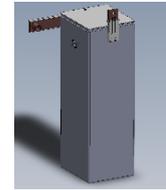


UCB

(DRAFT) THE INSTALLATION GUIDE



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INTRODUCTION

The Ultra Capacitor Battery (UCB) is a high-performance lithium hybrid capacitor battery designed for universal application in the energy storage industry.

Traditional ultracapacitors have long been heralded as the future of energy storage. The vast graphite or synthesised graphene electrostatic surface area within ultracapacitors facilitates extremely fast charge and discharge with no theoretical degradation and predicted cycle life of 10+ million \emptyset (cycles). The upside to electrostatic storage is very high peak power (W), the downside is comparatively low energy (Wh) density relative to a traditional lithium ion battery.

To enhance the energy density of an electrostatic ultracapacitor, 30-60nm \emptyset spheres of lithium titanate oxide ($\text{Li}_4\text{Ti}_5\text{O}_{12}$) form the cathode while highly porous graphite 5,000 -15,000nm \emptyset spheres form the anode. This increases the energy density (Wh) and decrease the power density (W) of the hybrid cell.

The nanospheres allow for safe mechanical movement of the anode and cathode substrates as temperatures and state of charge change delivering a highly durable and long-lasting cell.

Some lithium ion batteries with an SEI (solid electrolyte interphase) layer carry a risk of dendrite growth piercing the fragile SEI layer between the anode and the cathode as the cell ages or is mistreated. This can cause thermal run away or fire. Thanks to technological enhancements, the SEI layer is not required in the hybrid cells, further enhancing the safety and removing the risk of thermal runaway and fire.

The UCB hybrid cells:

- have a projected life of 25k-35k \emptyset at 25 °C
- are designed to retain over 80% of new capacity after 35k \emptyset at 25°C
- have a projected life of 4k–6k \emptyset at 55 °C
- operate safely over a wide temperature range of -50°C to + 60°C
- have 10 x greater energy density than electrostatic ultracapacitor cells
- have one of the very safest battery chemistries

The UCB is built with the hybrid cells by arranging them in series and parallel configurations along with an active balancing and protection system. The projected UCB life is 25+ years subject to maintenance as required.

Due to the very long projected product and \emptyset life of the UCB's the true cost of energy storage is greatly reduced compared with other battery technologies such as lead acid, common lithium ion and flow batteries.

The UCB:

- Is designed to operate for as long as a solar panel
- Is simple to install
- Is designed to allow parallel and series connection up to 800VDC
- Can charge and discharge very quickly

SAFETY

Only suitably qualified and capable persons should install this product.

Under no circumstance should a UCB be short circuited across the +ve and -ve terminals. Insulated tools and torque wrenches should be used.

Unless otherwise stated, all Allen bolts should be tightened to 7nm using a torque wrench.

Due to the UCB weight, suitable lifting techniques should be employed. It is recommended that two persons or a lifting apparatus be used to move and position each UCB. Prevent contact with water as damage caused by environmental conditions may void the warranty. Wear safety glasses and gloves while installing. Depending on the combination of UCBs, additional PPE and safety measures may be required. Consult the appropriate National Standards for correct safety procedures. Do not operate the UCB outside the voltage specification. Do not remove the fuse cover without written approval from the manufacturer. Do not short circuit as high current flow can cause a high energy arc flash and blow the fuse. Do not use in a mobile application without properly considering the effect of vibration. Damage caused by regular movement or vibration is not covered under warranty.

Before joining each UCB to the next, ensure that the main battery DC isolation switch is open. After all UCBs in a string are connected together, before turning on the string, ensure that the voltage across the input to the isolator is correct. Check the voltage from the -ve terminal to each +ve terminal progressively along the string of UCBs to ensure that the voltage increases from one UCB to the next in the expected manner.

When connecting in series to voltages over 120VDC, ensure safety is considered as per the relevant National Standards as DC voltages become dangerous above 120VDC.

As the UCB can be connected in series strings and parallel groups, before paralleling UCB series strings, ensure that the voltage of each series string is within 5% of other series strings.

UCB strings should be combined using suitably sized circuit breakers for the safest installation procedure.

Ensure that there is reasonable ventilation available. The cooler the environment, the longer the projected life. If installing within an enclosure, choose an enclosure with suitable heat dissipation to maintain low temperature.

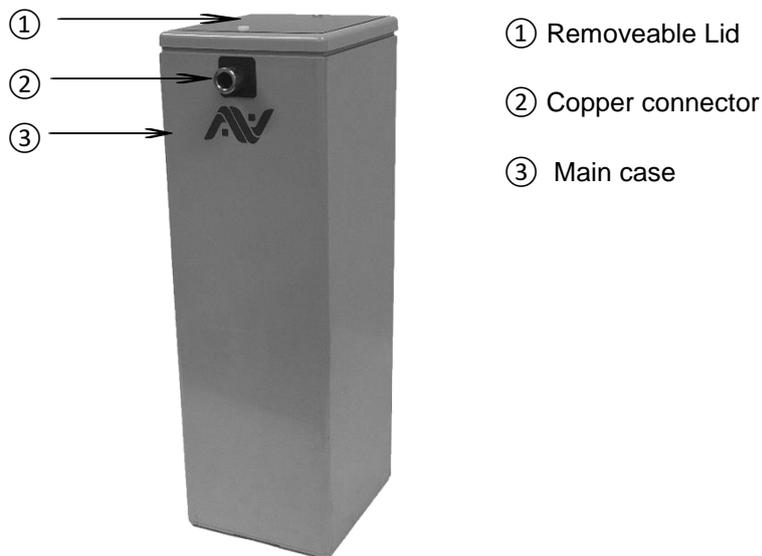
MODELS

Current models available:

Model	Rec. operating range			Energy @ C4 kWh	Max. Power kWp	Cycles projected		T range Recomm. Op. °C	T range Max. Max °C
	Low V	Nom. V	High V			○25°C	○55°C		
UCB2.3V2.2k	1.9	2.3	2.6	2.21	1.8	25-35k	4k-6k	-20 to + 50	-50 to + 60
UCB4.6V2.2k	3.8	4.6	5.2	2.21	3.6	25-35k	4k-6k	-20 to + 50	-50 to + 60
UCB6.9V2.2k	5.7	6.9	7.8	2.21	5.5	25-35k	4k-6k	-20 to + 50	-50 to + 60
UCB9.2V2.2k	7.6	9.2	10.4	2.21	7.3	25-35k	4k-6k	-20 to + 50	-50 to + 60
UCB13.8V2.2k	11.4	13.8	15.6	2.21	11	25-35k	4k-6k	-20 to + 50	-50 to + 60
UCB18.4V2.2k	15.2	18.4	20.8	2.21	14.7	25-35k	4k-6k	-20 to + 50	-50 to + 60
UCB27.6V2.2k	22.8	27.6	31.2	2.21	22	25-35k	4k-6k	-20 to + 50	-50 to + 60
UCB55.2V2.2k	45.6	55.2	62.4	2.21	44	25-35k	4k-6k	-20 to + 50	-50 to + 60

UNPACKING & INSPECTION

Carefully inspect the shipping packaging before beginning the installation.



DESIGN, INSTALLATION & WIRING

Refer to the operating voltage table below to select the suitable series and parallel combinations to match the system being connected to the UCB bank.

Modules	kWh	2.3 V module			4.6 V module			6.9 V module			9.2 V module			13.8 V module			18.4 V module			27.6 V module		
		Min.	Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.									
1	2.2	1.9	2.3	2.6	3.8	4.6	5.2	5.7	6.9	7.8	7.6	9.2	10.4	11.4	13.8	15.6	15.2	18.4	20.8	22.8	27.6	31.2
2	4.4	3.8	4.6	5.2	7.6	9.2	10.4	11.4	13.8	15.6	15.2	18.4	20.8	22.8	27.6	31.2	30.4	36.8	41.6	45.6	55.2	62.4
3	6.6	5.7	6.9	7.8	11.4	13.8	15.6	17.1	20.7	23.4	22.8	27.6	31.2	34.2	41.4	46.8	45.6	55.2	62.4	68.4	82.8	93.6
4	8.8	7.6	9.2	10.4	15.2	18.4	20.8	22.8	27.6	31.2	30.4	36.8	41.6	45.6	55.2	62.4	60.8	73.6	83.2	91.2	110.4	124.8
5	11	9.5	11.5	13	19	23	26	28.5	34.5	39	38	46	52	57	69	78	76	92	104	114	138	156
6	13.2	11.4	13.8	15.6	22.8	27.6	31.2	34.2	41.4	46.8	45.6	55.2	62.4	68.4	82.8	93.6	91.2	110	125	137	165.6	187.2
7	15.4	13.3	16.1	18.2	26.6	32.2	36.4	39.9	48.3	54.6	53.2	64.4	72.8	79.8	96.6	109	106	129	146	160	193.2	218.4
8	17.6	15.2	18.4	20.8	30.4	36.8	41.6	45.6	55.2	62.4	60.8	73.6	83.2	91.2	110	125	122	147	166	182	220.8	249.6
9	19.8	17.1	20.7	23.4	34.2	41.4	46.8	51.3	62.1	70.2	68.4	82.8	93.6	103	124	140	137	166	187	205	248.4	280.8
10	22	19	23	26	38	46	52	57	69	78	76	92	104	114	138	156	152	184	208	228	276	312
11	24.2	20.9	25.3	28.6	41.8	50.6	57.2	62.7	75.9	85.8	83.6	101	114	125	152	172	167	202	229	251	303.6	343.2
12	26.4	22.8	27.6	31.2	45.6	55.2	62.4	68.4	82.8	93.6	91.2	110	125	137	166	187	182	221	250	274	331.2	374.4
13	28.6	24.7	29.9	33.8	49.4	59.8	67.6	74.1	89.7	101	98.8	120	135	148	179	203	198	239	270	296	358.8	405.6
14	30.8	26.6	32.2	36.4	53.2	64.4	72.8	79.8	96.6	109	106	129	146	160	193	218	213	258	291	319	386.4	436.8
15	33	28.5	34.5	39	57	69	78	85.5	104	117	114	138	156	171	207	234	228	276	312	342	414	468
16	35.2	30.4	36.8	41.6	60.8	73.6	83.2	91.2	110	125	122	147	166	182	221	250	243	294	333	365	441.6	499.2
17	37.4	32.3	39.1	44.2	64.6	78.2	88.4	96.9	117	133	129	156	177	194	235	265	258	313	354	388	469.2	530.4
18	39.6	34.2	41.4	46.8	68.4	82.8	93.6	103	124	140	137	166	187	205	248	281	274	331	374	410	496.8	561.6
19	41.8	36.1	43.7	49.4	72.2	87.4	98.8	108	131	148	144	175	198	217	262	296	289	350	395	433	524.4	592.8
20	44	38	46	52	76	92	104	114	138	156	152	184	208	228	276	312	304	368	416	456	552	624
21	46.2	39.9	48.3	54.6	79.8	96.6	109	120	145	164	160	193	218	239	290	328	319	386	437	479	579.6	655.2
22	48.4	41.8	50.6	57.2	83.6	101	114	125	152	172	167	202	229	251	304	343	334	405	458	502	607.2	686.4
23	50.6	43.7	52.9	59.8	87.4	106	120	131	159	179	175	212	239	262	317	359	350	423	478	524	634.8	717.6
24	52.8	45.6	55.2	62.4	91.2	110	125	137	166	187	182	221	250	274	331	374	365	442	499	547	662.4	748.8
25	55	47.5	57.5	65	95	115	130	143	173	195	190	230	260	285	345	390	380	460	520	570	690	780
26	57.2	49.4	59.8	67.6	98.8	120	135	148	179	203	198	239	270	296	359	406	395	478	541	593	717.6	811.2
27	59.4	51.3	62.1	70.2	103	124	140	154	186	211	205	248	281	308	373	421	410	497	562	616	745.2	842.4
28	61.6	53.2	64.4	72.8	106	129	146	160	193	218	213	258	291	319	386	437	426	515	582	638	772.8	873.6
29	63.8	55.1	66.7	75.4	110	133	151	165	200	226	220	267	302	331	400	452	441	534	603	661	800.4	904.8
30	66	57	69	78	114	138	156	171	207	234	228	276	312	342	414	468	456	552	624	684	828	936
31	68.2	58.9	71.3	80.6	118	143	161	177	214	242	236	285	322	353	428	484	471	570	645	707	855.6	967.2
32	70.4	60.8	73.6	83.2	122	147	166	182	221	250	243	294	333	365	442	499	486	589	666	730	883.2	998.4
33	72.6	62.7	75.9	85.8	125	152	172	188	228	257	251	304	343	376	455	515	502	607	686			
34	74.8	64.6	78.2	88.4	129	156	177	194	235	265	258	313	354	388	469	530	517	626	707			
35	77	66.5	80.5	91	133	161	182	200	242	273	266	322	364	399	483	546	532	644	728			
36	79.2	68.4	82.8	93.6	137	166	187	205	248	281	274	331	374	410	497	562	547	662	749			
37	81.4	70.3	85.1	96.2	141	170	192	211	255	289	281	340	385	422	511	577	562	681	770			
38	83.6	72.2	87.4	98.8	144	175	198	217	262	296	289	350	395	433	524	593	578	699	790			
39	85.8	74.1	89.7	101	148	179	203	222	269	304	296	359	406	445	538	608	593	718	811			
40	88	76	92	104	152	184	208	228	276	312	304	368	416	456	552	624	608	736	832			
41	90.2	77.9	94.3	107	156	189	213	234	283	320	312	377	426	467	566	640	623	754	853			
42	92.4	79.8	96.6	109	160	193	218	239	290	328	319	386	437	479	580	655	638	773	874			
43	94.6	81.7	98.9	112	163	198	224	245	297	335	327	396	447	490	593	671	654	791	894			
44	96.8	83.6	101	114	167	202	229	251	304	343	334	405	458	502	607	686	669	810	915			
45	99	85.5	104	117	171	207	234	257	311	351	342	414	468	513	621	702	684	828	936			
46	101	87.4	106	120	175	212	239	262	317	359	350	423	478	524	635	718						
47	103	89.3	108	122	179	216	244	268	324	367	357	432	489	536	649	733						
48	106	91.2	110	125	182	221	250	274	331	374	365	442	499	547	662	749						
49	108	93.1	113	127	186	225	255	279	338	382	372	451	510	559	676	764						
50	110	95	115	130	190	230	260	285	345	390	380	460	520	570	690	780						
51	112	96.9	117	133	194	235	265	291	352	398	388	469	530	581	704	796						
52	114	98.8	120	135	198	239	270	296	359	406	395	478	541	593	718	811						
53	117	101	122	138	201	244	276	302	366	413	403	488	551	604	731	827						
54	119	103	124	140	205	248	281	308	373	421	410	497	562	616	745	842						
55	121	105	127	143	209	253	286	314	380	429	418	506	572	627	759	858						
56	123	106	129	146	213	258	291	319	386	437	426	515	582	638	773	874						
57	125	108	131	148	217	262	296	325	393	445	433	524	593	650	787	889						
58	128	110	133	151	220	267	302	331	400	452	441	534	603	661	800	905						
59	130	112	136	153	224	271	307	336	407	460	448	543	614	673	814	920						
60	132	114	138	156	228	276	312	342	414	468	456	552	624	684	828	936						
61	134	116	140	159	232	281	317	348	421	476	464	561	634	695	842	952						
62	136	118	143	161	236	285	322	353	428	484	471	570	645	707	856	967						
63	139	120	145	164	239	290	328	359	435	491	479	580	655	718	869	983						
64	141	122	147	166	243	294	333	365	442	499	486	589	666	730	883	998						
65	143	124	150	169	247	299	338	371	449	507	494	598	676									

Min.		Recommended minimum voltage for best performance
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Design Example

The target is 65kWh and the battery management inverter is an SPPRO 120V nominal inverter AC coupled with a Selectsun PV inverter.

From the “Typical inverter options” table, the orange coloured row is selected. Being AC coupled, the inverter operating range is 100 - 164VDC with a nominal voltage of 120VDC. Higher voltages strings where possible are recommended as current is reduced.

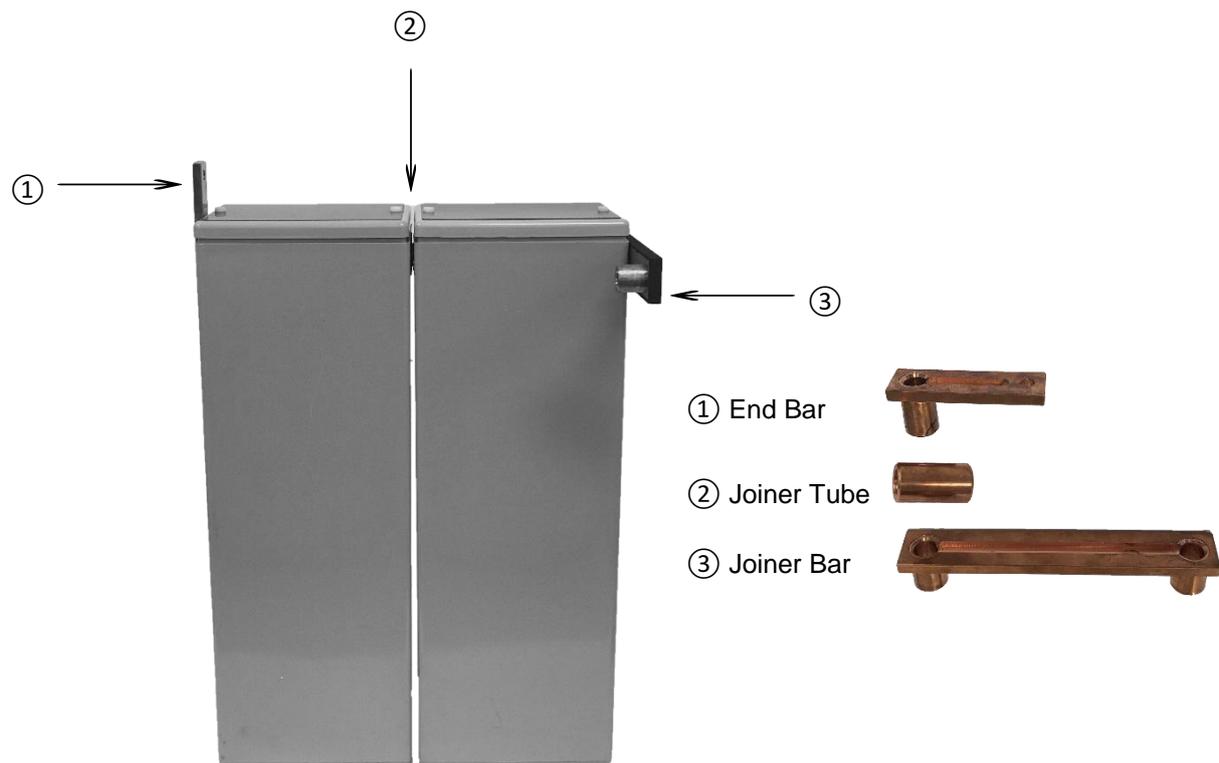
The options to reach the voltage window are 5, 7-11, 14-16, 18-22 depending on the module voltage chosen. 10 13.8V modules in series provides an operating window of 114-156VDC and is chosen as it provides for reasonable size strings of UCBs with respect to expanding the system at a later date.

To reach 65kWh, 3 strings of 10 are selected. $3 \times 10 \times 2.2 = 66\text{kWh}$. If the customer wants to expand at a later date, additional 22kWh strings can be added accordingly.

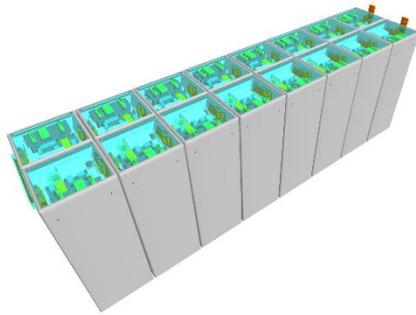
Alternative combinations would also work such as $2 \times 15 \times 2.2 = 66\text{kWh}$ using the 9.2V module.

Connection method

When the series-parallel combination is chosen, the physical layout can be selected and the End Bar, Joiner Tube and Joiner Bar set can be calculated.

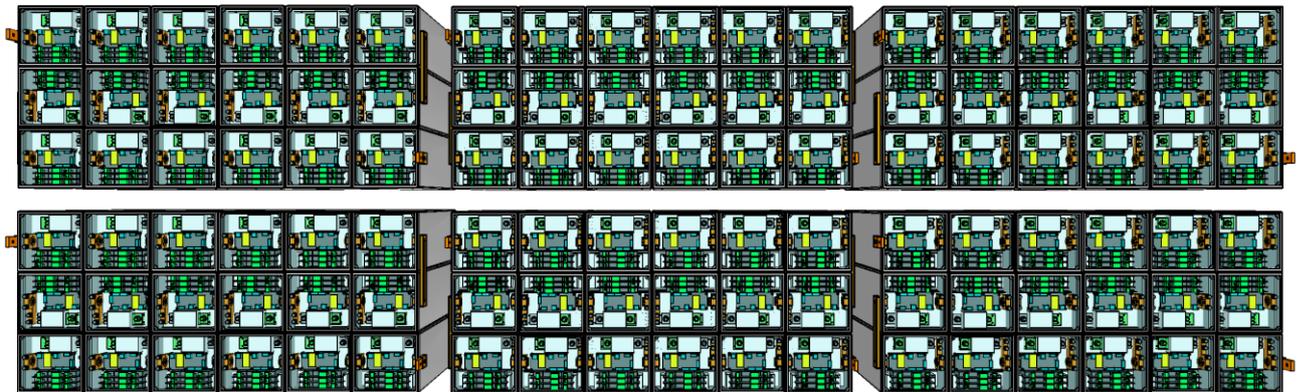


An example of 16 UCBs in series.



Connectors	Qty	Description	Location used	Material
End Bar	2	Connection point to isolator for system	First and Last UCB in series string	Copper with plastic cover
Joiner Tube	2x7=14	Joins UCBs in series	Between UCBs	Copper
Joiner Bar	1	Turns string back in opposite direction to allow for multiple rows of UCBs	At the end of two rows	Copper with plastic cover

An example of 6 parallel x 18 UCBs in series to be connected together.



Connectors	Qty	Description	Location used	Material
End Bar	2x6=12	Connection point to isolator for system	First and Last UCB in series string	Copper with plastic cover
Joiner Tube	5x3x6=90	Joins UCBs in series	Between UCBs	Copper
Joiner Bar	2x6=12	Turns string back in opposite direction to allow for multiple rows of UCBs	At the end of two rows	Copper with plastic cover

BALANCING CIRCUIT

A balancing cable is to be connected from one UCB to the next such that all UCBs are connected. The balancing cable can be arranged in a star and fashion when multiple strings of UCB are connected in parallel. The energy is transferred as an AC source so polarity is not important.

MONITORING

The balancing cable is to be connected to the protection control board. The board is described in the manual which accompanies it. This board is designed to instruct the charger to stop charging if any cell in any UCB goes over voltage.

ORIENTATION

UCBs can be installed tall and upright with the terminals at the top or laying flat with the terminals on the left and right sides.

SETUP OF SERIES STRINGS AND PARALLEL GROUPS

Only use insulated tools when working on UCBs. Safety glasses and gloves should be worn at all times.

Ensure that the series string of UCBs are connected to a circuit breaker. Add multiple series strings as required in parallel groups to reach the target energy amount.

Care should be taken when paralleling strings such that each string is within 5% of the voltage of the other strings so that they can equalise without significant current flow.

Unless otherwise stated, all Allen bolts should be tightened to 7nm using a torque wrench.

DISCLAIMER

Arvio Pty Ltd has developed the UCB for use in energy storage applications. Only suitably qualified and capable persons should assemble systems.

Arvio is not liable in any way for any costs associated with events relating to remote access failure or remote access operation.

NOTES

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