds. Figure 6 illustrates the impact of longer averaging times based on a controlled reference signal.

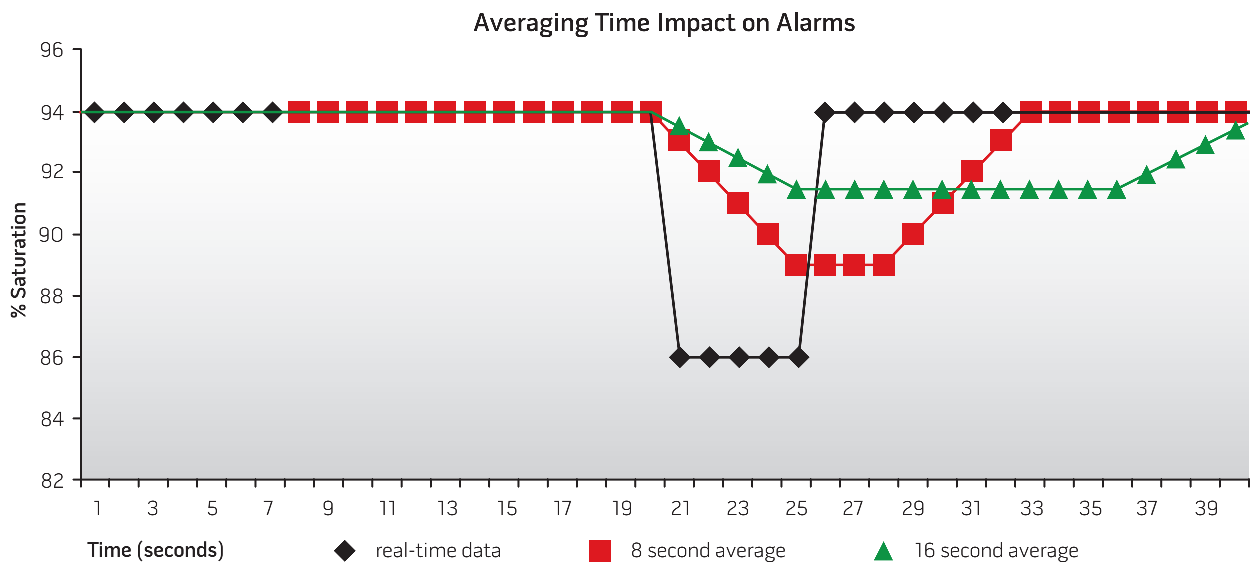


Figure 6. *Longer averaging times can filter the actual changes in saturation such that alarm thresholds may not be crossed for short duration desaturation events.*

Masimo does not recommend an averaging time greater than 16 seconds because it can mask clinically significant desaturations and delay the notification of actionable alarms.

COMPARISON OF GE ALARM DELAYS WITH MASIMO SET VS. SATSECONDS CALCULATION

Nellcor offers a feature called SatSeconds that reduces alarm frequency, similar in purpose to Masimo's evidence-based alarm threshold and delay settings. As previously noted, because Nellcor devices do not reliably measure-through motion and low perfusion, this analysis is expected to underestimate the alarm frequency when SatSeconds is used on a Nellcor pulse oximeter.

Table 3. Alarm thresholds and delay settings that result in a similar alarm frequency as SatSeconds.

Alarm Setting Equivalence to SatSeconds	
SatSeconds Setting at 90% Low SpO_2 Alarm Threshold	Equivalent Alarm Threshold and Delay Settings at Reducing Alarm Frequency
100	90% Low SpO_2 threshold, 15 second delay
50	90% Low SpO_2 threshold, 10 second delay
25	90% Low SpO_2 threshold, 10 second delay
10	90% Low SpO_2 threshold, 5 second delay

Please note that while alarm frequency at the various settings is similar, the actual events that trigger active alarms under each approach can vary.

SUGGESTED ALARM SETTINGS ON MASIMO PULSE OXIMETERS OPTIMIZING GE SETTINGS

The frequency of low SpO_2 alarms on GE monitors can be reduced by modestly lowering alarm threshold settings and adding audio alarm delays if available. Analysis in this report demonstrates a 45% reduction in alarm benefit for general care by reducing the lower alarm setting from 90% to 88%. A recent study by Graham and Cvach from The Johns Hopkins Hospital demonstrated a 63% reduction for the same modest reduction in alarm threshold setting in a medical progressive care unit. Optimizing alarm performance on GE monitors can be accomplished with the following:

- Ensure proper application of the SpO_2 Sensor
- Set alarm thresholds to the individual patient
- Set alarm delays, if available, to the longest possible setting
- Lowering the alarm setting by even one percent SpO_2 can substantially reduce the number of alarms
- Lowering alarm limits to 88% with a 5 second delay reduces alarms by up to 60%
- Extend averaging times to reduce transient SpO_2 changes

As always, clinicians must ensure proper application of the SpO_2 Sensor and set alarm thresholds to the individual patient and care setting.

Please note: The projected alarm frequencies in this analysis do not take into account the effect of the audible alarm on a patient's physiology.

REFERENCES

1. ECRI Institute (www.ecri.org)
2. Shah N et al. *Anesthesiology*, 2006; 105:A929.
3. Taenzer, et al. Defining Normality: Post Operative Heart Rate and SpO_2 Distribution of In-Hospital Patients. *American Anesthesiology Proceedings* 2010. A1466.
4. Graham KC et al. *American Journal of Critical Care*. 2010;19:28-37.

Masimo Americas
tel 1-877-4-Masimo
info-america@masimo.com

Masimo International
tel +41-32-720-1111
info-international@masimo.com

Masimo®
Closer to the Heart

7974-6145A-0310