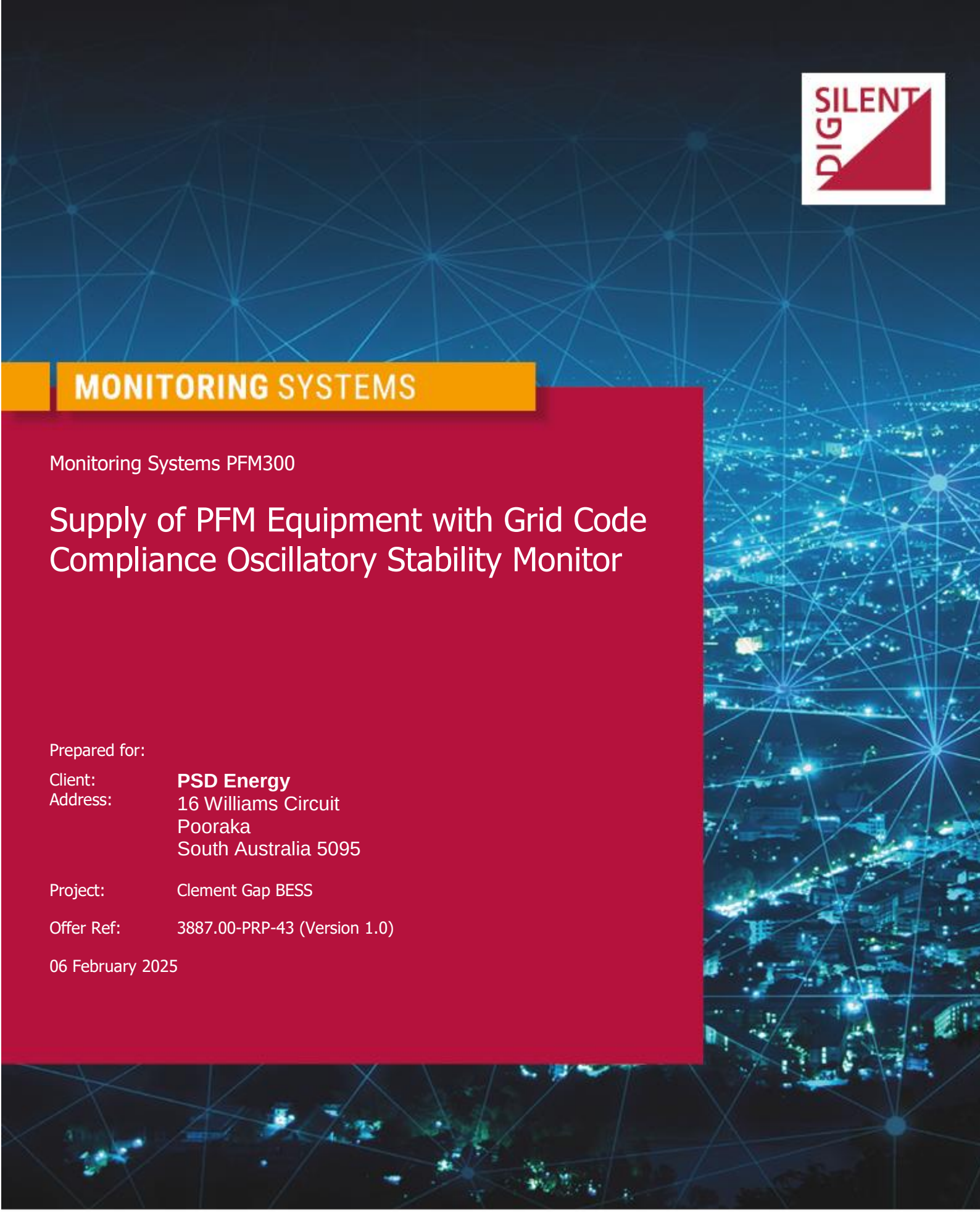

MONITORING SYSTEMS

Monitoring Systems PFM300

Supply of PFM Equipment with Grid Code Compliance Oscillatory Stability Monitor

Prepared for:

Client: **PSD Energy**
Address: 16 Williams Circuit
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South Australia 5095

Project: Clement Gap BESS

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COMMERCIAL OFFER EXCLUDED

1 Introduction

PSD Energy (hereafter **PSD**) has invited DIgSILENT Pacific (hereafter DIgSILENT) to submit a proposal for Monitoring Systems (PFM300) with the GridCode software licensed for Oscillatory Stability Monitoring (OSM) functionality.

Following the technical specification, DIgSILENT offers the required hardware, software functions and configurations on basis of the DIgSILENT Monitoring Systems and the integrated PowerFactory Software.

The PFM delivery will comprise the following components:

a. A PFM300 SSU15 with Grid Code Compliance (GCC) Oscillatory Stability Monitor (OSM) functionality

b. A non-functional housing for the panel assembly contractor

c. 36 months warranty and support.

d. 4G remote support equipment and service

2 Technical Offer

The DIgSILENT PFM system comprises the following components. For deliverables please refer to chapter 3.0.

2.1 Overview of PFM300 Equipment Features

2.1.1 Smart Signal Unit (SSU)

The Smart Signal Units (SSU) provide direct interface to secondary side VT and CT signal connection. In addition, the SSUs are holding small signal cards and digital I/O cards as required. A Smart Signal Unit can house a total number of up to 15 (SSU15-C) or 32 (SSU32-C) analogue and 16 digital channels.
If more channels required, a SSU32-C can be extended by several Signal Units (SU32). The total amount will be up to 160 analogue and 336 digital channels.
Also multiple Smart Signal Units can be installed at distributed locations and operated in parallel and synchronized by Ethernet connection. The PFM300 SSU and SU racks are a flexible slot-based system.

2.1.1.1 SSU32-C

The Smart Signal Unit (SSU32-C) is based on a 19" rack mounted industry-type CPU and controlling unit. Main SSU32-C characteristics are:

SSU32-C

IPC controller unit:	Embedded i7
Main memory:	16 GByte, DDRam
Hard disc:	256 GB SSD Memory
Networking:	2x Gigabit LAN (10/100/1000),1x Front LAN (10/100)
Time synchronization:	GPS (Optional)
Operation system:	Microsoft Embedded IoT
Analogue channels:	32
Digital channels:	16
Alarm contacts:	1 alive and 6 programmable (Optional)
Power Supply:	90-240 VAC, 110-360 VDC (Optional full redundant with two separate inputs)
Size:	19" rack mount 7*HU 11 x 449 x 316mm (HxWxD)

2.1.1.2 SSU15-C

The Smart Signal Unit (SSU15-C) is based on a 19" rack mounted industry-type CPU and controlling unit. Main SSU15-C characteristics are:

SSU15-C

IPC controller unit:	Intel Embedded Celeron
Main memory:	8 GByte, DDRam
Hard disc:	256 GB SSD Memory
Networking:	2x Gigabit LAN (10/100/1000),1x Front LAN (10/100)

Time synchronization:	GPS (Optional)
Operation system:	Microsoft Embedded IoT
Analogue channels:	15
Digital channels:	32
Alarm contacts:	1 alive and 6 programmable (Optional)
Power Supply:	90-240 VAC, 110-360 VDC
Size:	19" rack mount 7*HU 177 x 449 x 316mm (HxWxD)

2.1.1.3 Extension

The SSU32-C is available with an Extension module SSU32-C-E and can be extended with up to four SU32. The total amount of channels can be extended up to 160 analogue and 336 digital channels

SSU32-C-E
Same details like SSU32-C with an additional extension interface.

SU32

Analogue channels:	32
Digital channels:	16
Power Supply:	Supplied from SSU32-C-E
Size:	19" rack mount 3*HU 132.5 x 482.5 x 300mm (HxWxD)

DU128

Analogue channels:	0
Digital channels:	128
Power Supply:	Supplied from SSU32-C-E
Size:	19" rack mount 3*HU 132.5 x 482.5 x 300mm (HxWxD)

DU256

Analogue channels:	0
Digital channels:	256
Power Supply:	Supplied from SSU32-C-E
Size:	19" rack mount 6*HU 265 x 482.5 x 300mm (HxWxD)

2.1.1.4 Measurement cards

CT Input PFMI 1 Card

Nominal input range In:	3x 1A AC
Measuring range:	3.35A AC
Accuracy:	<0.2 % @50Hz
Overload capability:	50A 1 sec, 10A continues

CT Input PFMI 5 Card

Nominal input range In:	3x 1A/5A AC
Measuring range:	13.5A AC
Accuracy:	<0.2 % @50Hz
Overload capability:	150A 1 sec, 20A continues

VT Input PFMFU 120 Card	
Nominal input range Vn:	3x 100V AC
Measuring range:	210V AC
Accuracy:	<0.1% @50Hz
VT Input PFMFU 150 Card	
Nominal input range Vn:	3x 240V AC
Measuring range:	420V AC
Accuracy:	<0.1% @50Hz
Small Signal Input PFMSI 20 Card	
Nominal input range:	3x 4-20 mA
Measuring range:	+/- 20mA
Accuracy:	0.2%
PFM-DI Card	
Digital input:	8 channels (24V)
PFM-DO Card	
Digital output:	7 channels relays output

(1 Alive+ 6 programmable)

2.1.2 PFM300 Firmware

The PFM300 device can be configured direct via web interface. Operation commands like start-stop or manual triggering as well as reading of actual values can be done direct over the web interface. Status information and historic events can be displayed in filer based tables. The web interface has a multi user access control. Different user rights can be assigned by an Administrator.

Firmware updates are available for all licensed functionality under while under a valid support contact with DIgSILENT.

2.1.2.1 Recording Functions

The PFM features four types of recording mechanisms:

PFM Monitoring: The PFM monitoring process is continuously reading all signals from the signal unit, calculating RMS and harmonics quantities (snapshot recording). Monitoring signals are stored with a sampling rate of 1 Hz or below (typically 0.2 Hz). Monitoring is quite comparable with trending features of a SCADA system. However, such monitoring archives could be easily reviewed within the PFM system to get an initial and fast overview on the daily system operation. The PFM recording space is sufficient to store the complete information of a number of years.

RMS Recording: RMS recording is event driven based on trigger conditions. Typical RMS values recorded are: voltages (phase voltages, +/-/0-sequence voltages), currents, active/reactive/apparent power, power factor, frequency, frequency gradient, etc. The recording rate for RMS values is adjustable up to 2 samples/cycle. RMS recording archives are created for each triggered event. RMS recording periods can be freely configured. Typical settings are 60 secs pre-trigger time and 600 sec. Post trigger time with any number of re-trigger recording extensions.

IV Recording: Instantaneous values (IV values) recordings are also based on trigger conditions. Typical values stored are digital inputs, analogue inputs (signals from CTs and PTs). The recording rate for IV values is typically 250 or 300 samples/cycle. IV recording periods can be freely configured Typical settings are 0.5 secs pre-trigger time and 2.5 sec. post trigger time with any number of re-trigger recording extensions.

Trigger Conditions: Trigger conditions can be defined as required (limits, gradients, equations, digital input etc.) based on RMS and IV values. Complex algorithms are available to allow for trigger set/reset conditions to avoid nuisance triggering. Automatic re-triggering is supported shall new events appear during post-fault recording time thus extending the recording period (multiple- events recording). Trigger time labels are simply transferred via event file naming.

Captured data are stored in COMTRADE files in an automatically created folder structure where for each day/month/year a new subdirectory is created. Handling of such data is made via the comfortable PFM MasterStation Software.

IEEE C37.118 protocol: The PFM can work as a phasor measurement unit (PMU) and outputs a C37.118 stream to any phasor data concentrators (PDC). The PFM has also a C37.118 input for existing PMUs in the field.

2.1.3 PFM300 GCC Grid Code Compliance

The Grid Code Compliance functionality is an optional, licensed add on to the PFM300 standard firmware.
It provides a continuous online audit of grid code compliance and instant notification of non-compliant behaviour with traceability of grid code compliance triggered events via detailed reports.

It is noted that the configuration of a system to a GPS is jurisdiction-specific and although a user function, it requires advanced training. New customers should approach GCC as a configuration performed by DIgSILENT Pacific as a service.

Flexible monitor functions

Individual compliance functions can be configured to cover analysis such as:

- Frequency range
- LVRT, HVRT
- Reactive current behaviour based on voltage during LVRT
- Reactive power behaviour based on voltage or active power
- Active power behaviour controlled by frequency / voltage response regulation
- Meet Ramp Rate Control requirements
- Parameter settings can be static or dynamic via signal inputs

Online compliance status

Compliance status via Event Viewer and web interface
Traceability of all interim calculated values

Comprehensive reports

Interactive report generator
Statistical report showing all non-compliant events

Easy Configuration

Configuration via web-interface
Grid code standard configuration via Monitoring System Center: Grid Code Editor and Emulator
Templates available for common grid codes
Configurable additional inputs for further internal analysis

Multiple connection concept

Simultaneous data delivery to multiple independent parties
Independent report generation

2.1.4 PFM300 GCC Oscillatory Stability Monitor (OSM)

The GCC OSM functionality is a specific license under the GCC architecture targeting the AEMO criteria for generators connecting to the National Electricity Market (NEM). Across different TNSPs, specific variants in requirement occur and DIgSILENT Pacific have adjusted the configuration to the latest requirements that are understood to apply.

Some TNSP requirements are still uncompromising, despite the inherent limits of detecting sub-synchronous oscillations from trend data acquired from power measurement units (PMUs) that are tracking nominal frequency of the network. The functionality of the OSM with respect to measurement of amplitude and phase is bound by the mathematical principals underlying the approach to detection. This PFM OSM approach is the real-time analysis of the same methods employed by AEMO and TNSP in their observation of prior system events (i.e. through their own measurement and SCADA trends).

In general, the functioning principle is to check for amplitude modulation of voltage (V), real power (P in MW) and reactive power (Q in MVAr). This is achieved by automatically tracking up to four modulating frequencies below 50 Hz which have the highest amplitudes or in the case of Transgrid, tracking the highest amplitude across three frequency bands (0.1-1Hz, 1-10Hz, 10-25Hz).

If the amplitude of any oscillation frequency on either V, P or Q signal exceeds a threshold, an alarm event occurs.

Similarly, should the absolute phase difference between the oscillations of Q vs V undershoot a threshold, then another alarm event occurs. For estimating the phase difference, an average value of Q and V are used across all three phases.

If there is an amplitude or phase that exceeds thresholds alarms are mapped to output contacts.

It is noted that from the real time of the trigger condition to the closing of the contact, a delay of approximately 2 seconds occurs. This is because a certain number of samples must be gathered first, for a full cycle of the lowest detectable frequency to be complete.

In addition to the alarm contact, an additional output contact is pre-configured for activation in the event a trip action is required. DIgSILENT do not recommend trip contacts initiate any plant disconnection but instead are used to vote with a secondary vote such as operator action.

There are no TNSPs in Australia requiring a trip action however DIgSILENT has implemented a second-stage alarm.

Whenever an oscillation is detected, the high-speed recording is for the instantaneous value (IV) and fast (RMS) data streams. Phase angles of complex quantities are also saved to the recording. For the tracked modulating frequencies parameters, their amplitudes and phase angles are recorded.

It is noted that neither AEMO nor any TNSP have defined any methodologies for the identification of the source or root-cause of any detected oscillation. Hence such assessments are still expected to come from thorough post-event engineering investigations support by offline analysis of recordings.

Via additional software, PowerFactory Monitor MasterStation can retrieve all data automatically and centrally from any number of PFM units on the same network (even remotely).

2.2 PFM MasterStation Software

The MasterStation Software allows a comfortable operation management of one or more PFM Systems.
The following points can be done locally at the MasterStation.

- Display the actual status of each PFM System in the field.
- Comfortable overview of the trigger events from the PFM Systems.
- Easy analysis of the measurement records from the PFM Systems.
- Automatic analysis of grid conditions
- Manual trigger of recordings.
- Allow easy and comfortable backup.

The MasterStation supports a LAN connection to the PFM Systems. The PFM MasterStation System is a software packet which is installed on workstation on site or remotely at a central location with continuous communication link to the site.

It includes 3 parts of software:

- PowerFactory 2024 with MasterStation Package
- PFM EventViewer
- PFM Master SyncService
- Monitoring System Center

The PFM MasterStation Software can be installed on standard workstation of latest technology operated under MS-Windows 11.

2.3 DIgSILENT Remote Support Module

As a producer of software products, DIgSILENT is aware of the critical role of technical support and updates to the lifecycle of all our products. PowerFactory Monitoring Systems are the combination of an in-house hardware and software development producing a platform with flexibility for adoption of updates and additional features.

Although DIgSILENT Pacific has 4 offices in Australia, equipment is often installed in remote locations and connected to CT and VT wiring at the point of connection of a customer site. Return of the equipment back to base requires planned works and is logistically problematic. Additionally, mobilisation of DIgSILENT engineers to site becomes expensive and adds delay.

Hence, with experience of delivering some 75 systems through Australia, our current policy is that every PFM sold in Australia is equipped with standalone remote access system that is owned and maintained by DIgSILENT Pacific and with independent and secure communications.

The remote access system occupies a single rack unit (1RU) beneath each PFM and connects the PFM's front engineering port that has a fixed and static IP address. Other connections are an optional client internet connection (if made available) and power supply. In the case of poor 4G signal reception inside the rack, an external antenna is also provided.

The supply of each PFM includes free use of remote access facility for a 3 year term. The security appliance is from Tosibox Oy in Finland, being a premium ecosystem for OEM remote access technology, designed for this specific purpose. A remote access PC is also provided in the remote access module that contains DIgSILENT internal software and update tools.

The customer has the option of disabling remote access by the physical disconnection of the patch cable from the PFM front engineering port. The engineering port has a fixed static IP identical across all PFMs and it is impossible to bridge to rear networks ports located on the CPU or Communications Interface cards. The remote access system has no capability whatsoever of accessing any customer networks.

Each time that DIgSILENT accesses the PFM equipment remotely for maintenance checks, a notification is provided to the nominated email contact. Similarly, for any instance that additional works are required, then authorisation steps would apply under the applicable service level agreement (SLA).

At the end of the 3-year term, the SLA is either extended or the remote access equipment is returned. If there is any reason to replace the remote access equipment, DIgSILENT is responsible for all freight and support for the change out.

2.4 Supply of equipment

DIgSILENT Pacific local stocks of PFM300-SSU15 equipment in Australia in advance of orders and have the facilities for local configuration and calibration. In general, PFM SSU15 units can be provided within 8 weeks of order however a further 4 weeks may be required in case of surges in demand.

As there are many existing projects under time pressure, due an advanced state of construction, an optional service is available to supply a non-functional housing (NFH) to the client's contractor for panel fabrication. The NFH allows all wiring can be completed on a loan unit and then exchanged once the final units have completed their Factory Acceptance Test (FAT) with final settings. Appropriate transport cases and freights costs are included when a NFH is required.

2.5 Services

DIgSILENT Pacific can provide engineering support on site for site acceptance testing (SAT) or any maintenance activities required.

Engineering and specialist staff of DIgSILENT will be placed at the Project Manager's disposal, and will report to him on all matters regarding project handling.

Description	Rate (AUD Ex GST)
Field engineer (on-site)	$335/hr
Senior engineer (off-site)	$310/hr
Travelling time	$225/hr
All costs and expenses door-to-door	Cost + 10%

Note: DIgSILENT policy is to arrange for all staff travel and recovery costs of a reimbursable basis.