RedFlow
Telco Application Whitepaper
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redflow
advanced energy storage

1. Introduction

This article reports about the successful demonstration of the RedFlow Zinc Bromine Module (ZBM) integrated into a standard telecommunication (Telco) DC system at -48V. The ZBMs, installed directly on the DC bus, can replace standard lead acid batteries and support the load when the power from the grid or from a diesel generator (DG) is not available. In this specific study, the ZBMs are used to integrate renewable sources (PV) with an existing DG allowing the coexistence of multiple sources, absorbing the load and PV fluctuations and most importantly reducing the DG run time. The DG is simulated using the grid supply. This also demonstrates the excellent response of the ZBM in brown sites (where there is no reliable grid support).

This application is recognised to be of crucial importance for system integrators globally, as remote Base Telecommunication Stations (BTSs) must be powered at all times when a reliable source of energy is not available. This article covers the systems technical specifications, test conditions and criteria, test data analysis and conclusions.

2. System Specification

The key features related to RedFlow ZBM Telco system are listed below:

- the BTS load is 1kW and must be supported at all times (continuously 24/7)
- two ZBMs (48V, 200Ah) are connected in parallel to the existing DC bus
- the solar power (PV) available is 1kWp, 20° inclination, facing NE
- the power electronics consists of a bank of rectifiers (RECT, totalling 4kW) set at 56V and one solar controller (MPPT, 3kW)
- during the day (from 6:00 to 18:00, 12 hrs), the solar and the two ZBMs support the load until sunset
- during the night (from 18:00 to 6:00, 12 hrs), the generator turns on and, while supporting the load, charges the ZBM at approximately 1.4kW per ZBM, totalling 2.8kW

The system is shown in the following single line diagram (see Figure 1).

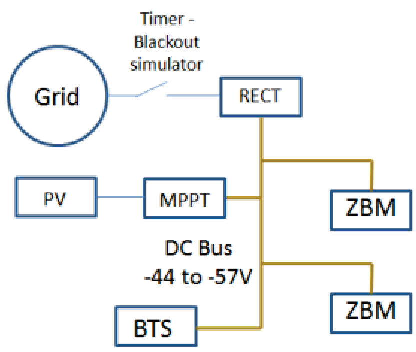

Figure 1: RedFlow telco system single line diagram

This shows:

- diesel generator run time reduces by 50% with no BTS downtime
- the successful integration of the ZBM in existing telco systems at - 48V using renewables
- the compatibility of the ZBM with standard off-the-shelf power electronics (see Figure 2)
- utilisation of the 100% depth of discharge (DoD) capability of ZBM batteries to successfully integrate renewables in a standard Telco system

Figure 2: RedFlow telco demonstration system installed in a powder-coated steel cabinet showing the ZBM at the bottom and power electronics above. Another ZBM is accommodated in another adjacent cabinet.

3. Test Conditions and Criteria

The demonstration system is setup at RedFlow's facility in Brisbane, Australia. The power electronics and one ZBM are installed in an outdoor cabinet. The other ZBM is accommodated in another adjacent outdoor cabinet. The test ran between July and August 2014. Some key ambient parameters in August are given in Table 1 below.

Table 1: Ambient parameters in July and August in Brisbane, Australia [1]

Month	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean daily sunshine (hours)
July	20.6	9.5	7.3
August	21.7	10.0	8.4

The average temperature swing is therefore more than 10° C with daily temperature extremes that can be even more than 23° C apart in July and more than 19° C apart in August. The ZBM is expected to be insensitive to this change of ambient conditions due to the large thermal mass provided by the 100 litres of water based electrolyte stored in the tanks.

[1] Bureau of Meteorology, Australian Government. 2014.

One digital timer (TM-619) is utilised to simulate the generator/grid's availability in the event of:

- A sudden blackout of the grid; or
- Maximum utilisation of the DG when it is used and to minimise the DG run time (and hence reduce diesel consumption and the need to replenish the diesel).

The timer is set to close the contact from 18:00 to 6:00 (12 hours) every day which provides power supply to the rectifiers (4 x 1kW modules) in order to charge the ZBMs and support the BTS load during the night time.

During the day (6:00-18:00, 12 hours), the BTS load is supported by 1kW solar and two ZBMs (N+1 deployment). The installed PV system of 1kW is estimated to generate an average of 4.2kWh energy per day which can be added to the 8kWh from the charged ZBMs. A total of 20kWh ensures the 1kW BTS load is supported continuously without any downtime. N+1 ZBM deployment ensures there is always an active ZBM connected on the DC bus so the other ZBM can enter the maintenance cycle at any time with no disruption.

4. Test Data Analysis

Approximately one-week of logged data is shown below in Figure 3. From this, the following observations can be made:

- The DC bus voltage (thick red line) is continuously supplied to the load within a range approximating -48V to -57V
- Even though one of the ZBMs entered its maintenance cycle (one every 5 days) the DC bus voltage is still maintained above the operating limits
- The batteries' State of Charge (SoC) curves show the 100% DoD with the batteries fully charged in the morning and completely discharged during operations
- The two ZBMs connected in parallel on the bus do not interfere with each other and no current flows from one ZBM to the other. This simplifies the design and reduces the self-discharge rate of the system
- The batteries' temperature did not change significantly during charging and discharging cycles. This is remarkable considering that the temperature swing between night and day is more than 10°C which is not visible in the reported graph
- The solar contribution is clearly visible in the voltage curves which show an increase during the Sun hours (solar supporting the load and charging the ZBMs). Alternatively, the discharge rate reduction during Sun hours can be clearly seen in the SoC curves: this demonstrates that the ZBM discharge slows down due to the solar contribution

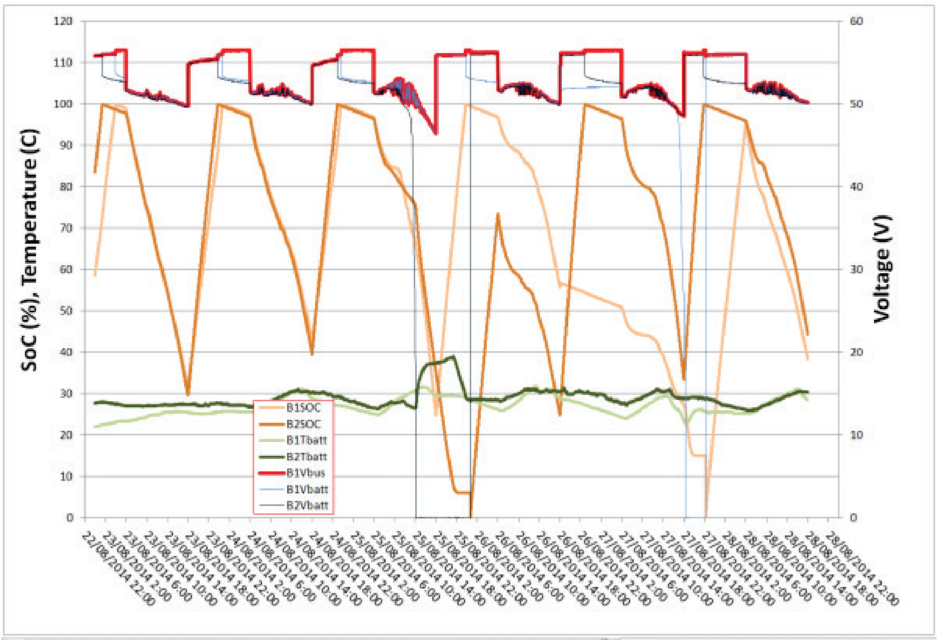

Figure 3: Test data

The result of the test exceeded expectations with the following points observed:

Using a ZBM has allowed us to integrate renewable generation in a standard Telco site where there is a diesel generator or an unreliable grid supply;

- The ZBM can be charged by the solar (or any other renewable source) as long as the power is supplied within the limits of the Telco DC bus. This can be easily achieved by using standard Telco power electronics as demonstrated in this application.
- Two or more ZBMs can be connected in parallel to support the DC bus at the same time. No interference and self-discharge is experienced. This means that longer blackouts or shorter DG run times can be achieved.
- The batteries absorb all the fluctuation and intermittency of the renewable generation or the load. This can be an advantage with less regular/stable sources of power (wind) and/or loads.
- The 50% run time reduction of the diesel generator can be easily achieved with *N+1* ZBMs deployed. It must be noted that if more solar power is available the run time reduction can be extended further. Redflow internal tests confirmed a reduction up to 80% with standard weather conditions.
- In the case of the complete discharge of the batteries, the ZBM suffered no degradation and the system was restored as soon as power is supplied again.
- The reduction of the diesel generator run time has the following advantages:
    - significant fuel cost savings
    - reduced operating expenses due to less servicing, maintenance and BTS down time
    - the removal of lead acid batteries;
    - diesel generator life time is extended and servicing interval time extended;
- Greenhouse gas emissions are also reduced when renewables are involved.

Extended tests performed over a month, proved the reliability of the system and the ZBM has a warranty of 12 months. The experimental data has been inserted into specific modelling software developed by Redflow in order to estimate the performance and savings in real Telecommunication sites powered by diesel generators. Real application data such as generator size, fuel cost and maintenance cost/hours, have been taken into consideration in the computation. The results shows that the Redflow ZBM can effectively solve the problem of renewables integration and can provide immediate savings and a good return on investment in a multitude of cases. The following table summarise the outcomes of the business case evaluation for 4 different Telco sites in which Redflow proposed its battery be deployed.

Table 2: Financial analysis of RedFlow telco system

Load (kW)	Solar (kW)	Number of ZBMs Installed	Diesel Generator Off Time (%)	Cost Reduction per Year (USD$)	Payback Time (years)	Return on Investment (%)
1	1	2	50%	$23,584	0.99	490%
1	5	3	80%	$27,568	2.26	752%
2	3	3	50%	$24,220	1.72	292%
2	5	5	80%	$26,515	2.92	253%

A typical installation of ZBM batteries in an existing Telco site is represented in Figure 4 below. As shown, the ZBMs can be connected directly to the DC bus replacing the existing lead acid batteries.

Figure 4: Typical Redflow telco installation

5. Conclusions

The integration of the RedFlow ZBM battery with standard Telco DC power electronics, renewables and grid/generator supply has been successfully demonstrated. With its 100% DoD, extended life, plastic construction and extremely wide temperature operating range, the ZBM proved to be the best choice for Telco sites experiencing unreliable power supply either from the grid or from DGs. The use of the ZBMs to reduce the DG run time generates further savings by reducing the frequency of DG maintenance/servicing (operating expenses). It also results in the DG operating at the most efficient point of the load/consumption curve. Furthermore, it can be expected that the DG run time reduction will be maximised by using larger PV installation coupled with matched ZBM energy capacity.

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