Case Study

Elspec Develops the World’s 1st Ride Through Compliant SVC “kVAR Booster” solution: Equalizer RT

Lanternoso Site

Overview

Asynchronous generators, including doubly-fed rotors, are widely used in wind farms. During voltage drops, any slight speed deviation of these rotors consumes large amounts of reactive energy. Due to the large demand for reactive power during significant voltage drops, FRT regulations have been implemented in many modern grid codes.

A typical voltage drop event is the result of a short circuit on one of the network branches. It takes at least 100-200 ms to isolate the faulty substation, potentially deteriorating the voltage stability. The majority of modern grid standards require reactive energy to be generated by local networks during a fault.

The most reliable reactive energy solutions are based on capacitor banks, Static VAR Compensation (SVC). However, utilizing an SVC as a ride-through solution has its disadvantages. The provided reactive current is proportional to the voltage, while the reactive power is proportional to the second power of the voltage (V^2).

The Elspec Solution

Elspec Ride Through solution for asynchronous Turbine is based on Elspec Real Time Static Var Compensation technology which is used worldwide.

The Equalizer, a transient free static compensation system, was modified in order to boost supplied kVAr capacity for short time voltage dips applications. The commercial name of the new system is known as Equalizer RT. The Equalizer RT system is based on the following features:

- Transient-free connection of capacitors
- Voltage Control operation mode – optimized to fulfill the PO12.3 Grid Code requirements.
- Ultra fast acquisition time - full compensation within less than 10mSec

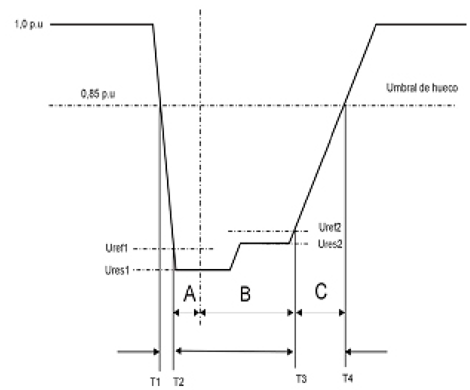
Spanish PO12.3 Grid Code Compliance

The purpose of this code is to provide a procedure to ensure the uniformity of tests and simulations, the precision of measurements, and the assessment of the response of wind farms in the event of voltage dips.

Measurement Techniques

The code requires that for all field tests, all of the records of voltage and current sampled for each phase must be carried out at a sampling frequency of 5 kHz minimum.

Note: T1-T4 are defined by the dip threshold (IEC 61000—4-30).



Voltage Dip Classification

Zone Classification

A, B, and C below are used to define three zones during the voltage dip. These zones are classified as a function of the dip threshold and the residual voltage. See figure 2.

- Zone A: all of the values of voltage Uef (1/4) between T2 and T2 + 150 ms.
- Zone B: all of the values of voltage Uef (1/4) between T2 + 150 ms and T3.

In This Document

Read how the Elspec Equalizer RT test installation:

- Successfully provided dynamic ride through compensation for an asynchronous 1.5 MS turbine
- Provided results that proved the Equalizer RT can be a solution for the FRT Spanish PO 12.3 Grid Code requirements

- Zone C: all of the values of voltage Uef (1/4) between T3 and the lesser of the following values, T4 and T3 + 150ms

Methodology for Calculating Power
Power consumption is expressed in normalized value (p.u.) to the registered nominal power of the WTG tested. Similarly, energy consumption values are expressed in normalized values of power by time unit in milliseconds (ms p.u.)

The voltage and current levels registered in the test, as well as data obtained from simulations must be included in the report form as per Table 1.

Three Phase Faults	OP 12.3 Requirement	Result
Zone A		
Net consumption Q<15% Pn (20ms)	-0.15 p.u.	
Zone B		
Net consumption P<10% Pn (20ms)	-0.1 p.u.	
Net consumption Q<5% Pn (20ms)	-0.05 p.u.	
Average In/I_{tot}	0.9 p.u.	
Extended Zone C		
Net consumption Ir < 1.5 In (20ms)	-1.5 p.u.	

Energy and Power Registry

The Elspec Test

The 1.5 MW turbine can be supplied with an automatic power factor correction system that makes it compliant with even very demanding grid codes; the turbine has ride-through capacity for all normal faults.

Test Setup
The RTC and the Equalizer RT containers were located in adjacent to the Turbine. The RTC container was connected to the medium voltage (20kV) in order to simulate voltage dips according to the Spanish Grid Code PO12.3. Elspec Equalizer RT system was connected at the turbine transformer output (690V). Elspec Equalizer RT container comprises also 4 Elspec G4K BLACKBOX model EG4420, advanced power analyzer in order to carry out measurements in the following network points:

- Grid input to the RTC container system 20kV.
- RTC container system output to the turbine: approximately 20% of the medium voltage (during the dips).
- Transformer output of the turbine - 690V (measurements of the turbines generator and the Equalizer RT system).
- Equalizer RT system output

The measurements were carried out continuously during the test period. All network parameters were recorded cycle by cycle at 1024 samples per cycle for voltages and 256 samples per cycle for currents. For more details, please refer to the G4k catalog web site www.elspec-ltd.com at products and services.

*)The value is changed in proportion to the voltage magnitude

Test Description Low Power
Low Power Test (10% - 30% of nominal)
The test comprises six tests as follows:

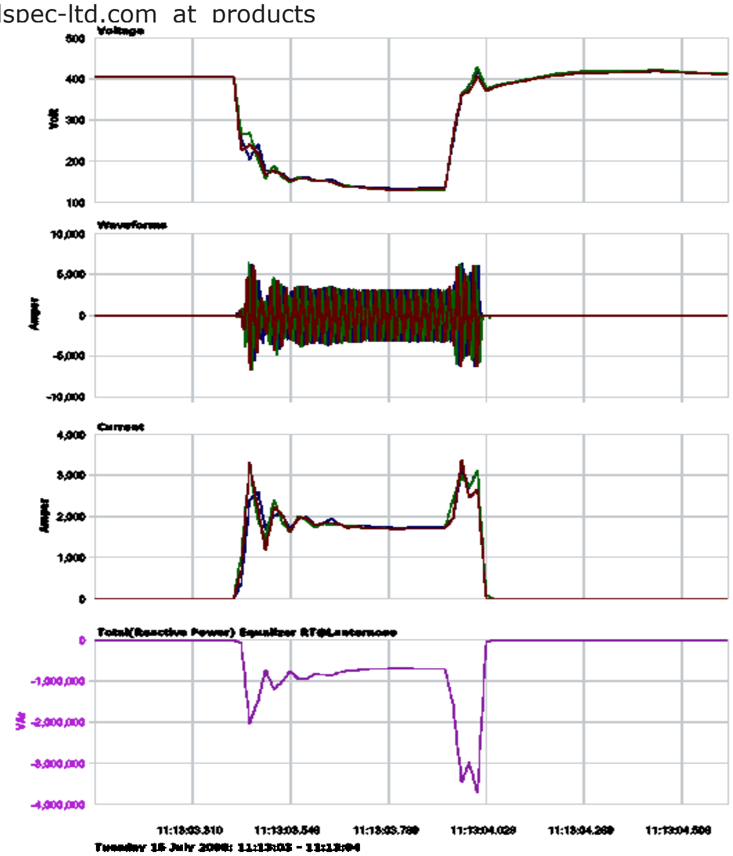
Three sequential unbalanced tests
Three sequential balanced tests

The following table provides the reactive current and energy values which were required from the Equalizer RT system in order to comply with PO12.3. The values were confirmed by qualified company for the PO12.3 test procedure, which was carried out by the supplier Ride Through test container.

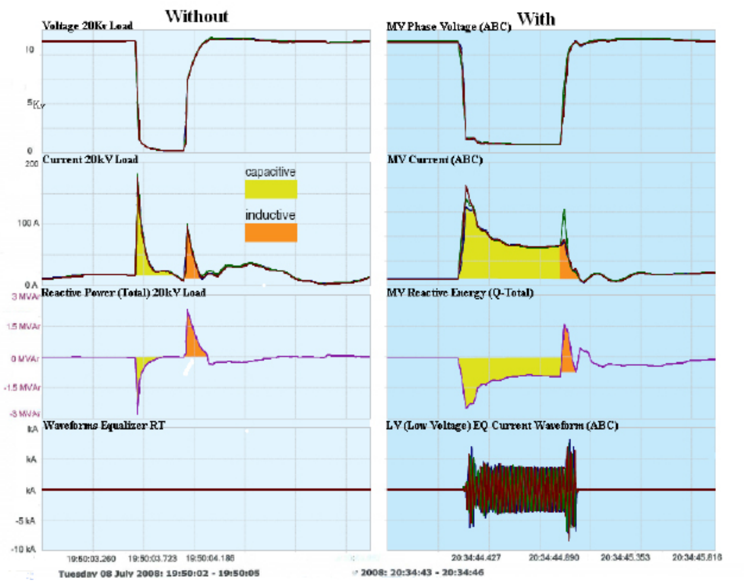
Zone	Reactive Current	Reactive Energy
A	Above 2000A	Above 800kVAr
B	Above 2000A	Above 800kVAr
C	2000A to 3500A	800 to 3300kVAr (*)

Low Power Conditions

(*)The value is changed in proportion to the voltage magnitude



Low Power Measurements



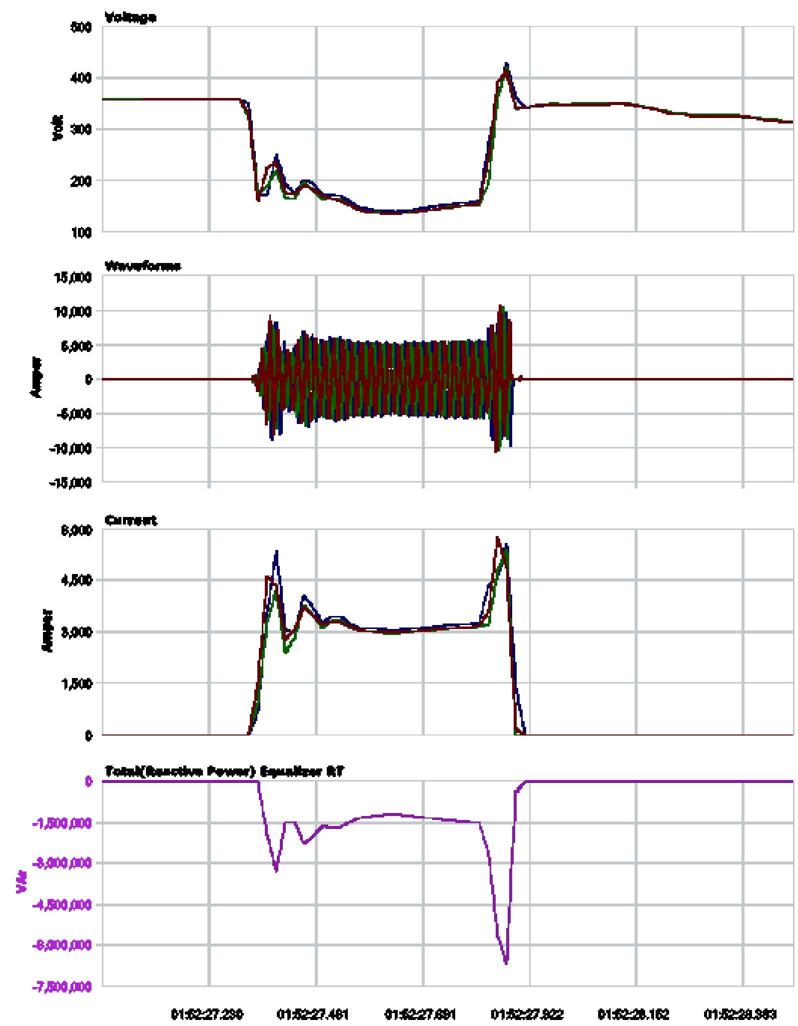
Equalizer RT solution: With and Without

Low Power Results
The effect of the Equalizer RT on the Grid at low power mode of operation of the turbine (<30%) is seen in Figure 4. It illustrates the consumption of the reactive energy and the current in MV at the connection point of the turbine to the Grid. It also provides the current waveform of the Equalizer RT in Low Voltage.

Without Equalizer RT, the consumption of reactive energy during Zone C almost reached 3 MVAR. With the Equalizer RT, it reduced to less than 500kVAR. In Zone A & B, the Equalizer RT contributes substantial reactive energy to the Grid (above 800kVAR).

High Power Test (more than 1300kW)
The test comprises the same set of parameters as the Low Power Test.

Three sequential unbalanced tests
Three sequential balanced tests



High Power Equalizer RT Measurements

(*)The value is changed in proportion to the voltage magnitude

The following table provides the relative current values which were required from the Equalizer RT system in order to comply with the PO12.3. The values were confirmed by a qualified company for PO12.3 algorithm.

Zone	Reactive Current	Reactive Energy
A	Above 3300A	Above 1500kVAr
B	Above 3300A	Above 1500kVAr
C	3500A-5500A	1500-6500kVAr (*)

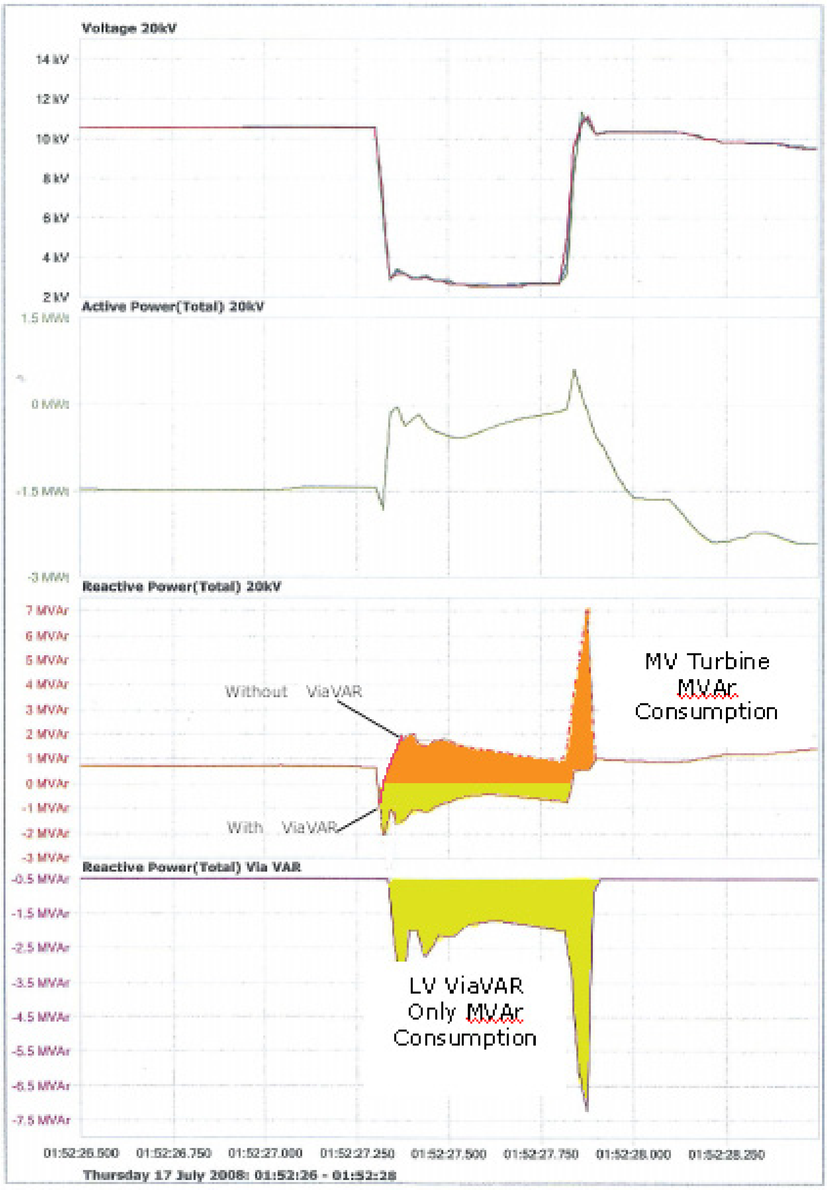
High Power Conditions

(*)The value is changed in proportion to the voltage magnitude

High Power Results

The effect of the Equalizer RT on the Grid at high power mode of operation of the turbine (>1300kW) is seen in Figure 6. It illustrates the consumption of the reactive energy and the current in MV at the connection point of the turbine to the Grid. It also provides the active power of the turbine.

Without the Equalizer RT, the consumption of reactive energy during Zone C almost reached 7 MVAR. With the Equalizer RT, it reduced to almost zero. In Zone A & B, the Equalizer RT contributes substantial reactive energy to the Grid (above 1500kVAR).



High Power Results

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International
Elspec Ltd.
P.O. Box 3019
4 HaShoham St., Zone 23
Caesarea Industrial Park
38900, Israel
Tel: +972-4-6272-470
Fax: +972-4-6272-465
email: info@elspec-ltd.com

North America
Elspec North America, Inc.
500 West South Street
Freeport, IL 61032
USA
Tel: +1-815-266-4210
Fax: +1-815-266-8910
email: info@elspecna.com

Europe
Elspec Portugal Lda.
Zona Industrial 1a Fase
4900-231 Chafe
Viana do Castelo
Portugal
Tel: +315-258-351-920
Fax: +315-258-351-607
email: info@elspecportugal.com