PULSE Small Wind Turbine Acoustic Sound Testing according to BWEA and AWEA Type 7915

Wind turbine noise is an increasingly important environmental issue throughout the world. International standards are constantly being developed to ensure consistency and accuracy in the measurement and analysis of noise emitted by wind turbine generator systems.

PULSE™ Small Wind Turbine Acoustic Sound Testing Type 7915 allows you to measure the acoustic noise of wind turbines with a maximum rated power of not greater than 100 kW, according to British Wind Energy Association (BWEA) and American Wind Energy Association (AWEA) standards and also IEC 61400–11, edition 3.0, Annex F.

Uses and Features

Uses

- Manufacturers of small wind turbines can define and verify/ validate acoustic emission performance
- Purchasers of small wind turbines can check the expected acoustic emission performance of new or refurbished units
- Planners and consultants can calibrate or validate their calculated environmental noise maps for single wind turbines or extensive wind farms

Features

- Measures acoustic noise levels according to BWEA Small Wind Turbine Performance and Safety Standard (29 February 2008) and yields an emission noise map
- Measures acoustic noise levels according to AWEA Small Wind Turbine Performance and Safety Standard (9.1 – 2009) and yields a rated sound level
- Measures acoustic noise levels according to IEC 61400–11 edition 3.0, Annex F and yields an emission map
- Measures operational and background noise with simultaneous CPB and FFT analysis
- Determines tonality
- Flexible interface to turbine and weather data
- Emission maps of sound pressure contours as a function of wind speed vs. distance from turbine tower
- PULSE-based system gives access to other PULSE analysis packages (licenses permitting)

Brüel & Kjær

Brüel & Kjær has developed a number of applications for the measurement, analysis and reporting of acoustic emission of wind turbines (Table 1). Due to the lower production cost of small wind turbines as well as the different designs, the standardization committees have found it appropriate to ease the demands on noise measurements. In particular, the requirement for nacelle anemometry has been waived. Type 7915 deals with small wind turbines, that is, wind turbines having a maximum power output of 100 kW, or a rotor swept area of 200 m^2 or less (rotor diameter 16 m (52 ft) for horizontal axis turbines).

Table 1
Current standards for acoustic measurements on wind turbines and the corresponding Brüel & Kjær PULSE applications

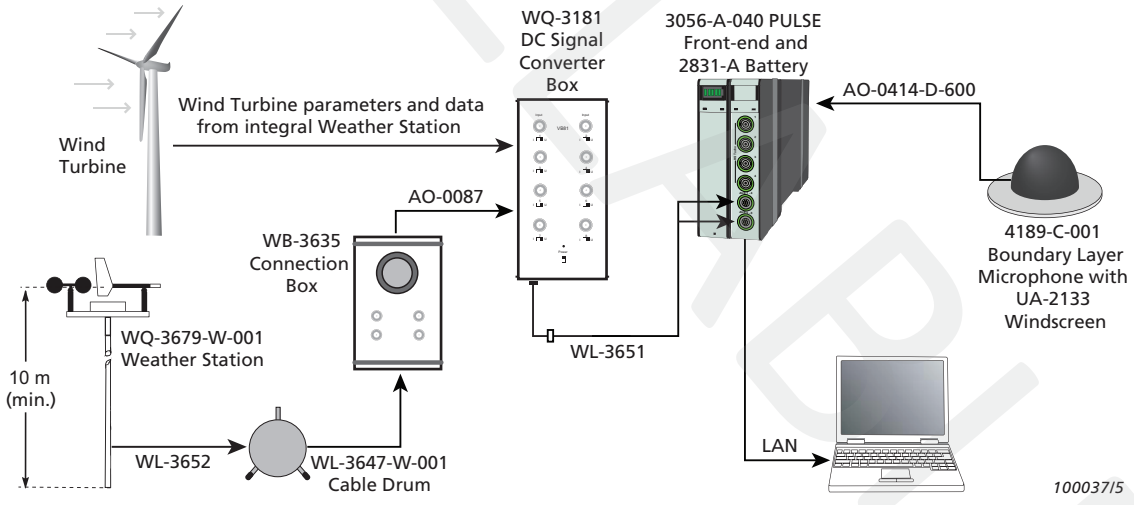
	PULSE Wind Turbines Sound Power Determination Type 7914		PULSE Small Wind Turbine Acoustic Sound Testing Type 7915		
Standard	**IEC 61400–11 edition 2.1**	**IEC 61400–11 edition 3**	**BWEA**	**AWEA**	**IEC Annex F**
Wind Turbine Type	Not restricted to wind turbines of a particular size or type		Applies to wind turbines with a rotor swept area of 200 m^2 or less (rotor diameter 16 m or 52 ft for horizontal axis turbines)		Applies to wind turbines with a maximum power output of <100 kW

A typical system incorporates a portable front-end PULSE LAN-XI data acquisition unit (Type 3056-A-040), a Type 4189 Microphone and preamplifier, a Battery Type 2831-A and a laptop PC, see Fig. 1. With PULSE, simultaneous CPB and FFT analyses can be made in real-time on the laptop PC and the portability of the system enables it to be easily transported to sites around the world. For acoustic sound testing, according to the small wind turbine standards, the measurement and reporting of electrical power, rotor RPM, pitch angle and yaw direction are not mandatory.

System Setup for Acoustical Measurements

Basically the measurements are performed according to IEC 61400–11, but specific departures from the IEC standards are provided in the AWEA and BWEA standards to account for technical differences between large and small wind turbines. Furthermore, the results are presented in a more consumer-friendly manner. The measurement microphone has to be placed downwind within ±45° for IEC 61400–11 (±60° for BWEA or ±15° for AWEA) of the wind direction, at a distance R_0 from the turbine tower, determined by the wind turbine height H and the blade diameter D. Specifically, $R_0 = H + D/2$.

Fig. 1
Small Wind Turbine Acoustic Sound Testing according to AWEA, BWEA and IEC 61400–11 Annex F, typical system



The data from the microphone and from the weather station are measured together, analysed in PULSE and a report produced. For further information on measurement procedure, please refer to the relevant standard (AWEA; BWEA, IEC 61400–11 Annex F).

Wind Speed Measurements

According to IEC 61400–11 Annex F, the wind speed must be measured directly using an anemometer placed at a height of at least 10 m (BWEA at least 5 m), preferably at rotor centre height, and not more than 25 m from the rotor centre.

Weather Station

Weather Station WQ-3679-W-001 fulfils IEC 61400–11 for the measurement of wind speed and wind direction. In IEC 61400–11, the following weather station specifications are given:

- **Anemometer**: The anemometer and its signal processing equipment shall have a maximum deviation from the calibration value of ± 0.2 m/s in the wind speed range from 4 m/s to 12 m/s. It will be capable of measuring the average wind speed over time intervals synchronized with the acoustic measurements
- **Wind Direction Transducer**: The wind direction transducer shall be accurate to within ±6°

WQ-3679-W-001 also measures temperature and atmospheric pressure.

Secondary Windscreen

A secondary windscreen is recommended by IEC 61400–11. The influence of Windscreen for Boundary Layer Microphone UA-2133 is included in the PULSE transducer database.

Acoustic Measurements

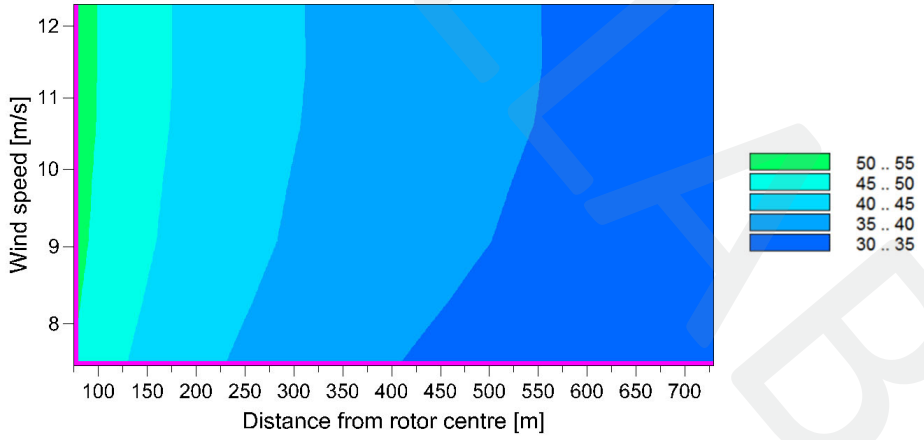
Type 7915 software guides you through the acoustic measurement procedure. Once you have made the measurement, the results are exported to Excel® to calculate immission noise maps, sound power levels, rated sound levels and tonal audibility (depending on standard used) ready for the report.

Reporting

When the measurement procedure is completed, Type 7915 allows you to produce a report according to the standard to document your findings. A typical report contains the configuration of the wind turbine and its operating conditions. The information reported depends on the standard being followed:

- **IEC 61400–11 Annex F:** An immission map based on determined sound power levels covering the wind speed range for which the sound power levels are available. The immission map shows sound pressure level contours as a function of wind speed vs. distance from the rotor centre
- **AWEA:** Rated Sound Level calculated at 60 m from rotor hub, excluding any contribution from background sound. Tonal analysis not required, but the presence of prominent tones must be observed and reported
- **BWEA:** Noise Label containing a Noise Map plotted at level of 40 and 45 dB (A) since these are the most relevant to the levels used for planning purposes. The map is plotted from the cut-in wind speed up to the cut-out wind speed for the given turbine

Fig. 2
Example of a noise contour plot



Specifications – Small Wind Turbine Acoustic Sound Testing according to BWEA and AWEA Type 7915

MEASUREMENTS
Measurement Positions: Records site layout, conditions (roughness)
Acoustic Measurements: Measures CPB, FFT, operational and background noise
Non-acoustic Measurements: Matches turbines with DC signals (Aux. channels); includes a weather station interface and an interface for receiving output power signals from the turbine (hardware required)

Parameters Measured: Wind speed, correction for background noise, apparent sound power levels, one third octave levels, tonality

REPORTING
Generated in Microsoft® Excel®

Type 7915 System with PULSE LAN-XI Module Type 3056

Type 7915 is a Windows®-based application for use with PULSE

Software is delivered via installation media (DVD or USB). The licence is either: node-locked to a PC host ID or dongle; or floating, locked to a network server

SYSTEM REQUIREMENTS

- PULSE Wind Turbine Sound Power Determination according to IEC 61400-11 Type 7914
- Microsoft® Windows® 10 Pro or Enterprise (x64) with either Current Branch (CB) or Current Branch for Business (CBB) servicing model; or Windows® 7 Pro, Enterprise or Ultimate (SP1) (x64) operating systems
- Microsoft® Office 2016 (x32 or x64) or Office 2013 (x32 or x64)
- Microsoft® SQL Server® 2014 Express (SP2) (included in installation), SQL Server® 2014 (SP2), SQL Server® 2012 R2, SQL Server® 2008 or 2008 R2 Express Edition SP1

RECOMMENDED SYSTEM CONFIGURATION

- Intel® Core™ i7, 3 GHz processor or better
- 32 GB RAM
- 480 GB Solid State Drive (SSD) with 20 GB free space, or better
- 1 Gbit Ethernet network*
- Microsoft® Windows® 10 Pro or Enterprise (x64), CB
- Microsoft® Office 2016 (x32)
- Microsoft® SQL Server® 2014 (SP2)
- Screen resolution of 1920 × 1080 pixels (full HD)

POWER REQUIREMENTS

Fulfils the requirements of ISO 7637−1 and 7637−2 with batteries
DC Input: 10 to 32 V DC

Power Consumption:

- DC Input: <15 W
- Max.: 26 W (while charging battery)
- Ext. Power Connector: LEMO coax., FFA.00.113, ground on shield

LAN-XI DATA ACQUISITION HARDWARE

The software automatically detects the front-end hardware connected and configures the system. If IEEE 1451.4 capable transducers (with standardized TEDS) are being used, these are also detected and attached automatically to the correct channel of the input module

For information about LAN-XI Data Acquisition Modules, see Product Data BP 2215

LAN-XI BATTERY MODULE TYPE 2831-A
Typical Operating Time: >7 hours with single module
Charging Time: 2 hours with ZG-0469 mains charger

ACOUSTIC NOISE EMISSION (AT 1 M)
Silent operation to 35 °C (95 °F) when not charging batteries.

DC OUTPUT
+5 V ±0.5 V, +12 V ±1.0 V; max. 0.4 A (1 A fused)
Connector: LEMO FGG.00.302

DIMENSIONS	Type 3056-A-040	Type 2831-A
Height:	132.6 mm (5.22″)	132.6 mm (5.22″)
Width:	27.5 mm (1.08″)	27.5 mm (1.08″)
Depth:	248 mm (9.76″)	248 mm (9.76″)
Weight:	750 g (1.65 lb)	1.0 kg (2.2 lb)

½″ PREPOLARIZED FREE-FIELD MICROPHONE TYPE 4189
Nominal Open-circuit Sensitivity: 50 mV/Pa, −26 dB ± 1.5 dB re 1 V/Pa
Capacitance: 14 pF at 250 Hz

DC SIGNAL CONVERTER BOX

The converter box (customized product) is used to condition the signals from the turbine and weather station to the auxiliary channel
Switchable between voltage and current inputs of 0 to 10 V, or 4 to 20 mA†

WEATHER STATION WQ-3679-W-001
Power Supply: 15 to 24 V DC
Output Wind Speed: 0 to 10 V = 0.3 to 75 m/s; **Accuracy**: 0.3 to 50 m/s, 1% of measured value or better than ± 0.2 m/s
Output Wind Direction: 0 to 10 V = 0 to 360°; **Accuracy:** ± 2°
Air Pressure:

- Conditioning Gain: 19.23 mV/hPa (>52 hPa/V)
- Measurement Range: 800 to 1060 hPa (0 to 5 V)
- Calibration: Manufacturer's certificate for the built-in barometer (Vaisala®, PTB 110) is enclosed with the Weather Station

Temperature:

- Conditioning Gain: 80 m V/°C (>12.5°/V)
- Measurement Range: –10 to +52.5 °C (14 to 126.5 °F)(≈ 0 to 5 V)
- Calibration Reference (24 °C (75.2 °F)): 2.4 V

Humidity:

- Conditioning Gain: 50 mV/%RH (>20% RH/V)
- Measurement Range: 20 to 90% RH (≈ 0.5 V to 4.5 V)
- Calibration Reference (5 to 60 °C (40 to 140 °F)): 1.65 V with 33% RH; 3.75 V with 75% RH

* A dedicated data acquisition network (LAN or WAN) is recommended; a network that only handles data from the front end improves the stability of the data

† The 4 to 20 mA range was chosen because many wind speed and wind direction sensors output 4 to 20 mA signals, and the turbine outputs the same power signal

Ordering Information

Software licenses are either node-locked or floating

Type 7915 **PULSE Small Wind Turbine Acoustic Sound Testing**
Requires:

- Type 7914: PULSE Wind Turbine Sound Power Determination according to IEC 61400-11

SOFTWARE MAINTENANCE AND SUPPORT AGREEMENTS

M1-7915	Agreement for Type 7915, one year
M3-7915	Update of M1-7915

Software maintence and support agreements are available for all software packages

Typical System

A typical system for Type 7915 is identical to a typical system for Type 7914. See Ordering Information in Product Data BP 2322 for details

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