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Review of Transmission System Security Standard in Oman

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Abstract: *This paper describes the main features and changes made in the second version of the Transmission Security Standard (TSS) in 2015 to cope with the development of the Main Interconnected Transmission System (MITS) including new large generating units and connections to internal and GCCIA systems. The TSS sets out the policies and procedures, as well as design and operating regulatory requirements. The component elements of the TSS are presented according to the functional parts of the OETC licensed transmission system to which they primarily apply, including, but not limited to: (1) MITS and the Dhofar power system, (2) generation connections at which a production facility feeds into the MITS, (3) demand connections, where demand is connected, including grid supply points, & demand groups, and (4) operational security standards. The criteria stipulated in the TSS represent normal requirements for the planning and operation of the OETC licensed transmission system. Design criteria and definitions are given in a more precise way in the new version. Operating limits are presented in terms of allowable voltage and frequency ranges. A dynamic model of Oman power system is obtained to perform transient stability studies to determine updated values of normal and frequent infeed loss risks. Simulation studies are presented to show system frequency responses to generation tripping when the system is operating at both minimum and maximum peak demand conditions.*

Key Words: Transmission Security Standard, Oman Grid, Generation Connection, Demand Connection, Transmission System Planning, Design, Operation and Security Criteria.

1. INTRODUCTION

There has been a considerable annual increase in the electricity demand in the Sultanate of Oman during recent years associated with the high development in various sectors including industrial, tourism, commercial and residential loads. The annual peak demand growth rate reaches about 9%. To cope with this high rate growth demand, new power stations have to be installed and connected to the power network, associated with the introduction of 400 kV as a backbone in the Main Interconnected Transmission System (MITS) [1]. Among these power stations are Sur 2000 MW IPP which is fully commissioned in 2014, Ibri 1509 MW IPP which is planned to be in service in 2018/2019 and Sohar III 1710 MW IPP in 2019. In addition, Salalah II 451 MW IPP is expected to be in service in 2019 and it will be connected to Dhofar Power System (DPS). Also, the first 50 MW Wind Farm project in the Sultanate of Oman will be connected to Dhofar transmission system in 2017 [2]. In its Seven Year Statement [3], OPWP has advised that it is planning a solar generation facility of about 200 MW to be located possibly near to Adam or Manah by 2019.

The addition of such large power stations, with large generating units, the growth of demand groups and the introduction of the 400 kV systems to the MITS require thoroughly reviewing the Transmission Security Standard (TSS) document. The TSS is implemented by the Oman Electricity Transmission Company (OETC) for the planning and operation of its licensed transmission system. The first version of the TSS was issued in 2006 in accordance with the Condition 26 of the OETC Transmission and Dispatch Licence and was amended in 2011.

This paper describes the main features and changes made in the second version of the TSS amended in 2015 to cope with the development of the MITS including large generating units and connections to internal and Gulf Co-operation Council Interconnection Authority (GCCIA) systems [4]. The component elements of the TSS are presented according to the functional parts of the OETC licensed transmission system to which they primarily apply, including, but not limited to:

- The MITS and the Dhofar power system
- The generation connections at which a production facility feeds into the MITS and Dhofar power system
- Demand connections, where demand is connected, including Grid Supply Points (GSP)s, and Demand Groups
- The operational security standards

The criteria presented in the updated version of the TSS represent normal requirements for the planning and operation of the OETC licensed transmission system. Additional criteria, for example covering more detailed and other aspects of quality of supply, are contained in the Grid Code [5] and Distribution Code [6], which should be read in conjunction with the TSS. Design criteria and definitions are given in a more precise way.

Updated values of the normal and infrequent infeed loss risks for the MITS are given in the second version of the TSS, and corresponding new values for the Dhofar grid are defined. Demand class definitions and supply restoration times are revised.

The paper is structured in the following sections: Section 2 provides the roles and scope of the TSS. Section 3 presents system description and modelling. Section 4 describes the methodology. Section 5 presents system design and operating values. Section 6 presents with transient stability studies to determine the NILR and IILR in addition to the maximum unit size.

Section 7 concerns with the proposed values of NILR and IILR for Dhofar system. Section 8 provides the main TSS amendments. Finally, Section 9 summarizes the main conclusions.

2. ROLES AND SCOPE OF THE TSS

This document sets out the Transmission Security Standard (the "Standard" or "TSS") that OETC will implement for the planning and operation of its licensed transmission system. The TSS has been prepared in accordance with Condition 26 of OETC's Transmission and Dispatch Licence. For ease of use, the component elements of the TSS are presented according to the functional parts of the OETC licensed transmission system to which they primarily apply. As illustrated in Fig. 1 there will be many parts of the OETC licensed transmission system where more than one set of criteria apply. In such parts, the requirements of all relevant criteria shall be met.

The criteria for radially connected generation, Grid System Operator (GSO) connections and demand connections are consistent with the criteria applied to the MITS. However, they are conditioned by the criteria for the relevant generation connections, GSO connections and/or demand connections. While it is a requirement for transmission capacity to meet the TSS criteria, it does not follow that transmission capacity should be reduced so that it only meets the minimum requirement of those criteria.

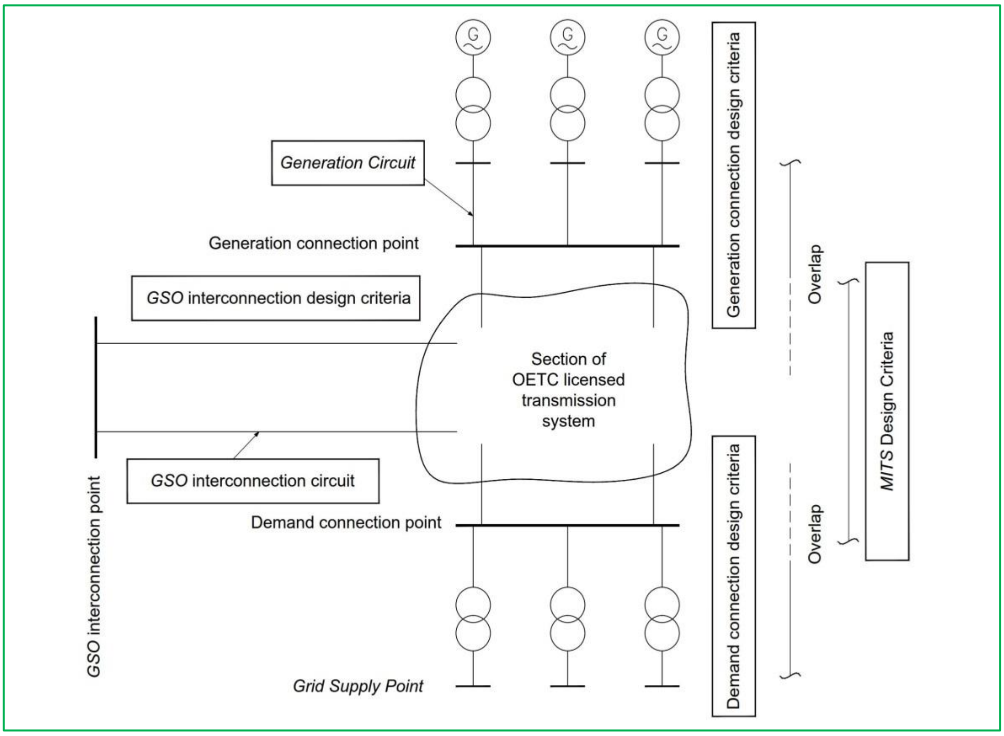

Fig. 1: Reach and overlap of the various design criteria specified in the TSS.

3. SYSTEM DESCRIPTION AND MODELLING

A. System Description

The Oman power system [1], [7] consists of three major power system grids as shown in Fig. 2:

1) Northern Grid: the Main Interconnected Transmission System (MITS)
2) Petroleum Development of Oman (PDO) Grid
3) Dhofar Grid

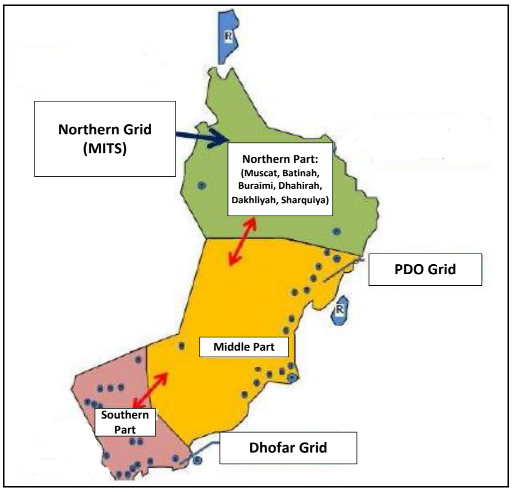

Fig.2: Oman power systems.

The Northern (MITS) and Dhofar grids are currently operated by the Oman Electricity Transmission Company (OETC). The existing MITS has three operating voltages, i.e. 400 kV, 220 kV and 132 kV. It extends across the whole northern part of Oman and interconnects bulk consumers and generators of electricity located in the northern part of Oman.

PDO and MITS grids are interconnected through Nahada-Nizwa 132 kV OHL. Also in the south, Dhofar system is at present connected to PDO system through 132 kV OHL from Thumrait grid station (OETC) to Harwail grid station (PDO).

The Oman power system is interconnected at 220 kV from Mahdah (Al Wasit) grid station with the power system of UAE (Abu Dhabi Transco) [8], which is a part of the GCC grid that links the electricity power systems of Kuwait, Saudi Arabia, Bahrain, Qatar, UAE and Oman. A new 400 kV link has proposed to connect Oman and UAE grids [9].

B. System Studies Assumptions

The present version of the TSS is dated July 2006, as amended by letter on 25th September, 2011, and has been taken into account. The minimum planning supply capacity following secured events as set out in the TSS 1st edition is assumed to apply. For the avoidance of doubt, we preformed two separate studies for each year, for the maximum and minimum demand. These studies were carried out to check compliance with the minimum planning supply capacity. The Peak demand studies checked (N-1) compliance and the minimum demand studies confirmed compliance for (N-2) outages.

The system studies were carried out with the PDO circuits floating in real and reactive power. Under these conditions, the current model of the PDO system has been judged to be acceptable, but future dynamic studies should be carried out with a full model of the PDO system. This also applies to the DPS. It is also recommended that when carrying out dynamic studies the generation and load at Sohar Aluminium Company (SAC) be modelled in accordance with the relevant energy exchange agreement between SAC and OPWP. The SAC load can represent quite a high percentage of the total system load at times of low OETC system demand. Clearly, as the demand on the OETC system grows, this issue will become less significant.

The modelling of the MITS interconnection with the GCCIA as proposed by OETC has been used. To the extent necessary, and mindful of the relative size of the generation presently and intended to be deployed within the GCCIA system, the default assumption has been one of an external grid for the GCCIA system. This assumption is acceptable for load-flow and contingency analysis, but could give inaccurate results for dynamic system studies.

The future system configurations modelled in the 2015 – 2019 system studies have been assumed to take place as planned by OETC. It is assumed that the system reinforcements modelled in these studies are required by the dates shown in the models and that they have been or will be implemented accordingly.

It can be seen from the analysis that the planned system modifications will improve TSS compliance. For the peak system demand of 2018 and 2019 there are only minor system overloads.

As there are only minor changes between the 1st and 2nd editions of the TSS in relation to secured events, the results of the contingency analyses fulfilled the requirements of both editions.

C. Basic Modelling Assumptions

These studies were of the OETC system only with the interconnection to the GCCIA system and the PDO system modelled as external grids in the DIgSILENT Power Factory® models. The studies supplied model the peak and minimum system demands for the years 2015 to 2019 inclusive. For dynamic studies, dynamic models of the PDO and GCCIA systems should be used. IMITS means the "Integrated MITS" which includes the MITS system and the Dhofar system. It was assumed that the IMITS DIgSILENT models for minimum operating conditions developed by OETC represent the load and generation conditions in the maintenance period. Pre-fault planning voltage limits are assumed to be ±5% deviation from nominal system voltage, as proposed in the 2nd edition of the TSS. Sufficient voltage performance margin for outage conditions is assumed to be ±10% deviation from nominal voltage. This value is common between the TSS 1st and 2nd editions.

4. METHODOLOGY

System studies have been carried out for the minimum and maximum operating conditions on the MITS based on system for the period of 2015 to 2019 inclusive. Comprehensive *DIgSILENT* Power Factory® models are vital to the success of these studies; therefore the models included:

- Representation of the interconnected systems with each system represented as an equivalent generator with appropriate inertia and governor model, giving the correct fault infeed
- Dynamic load modelling
- Dynamic generator data
- Interfaces with all direct-connected loads
- Representation of large consumers, such as Sohar Aluminium.

Transient stability studies are performed by simulating a trip of the largest generating unit or interconnection to other transmission systems to determine the frequency variations and Normal Infeed Loss Risk (NILR) and Infrequent Infeed Loss Risk (IILR) in addition to determine the maximum unit size. A trip of the largest consumer load has also been simulated to analyse the frequency variations. This has been done:

- In 'connected mode' with the MITS and DPS connected to other transmission systems
- In 'island mode' with the MITS and DPS disconnected from other transmission systems

Transient stability studies are extended to assess the impact of losing any bus-section or bus-coupler and to consider all the cases mentioned in the TSS. The studies include the effect of tripping generation of 1400 MW with the system running in island mode, disconnected from GCCIA and at system minimum demand.

Load flow studies have been undertaken, for different operating conditions, to check voltage variation and power factor requirements. Minimum cases have been derived from the maximum cases by scaling down the loads and using available information on generation dispatch and network configuration. We have analysed the impact of credible faults on system nodes as well as on prioritised customers. Various N-D and N-1 contingency analyses have been checked as for the existing and future configuration studies. The studies have checked the planning and operational criteria (e.g. N-1/N-2 criteria) when considering the connection of large size power plants, renewable energy generation sources and national and international interconnectors.

Studies have been performed to ensure that the following TSS technical requirements have been applied:

- That the existing generation connection criteria have been appropriately applied
- That appropriate consideration has been given to transmission access arrangements for combined cycle plant, intermittent or variable generation and cross-border/international grid interconnections
- That appropriate planning and operational criteria (e.g.: N-D/N-2 criteria) have been used when considering connection to large size plants (requiring secure power evacuation and supplies to auxiliaries) and fossil fuel plants
- Identification and appropriateness of applying N-1 and, if required N-2, criteria in specific locations
- Confirmation that the resilience of the transmission system to common mode failures, including transmission circuit routing and technology diversity, has been addressed
- Appropriate application of demand connection criteria to accommodate changes to group demands and connection designs in Oman
- Where non-compliant connections might exist, these have been identified

Based on system studies, we have identified any changes required in the TSS and/or the Grid Code. For the avoidance of doubt, the work presented does not include amending the Grid Code, but is limited to identifying TSS issues.

5. SYSTEM DESIGN AND OPERATIONAL VALUES

A. Quality of Supply

The Grid Code specifies various parameters including frequency, voltage, harmonic distortion and flicker. These parameters contribute to the quality of supply experienced by users.

B. System Parameters under Various Conditions

For purposes of the TSS and in respect of frequency and voltage, four conditions are identified for determining system parameter values, as follows:

Normal conditions – being conditions that apply on a continuous basis; these are the preferred conditions of the OETC licensed transmission system

- ***Disturbed conditions*** – being conditions in which the voltages are the same as for normal conditions, but the frequency limits have been changed and include, as a lower limit, the Normal Infeed Loss Risk frequency limit

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- ***Stretched conditions*** – being conditions that have two parts:
- ***Continuous stretched conditions*** that are not time dependant. Time limited Stretched Conditions that may only be experienced for no more than sixty continuous seconds
- ***Unacceptable conditions*** – being conditions that are never allowed in planning, design or operation

Transient frequency deviations that occur outside the limits of continuous operation stretched conditions and last less than sixty seconds shall only occur at reasonably infrequent intervals. This governs all relevant TSS criteria. Table I sets out the required values for the system parameters.

Table **I**: OETC system parameter values

<table>
<tr><th colspan="14">Quality of Supply – System Parameter values</th></tr>
<tr><th rowspan="5">Parameter</th><th colspan="13">Unacceptable conditions</th></tr>
<tr><td></td><th colspan="11">Stretched conditions</th><td></td></tr>
<tr><td></td><td colspan="2"></td><th colspan="6">Disturbed conditions</th><td colspan="2"></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td colspan="2"></td><th colspan="3">Normal conditions</th><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><th><</th><th>Low ≥</th><th>High <</th><th>Low ≥</th><th>High <</th><th>Low ≥</th><th>Target</th><th>High ≤</th><th>Low ></th><th>High ≤</th><th>Low ></th><th>High ≤</th><th>></th></tr>
<tr><td rowspan="2">Frequency Hz</td><td rowspan="2">47.50</td><td>47.50</td><td>49.50</td><td rowspan="2">49.50</td><td rowspan="2">49.95</td><td rowspan="2">49.95</td><td rowspan="2">50.00</td><td rowspan="2">50.05</td><td rowspan="2">50.05</td><td rowspan="2">50.50</td><td>50.50</td><td>51.50</td><td rowspan="2">51.50</td></tr>
<tr><td colspan="2">Less than 60 seconds</td><td colspan="2">Less than 60 seconds</td></tr>
<tr><td rowspan="3">Voltage kV</td><td>380</td><td colspan="2">380</td><td colspan="3">390</td><td>400</td><td colspan="3">410</td><td colspan="2">420</td><td>420</td></tr>
<tr><td>198</td><td colspan="2">198</td><td colspan="3">209</td><td>220</td><td colspan="3">231</td><td colspan="2">242</td><td>242</td></tr>
<tr><td>119</td><td colspan="2">119</td><td colspan="3">125</td><td>132</td><td colspan="3">139</td><td colspan="2">145</td><td>145</td></tr>
</table>

Notes on the Table:

a. The frequency values are derived from the Grid Code

b. The frequency value of 47.50 Hz is equal to the Infrequent Infeed Loss Risk frequency limit, also referred to as the "IILR frequency limit"

c. The frequency value of 49.50 Hz is equal to the Normal Infeed Loss Risk frequency limit, also referred to as the "NILR frequency limit"

6. FREQUENCY STABILITY STUDIES

A. Basic definitions

Loss of Power Infeed is defined as the output of a generation unit or a group of generation units or the import from GSO system(s) disconnected from the OETC licensed transmission system by a secured event, less the demand disconnected from the OETC licensed transmission system by the same secured event. For the avoidance of doubt if, following such a secured event, demand associated with the normal operation of the affected generation unit or generation units is automatically transferred to a supply point which is not disconnected from the system, e.g. the station board, then this has not been deducted from the total loss of power infeed to the OETC licensed transmission system. For the purpose of operational criteria, the loss of lower infeed includes the output of a single generation unit, CCGT module, or boiler lost as a result of such an event.

Normal Infeed Loss Risk (NILR) is defined as the value of lost power infeed that would cause the OETC licensed transmission system frequency to fall to a value equal to but not below the NILR frequency limit of 49.50 Hz.

Infrequent Infeed Loss Risk (IILR) is defined as the level of loss of power infeed risk which is covered over long periods operationally by frequency response to: (i) avoid a deviation of system frequency outside the range 49.50 Hz to 50.50 Hz for more than 60 seconds; and (ii) never below 47.50 Hz

B. Normal Infeed Loss Risk (NILR) and Maximum Generating Unit Size

Frequency stability studies were carried out using the OETC system DIgSILENT model, developed by OETC, for the minimum conditions for the years 2016, 2017 and 2018, with both interconnector circuits to the GCCIA system switched out of service. In other words, the IMITS was in 'island mode'. Studies were then carried out to calculate the maximum generator size that could be connected to the OETC system and not breach the following normal infeed risk rule.

The loss of the single largest generator on the system shall not cause:

i. Cascade failure

ii. Cause the system frequency to fall below 49.50 Hz

iii. Cause a loss of load

iv. Overloading of any system equipment

v. Unacceptable system voltage conditions

A number of frequency stability studies were carried based on the 2018 system study increasing the generator size from 460 MW in steps of 20 MW and the minimum system frequency on the OETC system was noted. This was done until a system frequency of 49.50 Hz was reached. Figure 3 shows the result of this analysis. These studies were carried out with the interconnector circuits to the GCCIA system modelled as being out of service. Figure 4 shows that at a frequency level of 49.50 Hz, the largest single infeed that can be connected to the system for the minimum demand period of 2018 is 610 MW. It should be noted that this is only correct for the system and generator conditions modelled. Since these modelled conditions are the most extreme that the OETC system should encounter, we conclude that the Normal Infeed Loss Risk should be:

- As specified for the TSS 1st edition, the NILS can be maintained at 500 MW from 2015 until 2018
- In 2018, and subject to further system studies at the time, the NILS can increased from 500 MW to 600 MW in 2018
- Since no new significant generation addition to the MITS is planned until 2019, the Normal Infeed Loss Risk in the TSS 2nd edition will be set at 600 MW

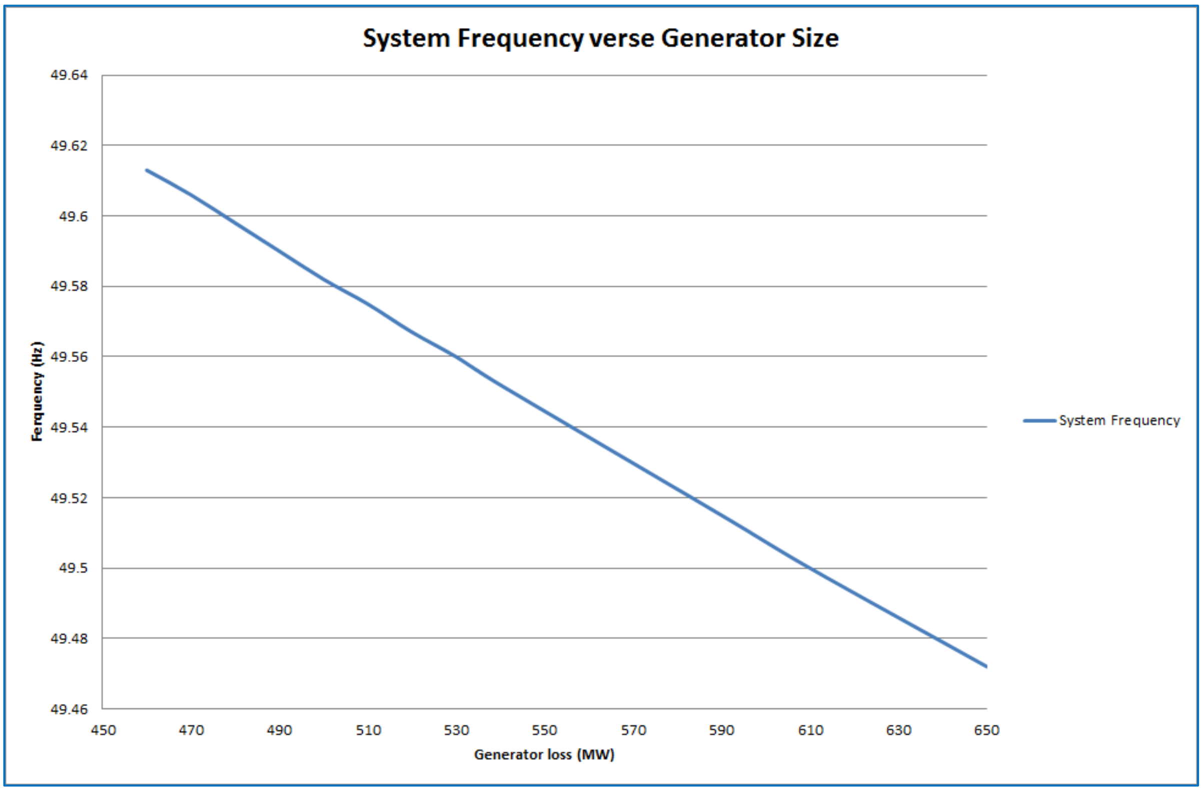

Fig. 3: Frequency versus generator size.

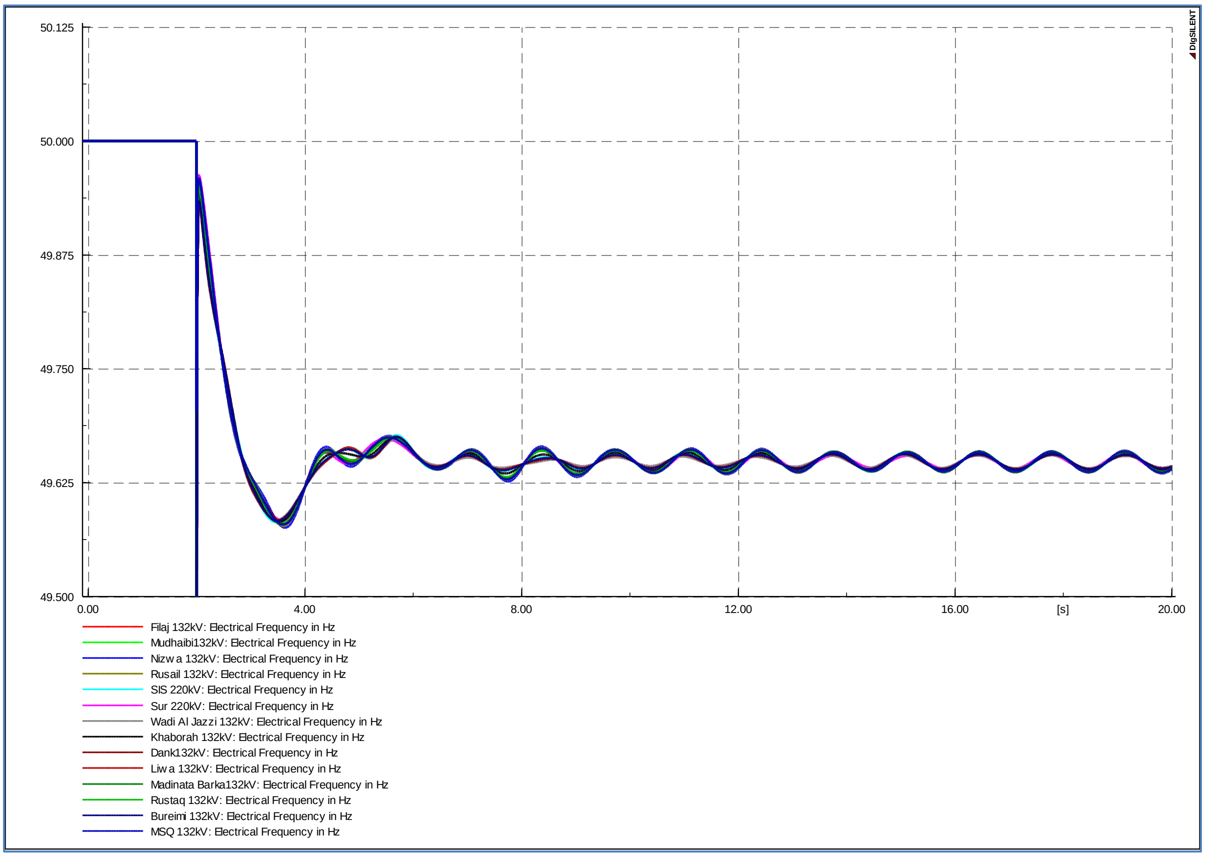

Fig. 4: System frequency – 2019 minimum demand following the loss of 600 MW.

It should be noted that this method of calculating the NILR was specified by OETC and does not strictly comply with the thinking of the TSS, because nowhere in the TSS 1st or 2nd edition are three outages considered. The NILR and IILR studies have been carried out: (i) at the time of the minimum system demand; with (ii) a double circuit outage; and (iii) the loss of the largest single generator.

The NILR of 500 MW was selected based on the system studies for 2017. If the NILR is higher than 500 MW before 2017, then it is recommended that dynamic studies be carried out to confirm the level of primary and secondary reserve required to secure the system during a planned outage of the double circuit between the OETC and GCCIA systems. Frequency stability studies were carried to the model the minimum system load of 2019 with the GCCIA interconnector circuits out of service. The loss of a single 600 MW generator at Sohar IPP causes the OETC system frequency to fall to 49.56 Hz, as shown in Fig. 4.

C. *Infrequent Infeed Loss Risk (IILR)*

Frequency stability studies where then carried out to model the effect of losing the infrequent infeed from the OETC System. It should be noted that only frequency stability issues were reviewed in this analysis and again these studies were carried out using the DIgSILENT 2016 minimum study with no connection to the GCCIA system. An infeed loss of 1200 MW did not breach the proposed standard for the OETC System based on the following outcomes specified in the TSS 2nd edition. Following an infrequent infeed loss there shall not be:

i. Cascade failure of the OETC System
ii. Unacceptable Voltage Conditions
iii. OETC System frequency falls to below 47.50 Hz
iv. OETC System frequency remains below 49.50 Hz for longer than 60 seconds

These rules have therefore been incorporated into the TSS 2nd edition. It should be noted that for the TSS 2nd edition that 1200 MW has been chosen for the Infrequent Infeed Loss Risk. This is because the amended Normal Infeed Loss Risk is 600 MW and due to substation design it can be seen that there is a benefit of the IILR being twice as large as the NILR. The TSS 2nd edition will state:

a. A Fault Outage of a section of Busbar can result in the loss of the IILR
b. A Fault outage of a Bus Section or Bus Coupler Circuit Breaker can result in the loss of the IILR
c. During a Planned Outage of a section of Busbar, a Fault Outage of another section of Busbar can result in the loss equal to the IILR

The system studies for the Infrequent Infeed Loss Risk were carried out with Under Frequency Load Shedding trip settings as defined in in Table II

Table II: Under Frequency Load Shedding settings

Stage	Frequency Threshold (Hz)	Amount of Load Shedding
Stage 1	49.3	5.0% of system load
Stage 2	49.2	8.0% of system load
Stage 3	49.0	7.5% of system load
Stage 4	48.8	7.5% of system load
Stage 5	48.6	7.5% of system load
Stage 6	48.4	7.5% of system load
Stage 7	48.3	Open interconnectors

So as to promote consistency with the NILR, we proposed a two-step approach to the IILR:

a. 1000 MW from 2015 until 2018
b. In 2018, and subject to further System Studies to be conducted at the time, the Infrequent Infeed Loss Risk can increased from 1000 MW to 1200 MW
c. Since no new significant generation addition to the MITS is planned until 2019, the Infrequent Infeed Loss Risk in the TSS 2nd edition will be set at 1200 MW

The resulting system studies show that around 35% of the total OETC demand will be shed on under frequency load shedding relays and that the system frequency will be restored to 49.70 Hz in around eight seconds; this is shown in Fig. 5.

System studies were carried out for the minimum demand period of 2019, and the IILR was increased to 1200 MW. This showed the system frequency fell to just below 49.2 Hz and recovered to a frequency higher than 49.5 Hz in around six seconds; this shown in the Fig. 6.

Based on specific system studies conducted, the following is recommended for the TSS 2nd edition:

- Normal Infeed Loss Risk: 600 MW
- Infrequent Infeed Loss Risk: 1200 MW

These figures are based on the assumption that the next generation to be connected to OETC system is planned for 2019 at the earliest.

7. INFEED LOSS RISKS FOR DHOFAR POWER SYSTEM

Frequency stability studies were carried out based on the Dhofar system model developed by OETC. These studies were carried out with the interconnection between the Dhofar system and the PDO system out of service. The magnitude of the NILR should be based on the interconnector circuits and the unit sizes of existing generators in the DPS. The following NILR and IILR values are recommended for the Dhofar Power System:

- Normal Infeed Loss Risk: 25 MW
- Infrequent Infeed Loss Risk: 40 MW

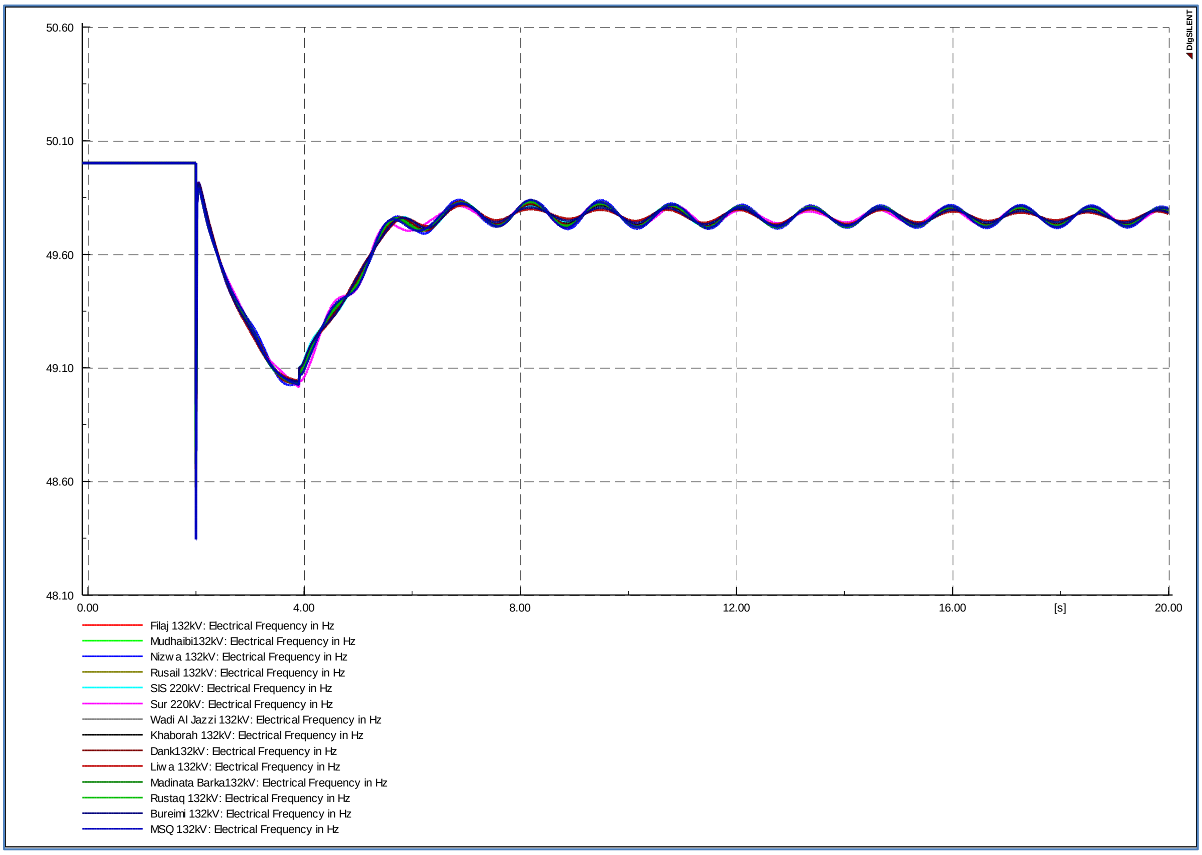

Fig. 5: System frequency – Infrequent infeed loss.

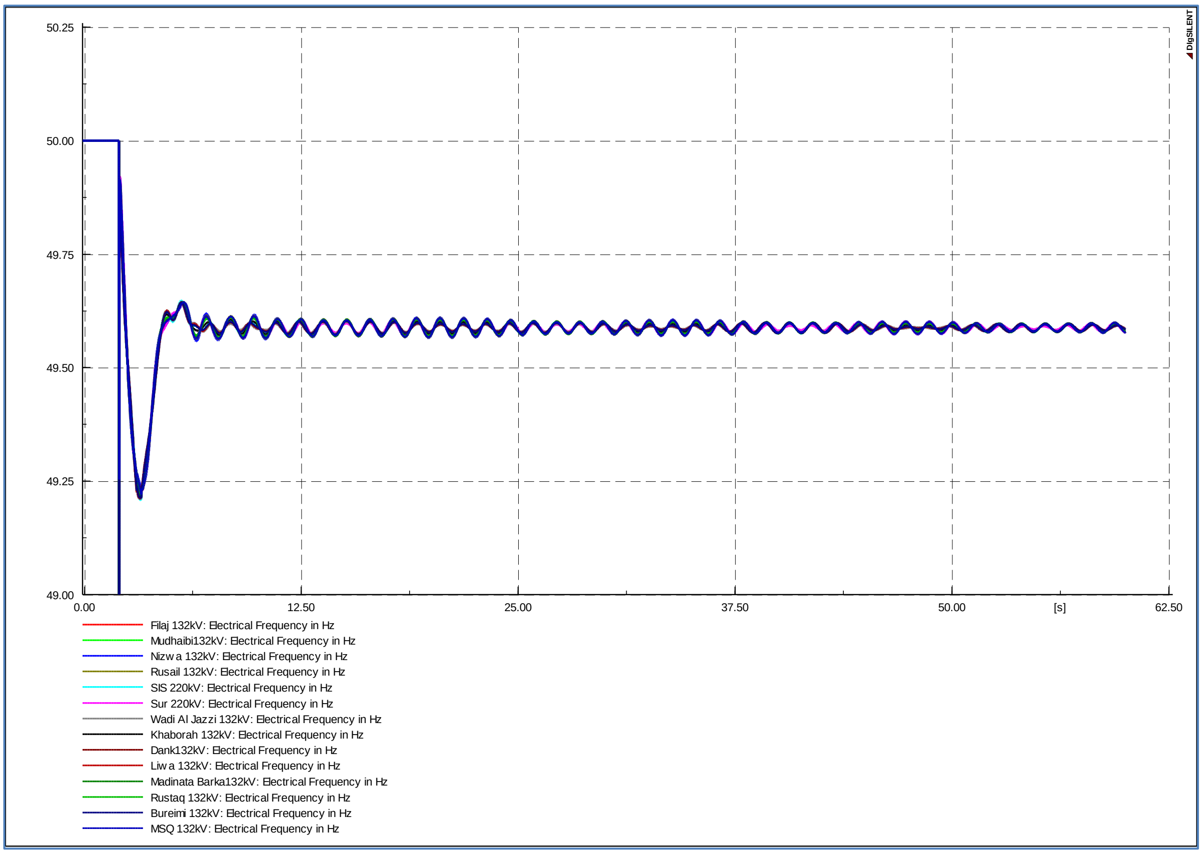

Fig. 6: System Frequency – IILR of 1200MW at minimum demand in 2019.

8. TSS AMENDMENTS

Following a review of the TSS 1st edition, the most important and critical change of the TSS is in the format, layout, organisation and consistency of drafting. There are a few recommended changes, as discussed below.

A. Key Parameter Tolerance Comparison between the TSS 1st and 2nd Editions

As a result of the systems studies, Table III compares the tolerances for critical parameters as between the TSS 1st and TSS 2nd edition. This shows that there are no detail changes recommended for the TSS 2nd edition.

Table III: Comparison for key parameters between editions

Parameter	Comments	TSS 1st edition	TSS 2nd edition
Voltage planning limits	Except 400 kV	±10%	
	400 kV only	Not stated	±5%
Frequency planning limits	Target	50 Hz	
	Normal Conditions See note (a)	49.95 Hz to 50.05 Hz	
	Stretched Conditions – continuous	49.5 Hz to 49.95 Hz or 50.05 Hz to 50.5 Hz	
	Stretched Conditions – less than 60 seconds	47.5 Hz to 49.5 Hz or 50.5 Hz to 52.5 Hz	
	Unacceptable	<47.5 Hz or >52.5 Hz	

Note: Special derogation is required for the DPS when operating in island mode.

B. Design of generation connections

- ***Frequent Infeed Loss Risk value***

The TSS 2nd edition has led to the development of a methodology describing how this generation level can be calculated and studied. Based on this approach, and with presently available information, we have calculated the NILR as 600 MW.

- ***Infrequent Infeed Loss Risk value***

The TSS 2nd edition has led to the development of a methodology describing how this generation level can be calculated and studied. Based on this approach, and with presently available information, we have calculated the Infeed Loss Risk as 1200 MW.

- ***Special Frequency Requirements for the DPS***

Following discussion arising under the Grid Code, we have taken account of the need for special frequency treatment for the DPS until such time as the 400 kV back-bone links the MITS to the DPS.
In essence, when the DPS is in island mode, the frequency range should be extended and the operating range should be between ≥49.70 Hz and ≤50.30 Hz.

C. Design of GSO Interconnections

An additional section has been added to the TSS 2nd edition describing how interconnector circuits between OETC and other Grid System Operators should be studied, planned and designed.

D. Design of Load Connections

It has been agreed that an additional load class should be added (being Load Class F) and that the MITS design criteria should apply to this class. It is also agreed that, following a secured event, momentary interruptions would be allowed for both load classes D and E. The provisions of the IEEE Standard 1366-2012 was taken as a course of action for the amendments to the TSS. Accordingly, and taking account of fault detection, clearance and reclosing times, plus time margins, a value of no more than one (1) minute has been proposed for the concept of momentary interruption. We note that this approach will lead, in certain applications, to only three and not four transformers being required for certain classes of supply. This represents a significant cost saving. Table IV shows the load classes of the TSS 2nd edition.

E. System Operational Criteria

This section of TSS has been simplified and brought into line with the planning criteria. For OETC's internal purposes, diagrams have been used to enhance understanding of target values for the operational parameters of frequency and voltage.

F. Studies of Existing System

There are no TSS amendments arising from the studies of existing system.

G. Future Configuration System Studies

The changes to the load class D and E could, in future, lead to a change in design of demand connections; this has to be agreed. In the TSS 2nd edition, we introduced a new load class compared to the TSS 1st edition. This amendment will assist in more effective designs in the load range of 115 MW to 300 MW.

9. CONCLUSIONS

The paper has summarized studies and results of revising the TSS of OETC. The most important and critical changes of the TSS are in the format, layout, organisation and consistency of drafting. Operating limits are presented in terms of allowable voltage and frequency ranges.
There are a few changes, including amendments of both NILR and IILR. These have been increased to 600 MW and 1200 MW respectively.

Table IV: Load class table extracted from the TSS 2nd edition.

Load Connections **Load Class definition and supply restoration times**						
Load Class	**Load Class boundaries**		**OETC System configuration**			
			Following a System Outage during the Restricted Period		**A Planned Outage followed by a single Fault Outage during the Maintenance Period**	
	Low MW >	High MW ≤	Required level of served Demand MW	Time to restore served Demand	Required level of served Demand MW	Time to restore served Demand
A	0	2	Total Load Group Demand	Repair time of faulted circuit	Maintenance Period Demand for the Load Group	No requirement
B	2	6		3 hours		No requirement
C	6	20		15 minutes		Return time of Planned Outage
D	20	115		Momentary Interruption allowed		Return time of Planned Outage
E	115	300	Subject to section 7.11	Momentary Interruption allowed	Subject to section 7.11	Momentary Interruption allowed
F	300		No loss of supply for the Secured Events described in the MITS Design Criteria			

Note: In this Table IV, the term *Momentary Interruption* means a loss of power that lasts for no more than one (1) minute from the start of the relevant *Fault Initiation Event*, with the restoration of power intended to be performed by automatic equipment.

An additional load class is added, namely Class F ranges from 115 MW to 300 MW. Following a secured event, momentary interruptions of no more than one (1) minute would be allowed for both load classes D and E. This approach will lead, in certain applications, to only 3 and not 4 transformers being required for certain classes of supply, thus resulting in a significant cost saving.

10. REFERENCES

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