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June 3, 2016

Natus Medical Incorporated DBA Excel-tech Ltd. (Xltek)
Sanjay Mehta
Senior Manager Quality and Regulatory Affairs
2568 Bristol Circle
Oakville, CA L6H5S1

Re: K152301

Trade/Device Name: Background Pattern Classification (BPC™)
Regulation Number: 21 CFR 882.1400
Regulation Name: Electroencephalograph
Regulatory Class: Class II
Product Code: OMA, ORT
Dated: April 22, 2016
Received: May 5, 2016

Dear Sanjay Mehta:

We have reviewed your Section 510(k) premarket notification of intent to market the device referenced above and have determined the device is substantially equivalent (for the indications for use stated in the enclosure) to legally marketed predicate devices marketed in interstate commerce prior to May 28, 1976, the enactment date of the Medical Device Amendments, or to devices that have been reclassified in accordance with the provisions of the Federal Food, Drug, and Cosmetic Act (Act) that do not require approval of a premarket approval application (PMA). You may, therefore, market the device, subject to the general controls provisions of the Act. The general controls provisions of the Act include requirements for annual registration, listing of devices, good manufacturing practice, labeling, and prohibitions against misbranding and adulteration. Please note: CDRH does not evaluate information related to contract liability warranties. We remind you, however, that device labeling must be truthful and not misleading.

If your device is classified (see above) into either class II (Special Controls) or class III (PMA), it may be subject to additional controls. Existing major regulations affecting your device can be found in the Code of Federal Regulations, Title 21, Parts 800 to 898. In addition, FDA may publish further announcements concerning your device in the Federal Register.

Please be advised that FDA's issuance of a substantial equivalence determination does not mean that FDA has made a determination that your device complies with other requirements of the Act or any Federal statutes and regulations administered by other Federal agencies. You must comply with all the Act's requirements, including, but not limited to: registration and listing (21 CFR Part 807); labeling (21 CFR Part 801); medical device reporting (reporting of medical device-

related adverse events) (21 CFR 803); good manufacturing practice requirements as set forth in the quality systems (QS) regulation (21 CFR Part 820); and if applicable, the electronic product radiation control provisions (Sections 531-542 of the Act); 21 CFR 1000-1050.

If you desire specific advice for your device on our labeling regulation (21 CFR Part 801), please contact the Division of Industry and Consumer Education at its toll-free number (800) 638-2041 or (301) 796-7100 or at its Internet address

<http://www.fda.gov/MedicalDevices/ResourcesforYou/Industry/default.htm>. Also, please note the regulation entitled, "Misbranding by reference to premarket notification" (21 CFR Part 807.97). For questions regarding the reporting of adverse events under the MDR regulation (21 CFR Part 803), please go to

<http://www.fda.gov/MedicalDevices/Safety/ReportaProblem/default.htm> for the CDRH's Office of Surveillance and Biometrics/Division of Postmarket Surveillance.

You may obtain other general information on your responsibilities under the Act from the Division of Industry and Consumer Education at its toll-free number (800) 638-2041 or (301) 796-7100 or at its Internet address

<http://www.fda.gov/MedicalDevices/ResourcesforYou/Industry/default.htm>.

Sincerely yours,

Michael J. Hoffmann -A

for Carlos L. Peña, PhD, MS
Director
Division of Neurological
and Physical Medicine Devices
Office of Device Evaluation
Center for Devices and Radiological Health

Enclosure

Indications for Use

510(k) Number (if known)

K152301

Device Name

Background Pattern Classification

Indications for Use (Describe)

The Background Pattern Classification algorithm is intended for:

- Neonatal patients, defined as from birth to 28 days post-delivery, and corresponding to a post-conceptual age of 37 to 46 weeks, in clinical environments such as the intensive care unit, operating room, and for clinical research.
- To analyze and identify background patterns in aEEG, including continuous and discontinuous activity, burst suppression, low voltage, and inactive patterns. The aEEG must be obtained from a pair of parietal electrodes located at positions corresponding with P3 and P4 of the International 10/20 System. The output of the background pattern classification algorithm must be reviewed and interpreted by qualified clinical practitioners.

The device does not provide any diagnostic conclusion about the patient's condition.

Type of Use (Select one or both, as applicable)

Prescription Use (Part 21 CFR 801 Subpart D)

Over-The-Counter Use (21 CFR 801 Subpart C)

CONTINUE ON A SEPARATE PAGE IF NEEDED.

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510K Summary

Date: June 3rd., 2016

Submitted by: Natus Medical Incorporated
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Contact Person:

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Proprietary Name: Background Pattern Classification Algorithm (BPc™)

Common Name: aEEG software

Classification Name (Number): Amplitude Integrated Electroencephalograph (882.1400),
Burst Suppression Detection Software for Electroencephalograph(882.1400).

Product code: OMA; ORT

Device Class: II

Predicate Devices: QP-160AK Trend program (K092573)

Description

BPc™ is a software only product that identifies background patterns seen on aEEG signal recorded from a pair of parietal electrodes (P3-P4) in neonates, defined as from birth to 28 days post-delivery, and corresponding to a post-conceptual age of 37 to 46 weeks. The classification of aEEG background pattern into one of five different classes is done in accordance with the scoring scheme described in the following table:

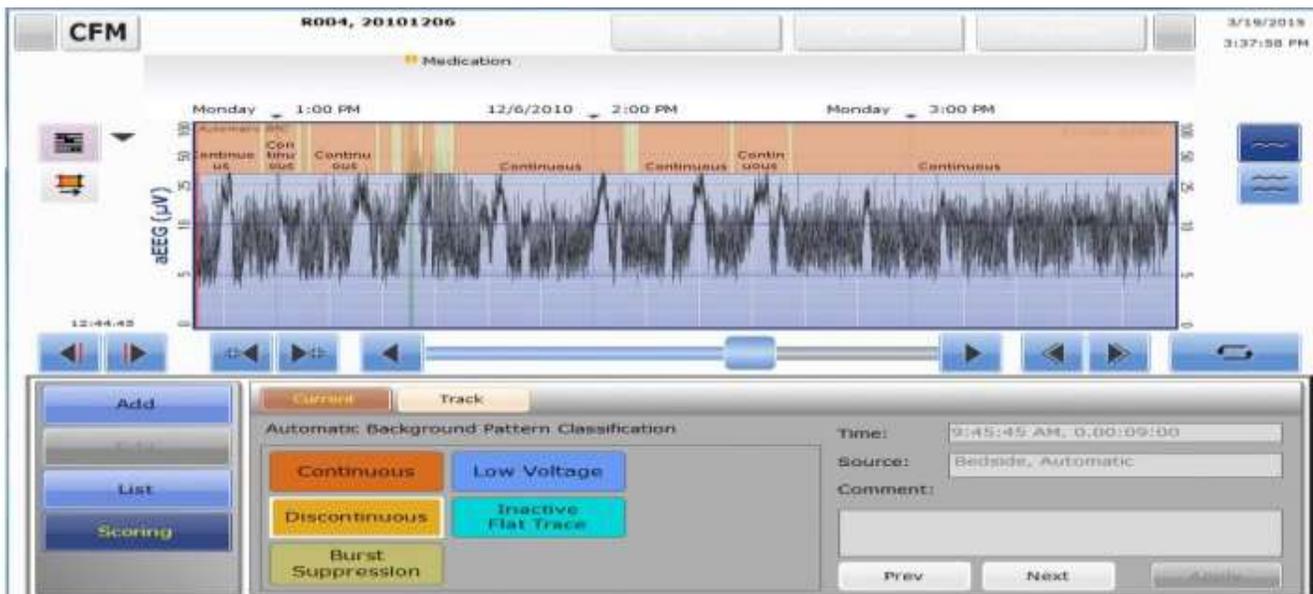
Classification of aEEG Patterns in Term Neonates

Describes the dominating type of electrocortical activity in the aEEG trace.

1. **Continuous (C)**: Continuous activity with lower (minimum) amplitude around (5 to) 7 to 10 μV and maximum amplitude of 10 to 25 (to 50) μV .
2. **Discontinuous (DC)**: Discontinuous background with minimum amplitude variable, but below 5 μV , and maximum amplitude above 10 μV .
3. **Burst-suppression (BSA)**: Discontinuous background with minimum amplitude without variability at 0 to 1 (2) μV and bursts with amplitude $>25 \mu\text{V}$. BS+ denotes burst density >100 bursts/h, and BS- means burst density <100 bursts/h.
4. **Low voltage (LV)**: Continuous background pattern of very low voltage (around or below 5 μV).
5. **Inactive, flat (FT)**: Primarily inactive (isoelectric tracing) background below 5 μV .

Similar to basic EEG interpretation, pattern recognition forms the basis of aEEG interpretation. The classification scheme takes in consideration variations in the amplitude for the lower and upper margin of the aEEG signal. The BPC™ algorithm applies a set of rules to estimate the background pattern based on upper and lower margins of the aEEG signal.

The output of the device consists in marked regions with the corresponding background pattern name and a list of detected patterns in the signal. These detections (marked regions) are then reviewed, accepted or discarded by the qualified medical practitioner. The software does not make any final decisions that result in any automatic diagnosis or treatment. None of the components of the device is responsible for data acquisition, review or any other function different from analysis.



BPC™ Output as presented to the end-user (top panel), BPC™ edit scoring overlay (lower panel)

Indications for Use

The Background Pattern classification algorithm is intended for:

- Neonatal patients, defined as from birth to 28 days post-delivery, and corresponding to a post-conceptual age of 37 to 46 weeks, in clinical environments such as the intensive care unit, operating room, and for clinical research.
- To analyze and identify background patterns in aEEG, including continuous and discontinuous activity, burst suppression, low voltage, and inactive patterns. The aEEG must be obtained from a pair of parietal electrodes located at positions corresponding with P3 and P4 of the International 10/20 System. The output of the background pattern classification algorithm must be reviewed and interpreted by qualified clinical practitioners.

The device does not provide any diagnostic conclusion about the patient's condition.

Predicate Comparison

The substantial equivalence of the BPC™ algorithm is based on its similarities to the cleared QP-160AK Trend program (K092573).

Device Feature	Subject Device BPC™ Algorithm	Predicate QP-160AK EEG Trend Program (K092573)	Comparison
Device Class	Class II	Class II	Same
Common Name	Amplitude Integrated electroencephalograph	Amplitude-integrated electroencephalograph	Same
Intended Use			
Purpose and function:	aEEG monitoring	EEG/aEEG monitoring	Different. Subject device only works on aEEG recordings. No safety/effectiveness concern.
Patient population	Neonatal	Neonatal	Same
Environment of use	Clinical environments (NICU, research)	Clinical environments (NICU, research)	Same
Intended User	qualified medical practitioners	qualified medical practitioners	Same
Signal Processing			
Input Signal	aEEG	EEG	Different. Subject device only works on aEEG recordings. No safety/effectiveness concern.
Number of Electrodes and location	2 electrodes located according at P3-P4 of the International 10-20 System	≥16 electrodes located according to the International 10-20 System	Different. (see Discussion)
Environment of use:	Clinical environments (NICU, research)	Clinical environments (NICU, research)	Same
Parameters and Performance			
Burst-Suppression	Yes	Yes	Same
Additional background patterns (i.e Continuous, discontinuous, flat trace)	Yes	No	Different. (see Discussion)

Device Feature	Subject Device BPC™ Algorithm	Predicate QP-160AK EEG Trend Program (K092573)	Comparison
PPA % (bootstrap CI)	C- 86 (77 – 94) D- 64 (51 – 77) BS- 89 (78 – 99) LV- 66 (50 – 83) FT- 80 (63 – 96) Overall- 77 (72 – 82)	Performance data Not Available	Unknown
FDR (false detection rate, False Positive/hour)	C- 0.3 D- 0.1 BS- 4.4 LV- 4.2 FT- 4.2 Overall- 2.5	Performance data Not Available	Unknown

Continuous(C)
 Discontinuous(D)
 Burst suppression (BS)
 Low voltage (LV)
 Inactive, flat (FT)

Discussion

Both devices are intended for aEEG monitoring in the neonatal population and to be used in same clinical environments. The predicate device however, has the addition of EEG. Even though EEG analysis is not a feature of the subject device, we believe this to have no impact on the safety and effectiveness of the subject device when used as labeled. Moreover, aEEG alone (as in the subject device) has been long established by the scientific community and accepted by the American Academy of Neurology (Shellhaas et al 2011) as a safe and effective monitoring tool for the neonatal population. In line with current medical practice and scientific evidence, the FDA has long determined product codes and cleared for market aEEG only devices (i.e FDA product code OMA, K071449, K031149). Hence, this difference does not affect the safety and effectiveness of the subject device as compared to the predicate.

The difference on input signal is also related to the aforementioned difference on signal analysis. While the predicate device input signal is the raw EEG the subject device uses the aEEG only. aEEG is a form of processed EEG signal, that is, aEEG is derived after collection of the raw EEG data, in this regard the subject device analyzes processed EEG. Even though the predicate device uses the raw EEG data, it actually requires some type of EEG processing in order to carry its intended function. Both devices use processed EEG as part of their function. Detection of background patterns on raw EEG versus aEEG is roughly equivalent (Toet et al 2002) although the difference on input signal dictates the method used on the detection algorithm. Safety and effectiveness of the subject device for the detection of background pattern has been established through clinical testing, that is comparison of device performance versus the Gold standard in clinical practice therefore we believe this difference does not affect the safety and effectiveness of the subject device as compared to the predicate.

The predicate device allows recording of aEEG from 16 channels or more while the subject device only uses the aEEG form two electrode locations (P3-P4). The restricted number of electrodes might

only provide a snapshot into the neonate's neurological state, however the background pattern classification based on P3-P4 has been previously established as valid, safe and effective given the intended use of the device (Spitzmiller et al 2007, al Naqeeb et al 1999). In acknowledgment of these facts FDA has previously cleared similar devices where only biparietal electrodes were available to monitor the state of the brain (K791580, K983229, K031149). In addition the background classification scheme adopted by the subject device is that accepted by the medical community and is based only on P3-P4 electrodes. Hence, the difference in the number of electrodes between the subject and predicate do not raise new concerns of safety/effectiveness for the subject device.

Performance data for the predicate device was not available at the time of this submission. Instead of comparing performance to that of the predicate we decided to establish performance of the BPC™ algorithm on its own merit as compared to the gold standard of care, which is performance of a panel of 3 medical experts carrying out the same task. Based on the results of the Clinical Validation we believe that subject device performance is equivalent to that of the gold standard (i.e medical experts). Furthermore, the subject device intended use and accompanying labeling clearly restrict the use of the device to qualified clinical practitioners who will "review(ed) and interpret(ed)" the output of the subject device. Therefore, provided that all clinical results are available to the users plus the set restrictions for device use are in place, we believe that the use of the device as intended is safe and effective and equivalent to the predicate.

IFU Comparison and Discussion

Note: Highlighted in **GREEN** are the components we claim equivalence to. In **GRAY** are components to which we do not claim equivalence.

Predicate device IFU

The QP-160AK Trend program **is a software only device** intended to be installed on the EEG-1200A series electroencephalograph to record, calculate, and display EEG data obtained from the EEG-1200A system. This device **is intended to be used by qualified medical practitioners**, trained in Electroencephalography, **who will exercise professional judgment when using the information.**

The intended use for each of this software's output is as follows:

- The EEG and aEEG waveforms are intended to help the user monitor the state of the brain.
- The user defined Fast Fourier Transform (FFT) parameters of this software (FFT power) are intended to help the user analyze the EEG waveform.
- **The burst suppression parameters of this software (interburst interval and bursts per minute) are intended to aid in the identification and characterization of areas of burst suppression pattern** in the EEG.

This device does not provide any diagnostic conclusion about the patient's condition to the user.

Subject device IFU

The Background Pattern **classification algorithm** is intended for:

- Neonatal patients, defined as from birth to 28 days post-delivery, and corresponding to a post-conceptual age of 37 to 46 weeks, in clinical environments such as the intensive care unit, operating room, and for clinical research.
- **To analyze and identify background patterns in aEEG, including continuous and discontinuous activity, burst suppression, low voltage, and inactive patterns. The aEEG must be obtained from a pair of parietal electrodes located at positions corresponding with P3 and P4 of the International 10/20 System. The output of the background pattern classification algorithm must be reviewed and interpreted by qualified clinical practitioners.**

The device does not provide any diagnostic conclusion about the patient's condition.

We claim equivalence to the aEEG monitoring and to the identification of burst suppression pattern.

Similarities:

- Both are software only.
- Both analyze brain electrical activity
- Both are used to monitor brain electrical activity.
- Both detect background patterns of the brain electrical activity.
- Both are meant to be used by qualified medical practitioners.
- None of the devices provide diagnostic conclusions.

Differences:

- Predicate uses aEEG and EEG.
- Predicate detects Burst suppression areas only and derives numeric parameters from the detected areas.
- Subject device detects background patterns other than burst-suppression.

IFU differences discussion

- *Predicate uses aEEG and EEG.*

The predicate uses aEEG and EEG. EEG analysis is not a feature of the subject device. aEEG is a form of processed EEG signal, that is, aEEG is derived from raw EEG data, in this regard the subject device analyzes processed EEG. Even though the predicate device uses the raw EEG data, it actually requires EEG processing in order to carry its intended function (i.e to derive parameters that will help the **"identification and characterization of areas of burst suppression pattern"**). On this regard we claim that both devices use processed EEG as part of their function. Detection of background patterns on raw EEG versus aEEG is equivalent although the difference on input signal dictates the method used for the detection algorithm. Safety and effectiveness of the subject device for the detection of

background pattern has been established through clinical testing, that is comparison of device performance versus the Gold standard in clinical practice. Moreover, aEEG alone (as in the subject device) has been long established by the scientific community and accepted by the American Academy of Neurology (Shellhaas et al 2011) as a safe and effective monitoring tool. In line with current medical practice and scientific evidence, the FDA has long determined product codes and cleared for market aEEG only devices (i.e FDA product code OMA, K071449, K031149). We then believe that this difference has no impact on the safety and effectiveness of the subject device when used as labeled.

- *Predicate detects Burst suppression areas only and derives numeric parameters from the detected areas.*

The subject device, as the predicate, detects Burst-suppression areas, however it does not derive any numeric parameter from this detection. Detection of burst-suppression areas (carried by both devices) precedes the parameter calculation and the effectiveness of the subject device in the detection of burst-suppression areas was established through clinical testing and shown to be equivalent to the gold standard of clinical practice. Hence, we believe that this feature of the subject device to be equivalent to the predicate.

As to the derivation of numeric parameters (as in the predicate) it requires additional computation beyond that required for detection only. This additional step does not only increase the probability of errors of the predicate device but also requires that the derived values are properly validated through clinical studies. We have no information as to the accuracy of the derived parameters on the predicate device, and given that the subject device refrains for any additional calculations we saw no need for such comparison in our clinical study. Calculation of (interburst interval and bursts per minute could also be done using the subject device but in our case that remains the responsibility of the qualified practitioner who has to do it manually at his own discretion. We therefore believe that this difference between devices has no impact on safety and effectiveness for the subject device when used as labeled.

- *Subject device detects background patterns other than burst-suppression.*

In addition to detection of Burst-suppression areas (as in the predicate) the subject device detects other types of background patterns. Detection of such other areas is carried based on general rules that includes and go beyond the burst-suppression. These rules were long established by the scientific community and the effective application of those rules on our device performance were established through clinical testing and shown to be equivalent to the gold standard of clinical practice. In addition the intended user of the device is informed in detailed of the device performance characteristics and limitations. We therefore believe that this difference between the subject and predicate device has been properly addressed and related risks mitigated raising no new questions about the safety and effectiveness of the subject device.

Conclusion

Based on the rationale discussed above we believe that; in spite of the differences in technological characteristics between the subject and the predicate device, the use of the BPC™ algorithm is safe and effective for the intended use and substantially equivalent to the predicate.

Brief Summary of Non-Clinical and Clinical Performance Tests

All functionalities and performance of the Background Pattern Classification (BPC™) Algorithm have been verified and validated through bench and clinical performance tests according to the intended use and user of the device.

Non-Clinical: The BPC™ device is compliant with all currently accepted safety standards for medical devices of its class which was demonstrated through testing, verification and validation of all components.

- 21 CFR part 820 Quality System Requirements
- Canadian Medical Device Regulations
- ISO 14971:2000, Medical Devices - Application of Risk Management to Medical Devices
- ISO13485: 2003, Medical devices — Quality management systems — Requirements for regulatory purposes.
- IEC 62304:2006. Medical Device Software. Software Life cycle processes.

Clinical: Natus conducted an extensive clinical test to: 1) Evaluate the positive percent agreement (i.e., detection sensitivity) and false detection rate of the BPC™ algorithm, and to 2) Demonstrate equivalence of the performance, in terms of positive percent agreement and false detection rates, of the BPC™ algorithm as compared to the gold standard, that is, background pattern as classified by a panel of 3 EEG board certified medical professionals.

BPC™ Clinical Validation

Dataset Description:

Gestational age at birth (Mean ± SD)	39.3 (± 1.9)
GENDER (Female/Male)	36/28

Analysis Method

EEG studies were de-identified, randomized and provided to board certified neurophysiologists that independently, blindly and manually marked background pattern states according to the classification scheme detailed below (see table) in the same manner they would normally do in clinical practice.

Classification of aEEG Patterns in Term Neonates.

Describes the dominating type of electrocortical activity in the aEEG trace.

1. **Continuous (C)**: Continuous activity with lower (minimum) amplitude around (5 to) 7 to 10 μ V and maximum amplitude of 10 to 25 (to 50) μ V.
2. **Discontinuous (D)**: Discontinuous background with minimum amplitude variable, but below 5 μ V, and maximum amplitude above 10 μ V.
3. **Burst-suppression (BS)**: Discontinuous background with minimum amplitude without variability at 0 to 1 (2) μ V and bursts with amplitude >25 μ V. BS+ denotes burst density >100 bursts/h, and BS- means burst density <100 bursts/h.
4. **Low voltage (LV)**: Continuous background pattern of very low voltage (around or below 5 μ V).
5. **Inactive, flat (FT)**: Primarily inactive (isoelectric tracing) background below 5 μ V.

Recordings were also independently submitted for analysis using the BPC™ algorithm.

Results

Inter Rater Performance

Inter-rater Positive Percent Agreement and False Detection / hour

	Rev1 (vs23)		Rev2 (vs13)		Rev3 (vs12)	
	PPA (%)	FDR (FD/h)	PPA (%)	FDR (FD/h)	PPA (%)	FDR (FD/h)
C	80 (70 – 90)*	1.2	68 (51 – 88)	0.7	96 (91 – 100)	5.5
D	73 (62 – 85)	3.3	67 (50 – 83)	5.5	46 (32 – 60)	4.4
BS	79 (61 – 93)	1.6	80 (63 – 100)	4.6	43 (24 – 61)	0.0
LV	68 (39 – 96)	3.0	67 (39 – 94)	1.5	90 (67 – 100)	5.6
FT	92 (72 – 100)	2.0	79 (55 – 100)	0.0	91 (70 – 100)	1.9
Overall	78 (71 – 84)	2.3	71 (63 – 80)	3.2	66 (59 – 74)	3.5

*Bootstrap 95% CI

Algorithm Performance Comparison

	PPA (%)	FDR (FD/h)
C	86 (77 – 94)*	0.3 (0.1 – 0.7)*
D	64 (51 – 77)	0.1 (0.1 – 0.3)
BS	89 (78 – 99)	4.4 (1.5 – 5.0)
LV	66 (50 – 83)	4.2 (2.3 – 4.8)
FT	80 (63 – 96)	4.2 (1.2 – 4.8)
Overall	77 (72 – 82)	2.5 (1.6 – 3.5)

*Bootstrap 95% CI

Conclusions

Based on the results of the clinical and non-clinical testing we have found BPC™ algorithm to be substantially equivalent to the predicate and safe and effective for its intended use.