MAC-BMC 600-watt Motor

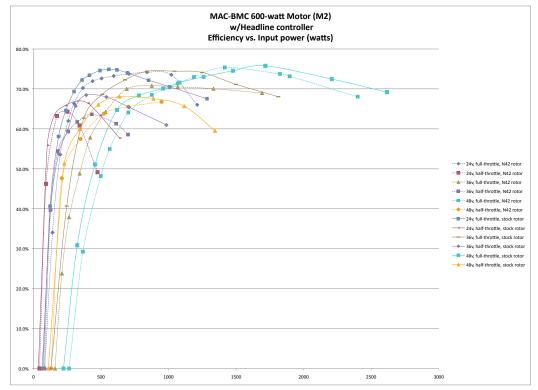
Motor: M2 Hall sensors tuned for CW rotation Winding: Delta (stock) Headline 48v controller

Stock rotor with composite magnet ring, 16-pole			Rotor with N42 Neodymium magnets, 16-pole		
24-volt supply			24-volt supply		
Full Throttle			Full Throttle		
Power (CycleAnalyst)	Power (PowerTap)	Efficiency	Power (CycleAnalyst)	Power (PowerTap)	Efficiency
72	0	0.0%	84	0	0.0
123	50	40.7%	141	48	34.0
186	108	58.1%	198	106	53.5
240	155	64.6%	258	160	62.0
300	208	69.3%	300	199	66.3
360	260	72.2%	366	257	70.2
414	304	73.4%	438	315	71.9
492	367	74.6%	504	366	72.6
558	418	74.9%	594	435	73.2
618	462	74.8%	708	522	73.7
696	515	74.0%	840	623	74.2
852	615	72.2%	1020	750	73.5
1008	711	70.5%	1212	800	66.0
			1212	800	00.0
1284	867	67.5%			
			24-volt supply		
24-volt supply			Half Throttle		
Half Throttle			Power (CycleAnalyst)	Power (PowerTap)	Efficiency
Power (CycleAnalyst)	Power (PowerTap)	Efficiency	45	0	0.0
36	0	0.0%	93	43	46.2
102	57	55.9%	174	110	63.2
102	99	63.5%	252		64.3
				162	
234	154	65.8%	342	208	60.8
324	217	67.0%	474	233	49.2
402	267	66.4%			
492	312	63.4%	36-volt supply		
636	367	57.7%	Full Throttle		
			Power (CycleAnalyst)	Power (PowerTap)	Efficiency
36-volt supply			159	0	0.0
Full Throttle			210	50	23.8
		E 60 1			
Power (CycleAnalyst)	Power (PowerTap)	Efficiency	264	100	37.9
130	0	0.0%	342	167	48.8
246	100	40.7%	420	243	57.9
372	233	62.6%	534	343	64.2
510	350	68.6%	690	483	70.0
678	490	72.3%	876	620	70.8
840	625	74.4%	1068	753	70.5
	777	74.4%	1332	933	70.0
1044					
1248	925	74.1%	1692	1167	69.0
1500	1067	71.1%			
1812	1233	68.0%	36-volt supply		
			Half Throttle		
36-volt supply			Power (CycleAnalyst)	Power (PowerTap)	Efficiency
Half Throttle			80	0	0.0
Power (CycleAnalyst)	Power (PowerTap)	Efficiency	126	50	39.7
65	0	0.0%	180	98	54.4
126	50	39.7%	258	153	59.3
186	100	53.8%	324	200	61.7
252	150	59.5%	432	275	63.7
312	205	65.7%	612	375	61.3
390	267	68.5%	700	410	58.6
540			700	410	50.0
	367	68.0%	40		
708	463	65.4%	48-volt supply		
984	600	61.0%	Full Throttle		
			Power (CycleAnalyst)	Power (PowerTap)	Efficiency
48-volt supply			264	0	0.0
Full Throttle					29.2
				107	
Power (CycleAnalyst)	Power (PowerTan)	Efficiency	366 498	107 240	
Power (CycleAnalyst)	Power (PowerTap)	Efficiency 0.0%	498	240	48.2
222	0	0.0%	498 564	240 310	48.2 55.0
222 324	0 100	0.0% 30.9%	498 564 702	240 310 450	48.2 55.0 64.1
222 324 456	0 100 233	0.0% 30.9% 51.1%	498 564 702 876	240 310 450 600	48.2 55.0 64.1 68.5
222 324 456 618	0 100 233 400	0.0% 30.9% 51.1% 64.7%	498 564 702 876 1008	240 310 450 600 710	48.2 55.0 64.1 68.5 70.4
222 324 456	0 100 233	0.0% 30.9% 51.1%	498 564 702 876	240 310 450 600	48.2 55.0 64.1 68.5 70.4
222 324 456 618	0 100 233 400	0.0% 30.9% 51.1% 64.7%	498 564 702 876 1008	240 310 450 600 710	48.2 55.0 64.1 68.5 70.4 71.3
222 324 456 618 780 960	0 100 233 400 533 673	0.0% 30.9% 51.1% 64.7% 68.3% 70.1%	498 564 702 876 1008 1068 1188	240 310 450 600 710 762 867	48.2 55.0 64.1 68.5 70.4 71.3 73.0
222 324 456 618 780 960 1080	0 100 233 400 533 673 773	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6%	498 564 702 876 1008 1168 1188	240 310 450 600 710 762 867 1067	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4
222 324 456 618 780 960 1080 1260	0 100 233 400 533 673 773 920	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0%	498 564 702 876 1008 1068 1188 1416 1824	240 310 450 600 710 762 867 1067 1345	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7
222 324 456 618 780 960 1080 1260	0 100 233 4400 533 673 773 920	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0% 74.5%	498 564 702 876 1008 1188 1416 1824	240 310 450 600 710 762 867 1067 1345 1387	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7
222 324 456 618 780 960 1080 1260 1476 1716	0 100 233 400 533 673 773 920 1100	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0% 74.5% 75.8%	498 564 702 876 1008 1068 1188 1416 1824	240 310 450 600 710 762 867 1067 1345	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7
222 324 456 618 780 960 1260 1476 1716 2208	0 100 233 400 533 673 773 920 1100 1300	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 74.5% 75.8% 72.5%	498 564 702 876 1008 1088 1188 1416 1824 1896 2400	240 310 450 600 710 762 867 1067 1345 1387	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7
222 324 456 618 780 960 1080 1260 1476 1716	0 100 233 400 533 673 773 920 1100	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0% 74.5% 75.8%	498 564 702 876 1008 1188 1416 1824	240 310 450 600 710 762 867 1067 1345 1387	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7
222 324 456 618 780 960 1260 1476 1716 2208	0 100 233 400 533 673 773 920 1100 1300	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 74.5% 75.8% 72.5%	498 564 702 876 1008 1088 1188 1416 1824 1896 2400	240 310 450 600 710 762 867 1067 1345 1387	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7
222 324 456 618 780 960 1080 1260 1476 1716 2208 2616	0 100 233 400 533 673 773 920 1100 1300	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 74.5% 75.8% 72.5%	498 554 702 876 1008 1068 1188 1416 1824 1896 2400 48-volt supply Half Throttle	240 310 450 6000 710 762 867 1067 1345 1387 1633	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0
222 324 456 618 780 960 1080 1260 1476 1716 2208 2616	0 100 233 400 533 673 773 920 1100 1300	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 74.5% 75.8% 72.5%	498 564 702 876 1008 1068 1188 1416 1824 1896 2400 48-volt supply Half Throttle Power (CycleAnalyst)	240 310 450 600 710 762 867 1067 1345 1387 1633	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0
222 324 456 618 780 960 1080 1260 1716 2717 48-volt supply	0 100 233 400 533 673 773 920 1100 1300 1600 1810	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 73.0% 74.5% 75.8% 69.2%	498 564 702 876 1008 1188 1188 1416 1824 1896 2400 48-volt supply Half Throttle Power (CycleAnalyst) 130	240 310 450 600 710 762 867 1067 1345 1387 1633	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0
222 324 456 618 780 960 1080 1260 1476 1716 2208 2616 48-volt supply Half Throttle Power (CycleAnalyst)	0 100 233 400 533 673 773 920 1100 1300 1600 1810	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0% 74.5% 75.8% 69.2%	498 564 702 876 1008 1168 1188 1416 1824 1896 2400 48-volt supply Half Throttle Power (CycleAnalyst) 210	240 310 450 600 710 762 867 1067 1345 1387 1633 Power (PowerTap) 0	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0 Efficiency 0.0 47.6
222 324 456 618 780 960 1080 1260 1716 2717 2208 2616	0 100 233 400 533 673 773 920 1100 1300 1600 1810	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 73.0% 74.5% 75.8% 69.2%	498 564 702 876 1008 1188 1188 1416 1824 1896 2400 48-volt supply Half Throttle Power (CycleAnalyst) 130	240 310 450 600 710 762 867 1067 1345 1387 1633	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0 Efficiency 0.0 47.6
222 324 456 618 780 960 1080 1260 1476 1716 2208 2616 48-volt supply Half Throttle Power (CycleAnalyst)	0 100 233 400 533 673 773 920 1100 1300 1600 1810	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0% 74.5% 69.2%	498 564 702 876 1008 1168 1188 1416 1824 1896 2400 48-volt supply Half Throttle Power (CycleAnalyst) 210	240 310 450 600 710 762 867 1067 1345 1387 1633 Power (PowerTap) 0	48.2 55.0 64.1 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0 Efficiency 47.6 57.5
222 324 456 618 780 960 1080 1260 1476 2208 2616 48-volt supply Half Throttle Power (CycleAnalyst) 110 228	0 100 233 400 533 673 773 920 1100 1600 1810 Power (PowerTap) 117	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0% 74.5% 75.8% 72.5% 69.2%	498 564 702 876 1008 1188 1188 1416 1824 1496 2400 48-volt supply Half Throttle Power (CycleAnalyst) 210 348 522	240 310 450 600 710 762 867 1067 1387 1633 Power (PowerTap) 0 0 200 3333	48.2 55.0 64.1.1 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0 Efficiency 0.0 47.6 57.5
222 324 456 618 780 960 1080 1260 1476 12718 2208 48-volt supply Half Throttle Power (CycleAnalyst) 288 342	0 100 233 4400 533 673 773 920 1100 1500 1600 1810 Power (PowerTap) 0 117 2055	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 75.8% 69.2% Efficiency 0.0% 51.3% 59.9%	498 564 702 876 1008 1188 1188 1416 1824 1896 2400 48-volt supply Half Throttle Power (CycleAnalyst) 130 210 348 522 702	240 310 450 600 710 762 867 1067 1345 1387 1633 Power (PowerTap) 0 100 200 333 460	48.2 55.0 64.1.1 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0 Efficiency 0.0 47.6 57.5 63.8
222 324 456 618 780 960 1080 1260 1476 2208 2616 48-volt supply Half Throttle Power (CycleAnalyst) 228 342 480	0 100 233 4400 533 532 532 532 532 532 532 532 532 532	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0% 74.5% 69.2% Efficiency 0.0% 51.3% 59.9%	498 564 702 876 1008 1188 1188 1416 1824 1496 2400 48-volt supply Half Throttle Power (CycleAnalyst) 210 348 522	240 310 450 600 710 762 867 1067 1387 1633 Power (PowerTap) 0 0 200 3333	48.2 55.0 64.1: 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0 Efficiency 0.0' 47.6 57.5 63.8
222 324 456 618 780 960 1080 1260 1476 2208 48-veit supply Half Throttle Power (CycleAnalyst) 28 480 636	0 100 233 400 533 673 773 920 1100 1300 1810 Power (PowerTap) 0 117 205 317 433	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0% 74.5% 75.8% 72.5% 69.2%	498 564 702 876 1008 1188 1188 1416 1824 1896 2400 48-volt supply Half Throttle Power (CycleAnalyst) 130 210 348 522 702	240 310 450 600 710 762 867 1067 1345 1387 1633 Power (PowerTap) 0 100 200 333 460	48.2 55.0 64.1:1 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0 Efficiency 47.6 57.5 63.8 65.5 66.8
222 324 456 618 780 960 1080 1260 1476 2208 2616 48-volt supply Half Throttle Power (CycleAnalyst) 228 342 480 636 888	0 100 233 4400 533 673 773 920 1100 1300 1810 Power (PowerTap) 0 117 205 317 433 6600	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0% 74.5% 72.5% 69.2% Efficiency 0.0% 51.3% 59.9% 66.0% 68.1%	498 564 702 876 1008 1188 1188 1416 1824 1896 2400 48-volt supply Half Throttle Power (CycleAnalyst) 130 210 348 522 702	240 310 450 600 710 762 867 1067 1345 1387 1633 Power (PowerTap) 0 100 200 333 460	48.2 55.0 64.1: 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0 Efficiency 0.0' 47.6 57.5 63.8
222 324 456 618 780 960 1080 1260 1476 2208 48-veit supply Half Throttle Power (CycleAnalyst) 28 480 636	0 100 233 400 533 673 773 920 1100 1300 1810 Power (PowerTap) 0 117 205 317 433	0.0% 30.9% 51.1% 64.7% 68.3% 70.1% 71.6% 73.0% 74.5% 75.8% 72.5% 69.2%	498 564 702 876 1008 1188 1188 1416 1824 1896 2400 48-volt supply Half Throttle Power (CycleAnalyst) 130 210 348 522 702	240 310 450 600 710 762 867 1067 1345 1387 1633 Power (PowerTap) 0 100 200 333 460	48.2 55.0 64.1: 68.5 70.4 71.3 73.0 75.4 73.7 73.2 68.0 Efficiency 0.0' 47.6 57.5 63.8









Notes: Efficiency was measured by comparing energy drawn from the battery according to a Cycle Analyst and comparing that to energy sent to the rear wheel of the bicycle as read from a PowerTap hub. Motor power passes through a chain and sprocket (#25 chain; 11t - 901) to a mid-drive, which is then passed to the rear wheel using normal bicycle chain (15t - 34t). Efficiency of the two-stage chain and sprocket drive is probably around 93%-95%, so actual motor/controller efficiency is about 6.5% greater. The right-most markers indicate the maximum usable power.