

## RFL Alternator versus Sawafuji Alternator

*A comparison on the Kubota Diesel Engine (Kubota GL6000 Lowboy GenSet)*



*The RF series Radial Flux Generators are a single stator, single rotor permanent magnet design. The combination of novel winding techniques with innovative rotor and stator design gives the RF series significant advantage over current commercially available technologies.*

*The RF series generators are designed specifically to be compact, lightweight whilst remaining highly efficient. All materials used in construction are conventional, so as to minimize manufacturing cost whilst still providing the specified performance.*

*The RFL RF2-12.5 Bi-Gen is a technologically advanced PM brushless alternator, offering highest energy efficiencies while maintaining minimal physical size. It sets a new industry standard. Its PM design Brush-Less Internal Magnetic Voltage Regulation (No AVR or electronics) means that possible points of failure are kept to a minimum by eliminating traditional brushes and AVRs.*


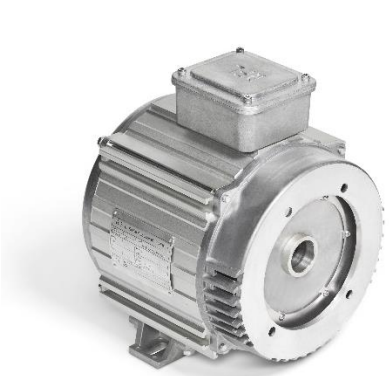
*The Kubota GL6000 Alternator (Sawafuji Elec Co) was tested as a comparison point for a Single Phase application where the generator is supplying into a circuit that can be split into 2 separate Single phase circuits (20 Amp 240V each) to demonstrate the advantages of the RFL Bi-Gen connection. Tests results of fuel economy, load and other physical factors were conducted.*

### Testing Procedure

The original Sawafuji Alternator was run through a series of load and fuel usage tests, with the load connected directly to the output side of the main switch.

It was replaced with the RFL RF2-12.5 Bi-Gen alternator. This required a new adaptor plate and a new mounting feet bracket. A bespoke modification was required to fit the engine housing and a custom feet mounting was made to allow mounting to the body of the shorter RFL alternator.

### Specifications

		
<b>Alternator</b>	<b>Sawafuji Elec Co Ltd</b>	<b>Radial Flux Laboratories Pty Ltd</b>
<b>Type</b>	GL90 A0	<b>RF2-7.5 Bi-Gen</b>
<b>Poles</b>	2 Poles	2 Poles
<b>Phase</b>	1 Phase	2 Phase
<b>Frequency</b>	50Hz	50Hz
<b>RPM</b>	3000 RPM	3000 RPM
<b>Voltage Range</b>	240-220 V	255-208 V
<b>Effective Power</b>	5.5 kW	6 kW
<b>Regulation</b>	Brushed AVR Controlled*	Brush-Less No AVR*
<b>Enclosure</b>	IP23	IP23
<b>Length/OD</b>	370mm/300mm	192mm/230mm
<b>Weight</b>	40 kg	28 kg

Physical Comparison



Figure 1 - Sawafuji physical size



Figure 2 - RFL Alternator physical size



Figure 3 - Sawafuji AVR

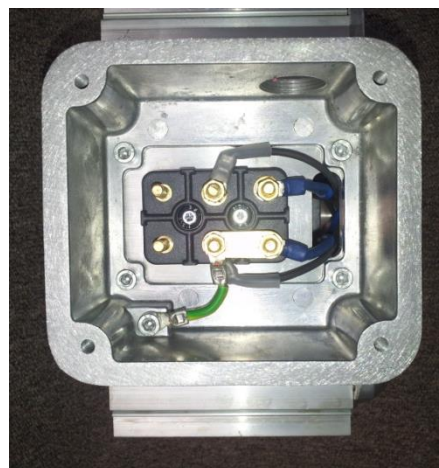


Figure 4 - RFL Terminal Block



*Figure 5 – Rotor Comparison (Sawafuji Left, RFL Alternator Right)*



## Fuel/Performance Results

### Sawafuji Test Results

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Date	28-06-16	Gen- Set Type	Kubota GL6000D - AU- B Lowboy 3 Diesel Generator set
Test By	Jason Zhang	Engine	Kubota Diesel Engine
		Alternator	Sawafuji
		Fuel Type	Diesel

Load 1 (Watts)	Load 2 (Watts)	Total (Watts)	Volts	Current 1 (Amps)	Current 2 (Amps)	Frequency (Hz)	Time (min)	Fuel Used (L)	THD
0	0	0	238	0	0	51.6	0	0.05	7.5
1010	0	1010	237	4.33	4.33	50.5	5	0.08	
1040	1040	2080	236	4.3	4.3	49.75	10	0.10	20.2
2065	2065	4130	233	8.9	8.9	47.8	15	0.15	8
2175	2175	4350	231	9.39	9.39	47.45	20	0.16	20.32
2800	2800	5600	226	12.65	12.65	46	25	0.20	8.8
2800	2800	5600	224	12.6	12.6	45.9	30	0.20	

The Sawafuji Alternator achieves 5.6kW at 46Hz, engine begins to struggle and sounds very strained.

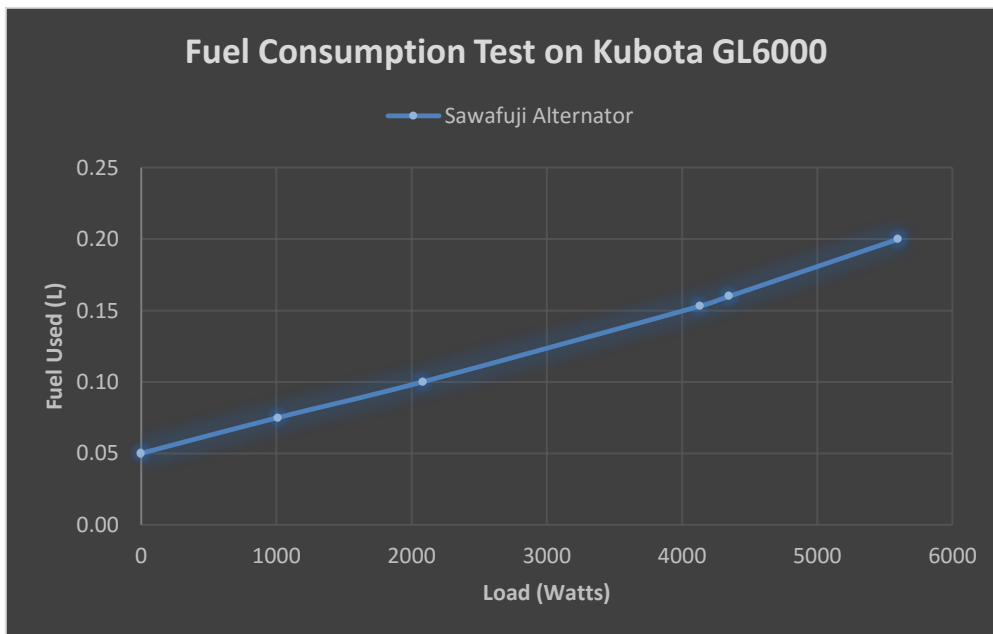


Figure 6 – Sawafuji fuel consumption graph



Figure 7 – Sawafuji waveform under load

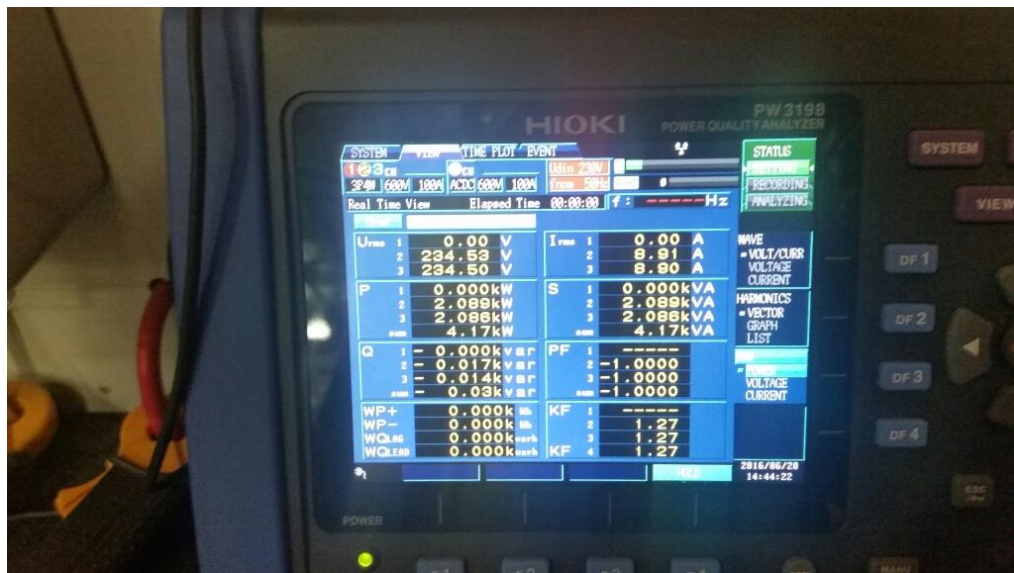


Figure 8 – Power analyser screenshot at 4.17kW

## RFL Alternator Test Results

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Date	04-07-16	Gen- Set Type	Kubota GL6000D - AU- B Lowboy 3 Diesel Generator set
Test By	Jason Zhang	Engine	Kubota Diesel Engine
		Alternator	RFL Alternator RF2-7.5 Bigen
		Fuel Type	Diesel

Load 1 (Watts)	Load 2 (Watts)	Total (Watts)	Volts	Current 1 (Amps)	Current 2 (Amps)	Frequency (Hz)	Time (min)	Fuel Used (L)	THD
0	0	0	258	0	0	51.5	0	0.05	2.6
1120	0	1120	247	0	4.52	50.8	5	0.07	6.5
1085	1110	2195	245	4.43	4.5	50.1	10	0.10	6.5
2030	2040	4070	230	8.78	8.8	48.4	15	0.14	7.1
2260	2180	4440	227	9.97	9.78	48	20	0.15	5.5
2640	2650	5290	216	12.2	12.2	47.2	25	0.17	7.2
2850	2750	5600	214	13.28	13.05	47.05	30	0.18	5.98
3100	3110	6210	204	15.08	15.16	46.5	35	0.20	1.6

Engine achieves 6.2kW at the same 46kW. Engine begins to struggle similar to the previous test. Voltage also dips to below minimum standard for single phase supply. Therefore, can only rate at around 6kW, though this is helpful in increasing its motor start capability.

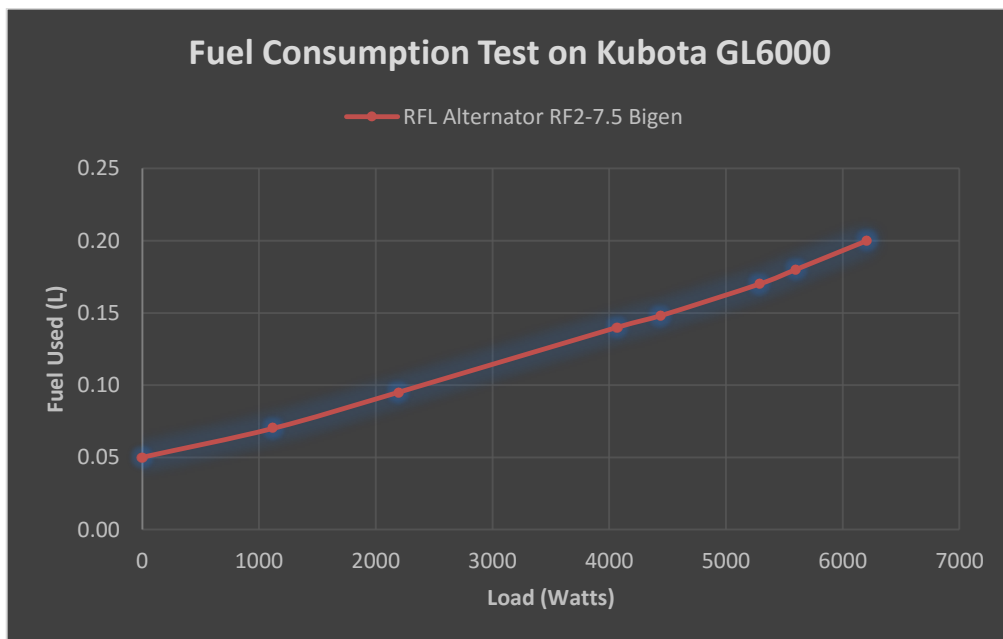


Figure 9 – RFL Alternator Fuel Consumption graph

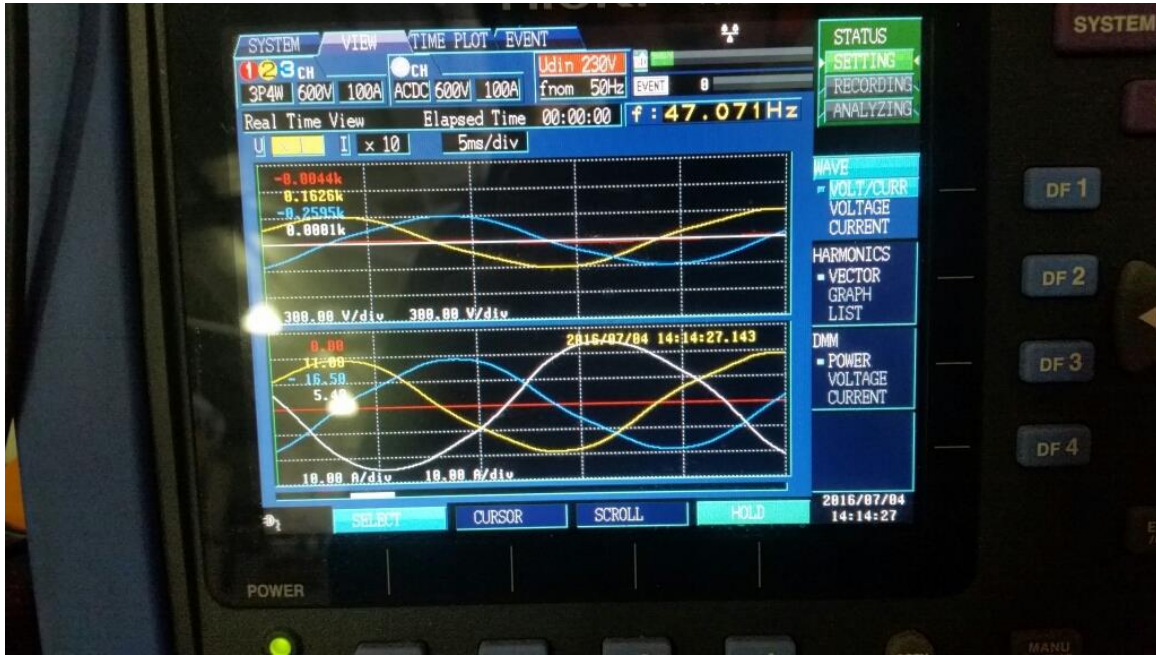


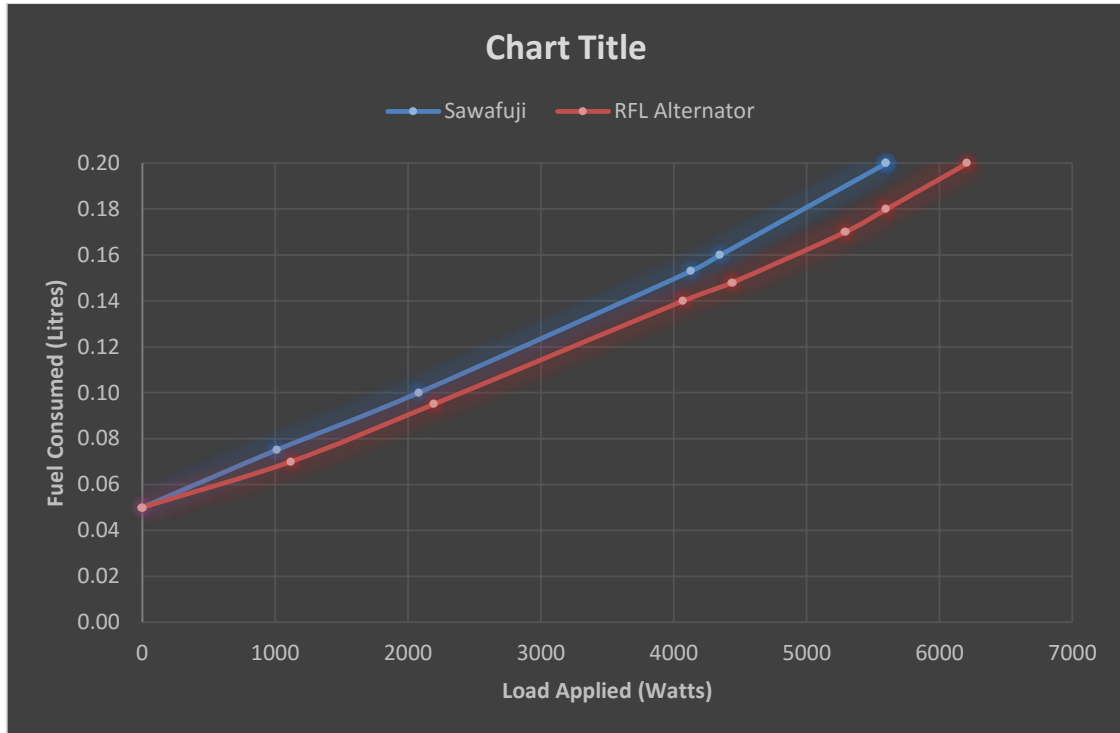
Figure 10 – RFL Alternator waveform under load



Figure 11 – Power analyser screenshot at 5.59kW



## Fuel Consumption Comparison Graph Between Sawafuji and RFL Alternators



### Conclusion

Using 46Hz as the frequency when the Kubota engine begins to struggle, the Sawafuji achieves 5.6kW while the RFL Alternator is able to reach 6.2kW, which is an improvement of around 10% in performance. This is while maintaining THD at reasonable levels of around 5-7% during load. The Sawafuji THD was found to reach 20% with occasional spikes of around 22%. The waveform is clearly seen to be severely distorted with a large 3<sup>rd</sup> and 5<sup>th</sup> harmonic distortion.

The fuel consumption was also found to be an improvement of around 10% in the RFL alternator, using 0.18L at 5.6kW compared to 0.2L with the Sawafuji. This fuel consumption value was found to be consistent with the quoted fuel usage in the Kubota GL6000 Lowboy manual.

The RFL's increased performance, superior THD, and lower fuel consumption is all with the added benefits of reduced weight, and smaller physical size.