ภาคผนวก ก

ข้อมูลที่ใช้สอนโครงข่ายประสาทเทียม

ก.1 ผลการ Simulation การทำงานของมอเตอร์ที่สภาวะการทำงานต่าง ๆ

การ Simulation การทำงานของมอเตอร์ที่สภาวะการทำงานต่าง ๆ ด้วยโปรแกรม MATLAB ทำให้ทราบค่าทางไฟฟ้าที่จุดทำงานนั้น ๆ ผลการ Simulation แสดงดังตารางที่ ก-1

ตารางที่ ก-1 ผลการ simulation การทำงานของมอเตอร์ที่สภาวะการทำงานต่าง ๆ

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
7.0191	230	50	4.60	0.057	2829	3.977	2.305	0.840	90.22
7.0391	225	50	4.50	0.060	2820	4.043	2.314	0.848	89.82
7.0341	220	50	4.40	0.063	2811	4.103	2.316	0.855	89.41
7.0056	215	50	4.30	0.066	2802	4.158	2.310	0.861	89.00
6.9550	210	50	4.20	0.069	2793	4.205	2.296	0.867	88.58
6.9681	205	50	4.10	0.073	2781	4.293	2.305	0.873	88.03
6.9513	200	50	4.00	0.078	2769	4.373	2.304	0.878	87.48
6.9384	207	45	4.60	0.063	2530	3.948	2.060	0.840	89.23
6.9261	202.5	45	4.50	0.066	2522	3.998	2.059	0.848	88.83
6.9820	198	45	4.40	0.070	2511	4.088	2.079	0.856	88.29
6.9233	193.5	45	4.30	0.073	2503	4.127	2.065	0.862	87.88
6.9255	189	45	4.20	0.077	2492	4.203	2.069	0.868	87.34
6.9752	184.5	45	4.10	0.082	2479	4.313	2.089	0.875	86.65
6.9901	180	45	4.00	0.087	2465	4.412	2.099	0.881	85.97
6.9786	184	40	4.60	0.072	2227	3.977	1.854	0.844	87.81

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
6.9213	172	40	4.30	0.083	2201	4.141	1.848	0.865	86.34
6.9507	168	40	4.20	0.088	2189	4.233	1.860	0.872	85.66
6.9493	164	40	4.10	0.093	2177	4.317	1.864	0.878	84.99
6.9793	160	40	4.00	0.099	2162	4.428	1.878	0.884	84.17
6.9560	161	35	4.60	0.083	1926	3.981	1.630	0.848	86.08
6.9401	157.5	35	4.50	0.087	1917	4.033	1.629	0.855	85.56
6.9688	154	35	4.40	0.092	1907	4.113	1.639	0.863	84.90
6.9694	150.5	35	4.30	0.097	1896	4.187	1.643	0.869	84.23
6.9436	147	35	4.20	0.102	1886	4.252	1.641	0.875	83.57
6.9478	143.5	35	4.10	0.108	1873	4.342	1.647	0.881	82.77
6.9725	140	35	4.00	0.115	1859	4.453	1.658	0.887	81.83
6.9887	138	30	4.60	0.099	1622	4.016	1.419	0.853	83.65
6.9804	135	30	4.50	0.104	1613	4.075	1.420	0.861	83.00
6.9460	132	30	4.40	0.109	1604	4.128	1.417	0.867	82.35
6.9470	129	30	4.30	0.115	1593	4.203	1.421	0.874	81.57
6.9183	126	30	4.20	0.121	1582	4.270	1.420	0.879	80.79
6.9095	123	30	4.10	0.128	1570	4.355	1.422	0.885	79.87
6.9131	120	30	4.00	0.136	1555	4.457	1.428	0.890	78.83
6.7929	230	50	4.60	0.055	2835	3.873	2.229	0.834	90.49
6.8249	225	50	4.50	0.058	2826	3.941	2.242	0.840	90.09
6.8315	220	50	4.40	0.061	2817	4.003	2.247	0.851	89.68
6.5652	230	50	4.60	0.053	2841	3.770	2.152	0.827	90.76
6.6092	225	50	4.50	0.056	2832	3.839	2.169	0.837	90.36
6.6275	220	50	4.40	0.059	2823	3.903	2.178	0.846	89.95
6.6215	215	50	4.30	0.062	2814	3.961	2.179	0.853	89.54
6.5925	210	50	4.20	0.065	2805	4.013	2.173	0.859	89.13

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
6.6277	205	50	4.10	0.069	2793	4.105	2.188	0.867	88.58
6.6323	200	50	4.00	0.073	2781	4.189	2.194	0.873	88.03
6.6364	207	45	4.60	0.060	2538	3.809	1.967	0.832	89.63
6.6400	202.5	45	4.50	0.063	2530	3.862	1.971	0.840	89.23
6.6217	198	45	4.40	0.066	2522	3.909	1.969	0.848	88.83
6.5827	193.5	45	4.30	0.069	2514	3.952	1.960	0.854	88.43
6.6050	189	45	4.20	0.073	2503	4.031	1.970	0.862	87.88
6.5996	184.5	45	4.10	0.077	2492	4.103	1.972	0.868	87.34
6.5681	180	45	4.00	0.081	2481	4.166	1.967	0.874	86.79
6.4508	230	50	4.60	0.052	2844	3.718	2.114	0.824	90.89
6.3920	225	50	4.50	0.054	2838	3.738	2.096	0.831	90.63
6.4220	220	50	4.40	0.057	2829	3.804	2.109	0.840	90.22
6.4273	215	50	4.30	0.060	2820	3.863	2.113	0.848	89.82
6.4092	210	50	4.20	0.063	2811	3.917	2.110	0.855	89.41
6.3691	205	50	4.10	0.066	2802	3.964	2.100	0.861	89.00
6.3898	200	50	4.00	0.070	2790	4.051	2.111	0.869	88.45
6.4335	207	45	4.60	0.058	2543	3.717	1.906	0.826	89.90
6.4477	202.5	45	4.50	0.061	2535	3.771	1.913	0.835	89.50
6.4396	198	45	4.40	0.064	2527	3.820	1.913	0.843	89.10
6.4106	193.5	45	4.30	0.067	2519	3.864	1.907	0.850	88.70
6.4431	189	45	4.20	0.071	2508	3.945	1.920	0.858	88.16
6.3710	184.5	45	4.10	0.074	2500	3.977	1.901	0.864	87.75
6.4254	180	45	4.00	0.079	2487	4.084	1.922	0.871	87.06
6.3614	184	40	4.60	0.065	2244	3.693	1.685	0.823	88.73
6.4269	180	40	4.50	0.069	2234	3.771	1.705	0.837	88.21
6.3850	176	40	4.40	0.072	2227	3.801	1.696	0.844	87.81

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
6.4008	172	40	4.30	0.076	2218	3.871	1.703	0.853	87.28
6.3917	168	40	4.20	0.080	2208	3.931	1.704	0.860	86.74
6.4256	164	40	4.10	0.085	2196	4.022	1.717	0.868	86.07
6.4291	160	40	4.00	0.090	2184	4.104	1.722	0.874	85.39
6.2207	230	50	4.60	0.050	2850	3.616	2.037	0.816	91.16
6.1734	225	50	4.50	0.052	2844	3.638	2.023	0.824	90.89
6.2151	220	50	4.40	0.055	2835	3.704	2.039	0.834	90.49
6.2317	215	50	4.30	0.058	2826	3.766	2.047	0.843	90.09
6.2246	210	50	4.20	0.061	2817	3.821	2.048	0.851	89.68
6.1951	205	50	4.10	0.064	2808	3.870	2.041	0.857	89.27
6.2266	200	50	4.00	0.068	2796	3.959	2.055	0.865	88.72
6.2292	207	45	4.60	0.056	2549	3.626	1.844	0.819	90.16
6.1568	202.5	45	4.50	0.058	2543	3.636	1.824	0.826	89.90
6.1643	198	45	4.40	0.061	2535	3.687	1.829	0.835	89.50
6.2373	193.5	45	4.30	0.065	2525	3.777	1.853	0.845	88.97
6.1981	189	45	4.20	0.068	2516	3.817	1.844	0.852	88.56
6.2172	184.5	45	4.10	0.072	2506	3.893	1.853	0.860	88.02
6.2093	180	45	4.00	0.076	2495	3.962	1.855	0.867	87.47
6.1825	184	40	4.60	0.063	2249	3.612	1.636	0.821	88.99
6.1730	180	40	4.50	0.066	2242	3.652	1.635	0.829	88.60
6.2249	176	40	4.40	0.070	2232	3.726	1.652	0.840	88.08
6.1741	172	40	4.30	0.073	2225	3.756	1.641	0.847	87.68
6.1782	168	40	4.20	0.077	2215	3.819	1.645	0.855	87.14
6.2255	164	40	4.10	0.082	2203	3.911	1.661	0.863	86.47
6.1790	160	40	4.00	0.086	2194	3.960	1.652	0.869	85.93
6.2000	161	35	4.60	0.073	1947	3.629	1.446	0.825	87.38

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
6.2254	157.5	35	4.50	0.077	1938	3.687	1.455	0.835	86.87
6.2276	154	35	4.40	0.081	1930	3.740	1.458	0.844	86.34
6.2080	150.5	35	4.30	0.085	1922	3.787	1.456	0.851	85.82
6.2286	147	35	4.20	0.090	1911	3.861	1.464	0.860	85.16
6.2226	143.5	35	4.10	0.095	1901	3.928	1.466	0.867	84.50
6.1917	140	35	4.00	0.100	1890	3.988	1.462	0.873	83.83
5.9891	230	50	4.60	0.048	2856	3.515	1.959	0.808	91.42
5.9532	225	50	4.50	0.050	2850	3.538	1.949	0.816	91.16
6.0067	220	50	4.40	0.053	2841	3.606	1.969	0.827	90.76
6.0348	215	50	4.30	0.056	2832	3.669	1.981	0.837	90.36
6.0387	210	50	4.20	0.059	2823	3.726	1.985	0.846	89.95
6.0198	205	50	4.10	0.062	2814	3.777	1.981	0.853	89.54
5.9796	200	50	4.00	0.065	2805	3.822	1.971	0.859	89.13
6.0236	207	45	4.60	0.054	2554	3.535	1.782	0.812	90.42
5.9613	202.5	45	4.50	0.056	2549	3.547	1.765	0.819	90.16
5.9792	198	45	4.40	0.059	2541	3.599	1.772	0.829	89.77
5.9752	193.5	45	4.30	0.062	2533	3.647	1.773	0.838	89.37
6.0334	189	45	4.20	0.066	2522	3.732	1.794	0.848	88.83
5.9846	184.5	45	4.10	0.069	2514	3.768	1.782	0.854	88.43
5.9910	180	45	4.00	0.073	2503	3.839	1.787	0.862	87.88
6.0025	184	40	4.60	0.061	2254	3.532	1.587	0.814	89.25
6.0023	180	40	4.50	0.064	2246	3.573	1.589	0.824	88.86
5.9828	176	40	4.40	0.067	2239	3.609	1.586	0.832	88.47
6.0217	172	40	4.30	0.071	2230	3.679	1.599	0.842	87.94
6.0347	168	40	4.20	0.075	2220	3.743	1.605	0.851	87.41
6.0234	164	40	4.10	0.079	2210	3.801	1.605	0.858	86.88

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
5.9892	160	40	4.00	0.083	2201	3.852	1.599	0.865	86.34
5.9687	161	35	4.60	0.070	1953	3.525	1.391	0.817	87.76
6.0067	157.5	35	4.50	0.074	1945	3.585	1.402	0.828	87.25
6.0210	154	35	4.40	0.078	1936	3.639	1.408	0.837	86.74
6.0131	150.5	35	4.30	0.082	1928	3.688	1.408	0.8456	86.21
5.9842	147	35	4.20	0.086	1919	3.732	1.404	0.853	85.69
5.9933	143.5	35	4.10	0.091	1909	3.801	1.409	0.861	85.03
5.9769	140	35	4.00	0.096	1898	3.863	1.408	0.868	84.36
5.9807	138	30	4.60	0.083	1651	3.542	1.206	0.823	85.69
6.0297	135	30	4.50	0.088	1642	3.609	1.219	0.834	85.06
5.9959	132	30	4.40	0.092	1634	3.642	1.214	0.842	84.55
5.9990	129	30	4.30	0.097	1625	3.699	1.217	0.850	83.91
5.9793	126	30	4.20	0.102	1616	3.749	1.216	0.858	83.26
5.9861	123	30	4.10	0.108	1606	3.820	1.220	0.866	82.48
6.0115	120	30	4.00	0.115	1593	3.910	1.229	0.874	81.57
5.756	230	50	4.60	0.046	2862	3.414	1.882	0.799	91.68
5.8426	225	50	4.50	0.049	2853	3.488	1.912	0.812	91.29
5.7970	220	50	4.40	0.051	2847	3.508	1.899	0.820	91.03
5.8365	215	50	4.30	0.054	2838	3.572	1.914	0.831	90.63
5.7574	210	50	4.20	0.056	2832	3.583	1.890	0.837	90.36
5.8433	205	50	4.10	0.060	2820	3.684	1.921	0.848	89.82
5.8133	200	50	4.00	0.063	2811	3.730	1.914	0.855	89.41
5.8166	207	45	4.60	0.052	2560	3.445	1.719	0.804	90.68
5.7645	202.5	45	4.50	0.054	2554	3.458	1.705	0.812	90.42
5.7929	198	45	4.40	0.057	2546	3.512	1.716	0.823	90.03
5.7990	193.5	45	4.30	0.060	2538	3.561	1.720	0.832	89.63

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
5.7842	189	45	4.20	0.063	2530	3.604	1.717	0.840	89.23
5.8281	184.5	45	4.10	0.067	2519	3.684	1.733	0.850	88.70
5.7703	180	45	4.00	0.070	2511	3.717	1.719	0.856	88.29
5.8214	184	40	4.60	0.059	2258	3.452	1.538	0.807	89.51
5.8306	180	40	4.50	0.062	2251	3.494	1.542	0.817	89.12
5.8202	176	40	4.40	0.065	2244	3.532	1.541	0.827	88.73
5.7913	172	40	4.30	0.068	2237	3.565	1.536	0.835	88.34
5.8177	168	40	4.20	0.072	2227	3.631	1.545	0.844	87.81
5.8193	164	40	4.10	0.076	2218	3.691	1.548	0.853	87.28
5.7975	160	40	4.00	0.080	2208	3.744	1.545	0.860	86.74
5.8134	161	35	4.60	0.068	1957	3.456	1.354	0.811	88.02
5.7860	157.5	35	4.50	0.071	1951	3.483	1.349	0.820	87.64
5.8126	154	35	4.40	0.075	1943	3.538	1.357	0.830	87.12
5.8164	150.5	35	4.30	0.079	1934	3.589	1.360	0.839	86.61
5.7988	147	35	4.20	0.083	1926	3.634	1.358	0.848	86.08
5.8194	143.5	35	4.10	0.088	1915	3.706	1.366	0.856	85.42
5.8140	140	35	4.00	0.093	1905	3.770	1.368	0.864	84.76
5.6389	230	50	4.60	0.045	2865	3.364	1.843	0.794	91.80
5.6202	225	50	4.50	0.047	2859	3.389	1.838	0.803	91.55
5.5858	220	50	4.40	0.049	2853	3.410	1.828	0.812	91.29
5.6368	215	50	4.30	0.052	2844	3.476	1.847	0.824	90.89
5.5682	210	50	4.20	0.054	2838	3.489	1.826	0.831	90.63
5.5761	205	50	4.10	0.057	2829	3.544	1.831	0.840	90.22
5.5617	200	50	4.00	0.060	2820	3.594	1.829	0.848	89.82
5.6084	207	45	4.60	0.050	2565	3.355	1.657	0.795	90.93
5.5665	202.5	45	4.50	0.052	2560	3.370	1.645	0.804	90.68

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
5.6054	198	45	4.40	0.055	2552	3.425	1.659	0.816	90.29
5.6217	193.5	45	4.30	0.058	2543	3.475	1.666	0.826	89.90
5.6166	189	45	4.20	0.061	2535	3.520	1.666	0.835	89.50
5.5914	184.5	45	4.10	0.064	2527	3.560	1.661	0.843	89.10
5.6219	180	45	4.00	0.068	2516	3.635	1.673	0.852	88.56
5.6392	184	40	4.60	0.057	2263	3.373	1.489	0.800	89.76
5.5711	180	40	4.50	0.059	2258	3.377	1.472	0.807	89.51
5.5744	176	40	4.40	0.062	2251	3.417	1.475	0.817	89.12
5.6365	172	40	4.30	0.066	2242	3.489	1.493	0.829	88.60
5.5986	168	40	4.20	0.069	2234	3.519	1.485	0.837	88.21
5.6131	164	40	4.10	0.073	2225	3.581	1.492	0.847	87.68
5.6038	160	40	4.00	0.077	2215	3.637	1.492	0.855	87.14
5.5787	161	35	4.60	0.065	1964	3.354	1.298	0.801	88.39
5.5634	157.5	35	4.50	0.068	1957	3.381	1.296	0.811	88.02
5.6022	154	35	4.40	0.072	1949	3.438	1.307	0.823	87.51
5.6179	150.5	35	4.30	0.076	1940	3.491	1.312	0.833	86.99
5.6118	147	35	4.20	0.080	1932	3.538	1.313	0.842	86.48
5.5850	143.5	35	4.10	0.084	1924	3.579	1.309	0.849	85.95
5.5944	140	35	4.00	0.089	1913	3.647	1.314	0.858	85.29
5.4035	230	50	4.60	0.043	2871	3.265	1.765	0.783	92.06
5.3964	225	50	4.50	0.045	2865	3.291	1.764	0.794	91.80
5.3732	220	50	4.40	0.047	2859	3.314	1.757	0.803	91.55
5.4358	215	50	4.30	0.050	2850	3.380	1.780	0.816	91.16
5.3777	210	50	4.20	0.052	2844	3.395	1.762	0.824	90.89
5.3965	205	50	4.10	0.055	2835	3.452	1.770	0.834	90.49
5.3925	200	50	4.00	0.058	2826	3.503	1.771	0.843	90.09

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
5.3989	207	45	4.60	0.048	2570	3.267	1.594	0.786	91.18
5.3672	202.5	45	4.50	0.050	2565	3.282	1.585	0.795	90.93
5.4167	198	45	4.40	0.053	2557	3.338	1.602	0.808	90.55
5.4432	193.5	45	4.30	0.056	2549	3.389	1.611	0.819	90.16
5.3633	189	45	4.20	0.058	2543	3.394	1.589	0.826	89.90
5.4323	184.5	45	4.10	0.062	2533	3.477	1.612	0.838	89.37
5.3974	180	45	4.00	0.065	2525	3.514	1.604	0.843	88.97
5.3639	184	40	4.60	0.054	2270	3.256	1.415	0.787	90.13
5.3967	180	40	4.50	0.057	2263	3.300	1.425	0.800	89.76
5.4092	176	40	4.40	0.060	2256	3.340	1.430	0.811	89.38
5.4024	172	40	4.30	0.063	2249	3.376	1.430	0.821	88.99
5.3773	168	40	4.20	0.066	2242	3.408	1.425	0.829	88.60
5.4050	164	40	4.10	0.070	2232	3.472	1.434	0.840	88.08
5.4083	160	40	4.00	0.074	2222	3.530	1.438	0.849	87.55
5.4210	161	35	4.60	0.063	1968	3.286	1.260	0.794	88.64
5.4138	157.5	35	4.50	0.066	1961	3.314	1.260	0.805	88.27
5.3900	154	35	4.40	0.069	1955	3.339	1.256	0.814	87.89
5.4176	150.5	35	4.30	0.073	1947	3.393	1.264	0.825	87.38
5.4230	147	35	4.20	0.077	1938	3.441	1.267	0.835	86.87
5.4073	143.5	35	4.10	0.081	1930	3.485	1.266	0.844	86.34
5.4278	140	35	4.00	0.086	1919	3.554	1.273	0.853	85.69
5.3931	138	30	4.60	0.074	1667	3.282	1.084	0.798	86.81
5.4128	135	30	4.50	0.078	1660	3.323	1.090	0.810	86.31
5.4128	132	30	4.40	0.082	1652	3.360	1.091	0.820	85.82
5.3943	129	30	4.30	0.086	1645	3.394	1.089	0.830	85.31
5.4108	126	30	4.20	0.091	1636	3.450	1.095	0.840	84.68

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
5.4046	123	30	4.10	0.096	1627	3.500	1.096	0.849	84.03
5.3772	120	30	4.00	0.101	1618	3.544	1.093	0.856	83.39
5.1665	230	50	4.60	0.041	2877	3.168	1.686	0.772	92.30
5.1711	225	50	4.50	0.043	2871	3.194	1.689	0.783	92.06
5.1592	220	50	4.40	0.045	2865	3.218	1.686	0.794	91.80
5.2334	215	50	4.30	0.048	2856	3.286	1.712	0.808	91.42
5.1859	210	50	4.20	0.050	2850	3.302	1.698	0.816	91.16
5.2156	205	50	4.10	0.053	2841	3.360	1.710	0.827	90.76
5.2221	200	50	4.00	0.056	2832	3.413	1.714	0.837	90.36
5.1880	207	45	4.60	0.046	2576	3.179	1.531	0.775	91.43
5.1667	202.5	45	4.50	0.048	2570	3.196	1.525	0.786	91.18
5.2267	198	45	4.40	0.051	2562	3.252	1.544	0.800	90.81
5.1732	193.5	45	4.30	0.053	2557	3.262	1.530	0.808	90.55
5.1929	189	45	4.20	0.056	2549	3.310	1.537	0.819	90.16
5.1916	184.5	45	4.10	0.059	2541	3.354	1.539	0.829	89.77
5.1706	180	45	4.00	0.062	2533	3.392	1.534	0.838	89.37
5.1789	184	40	4.60	0.052	2275	3.179	1.365	0.778	90.38
5.2213	180	40	4.50	0.055	2268	3.223	1.378	0.792	90.01
5.1595	176	40	4.40	0.057	2263	3.227	1.362	0.800	89.76
5.1661	172	40	4.30	0.060	2256	3.264	1.366	0.811	89.38
5.2287	168	40	4.20	0.064	2246	3.335	1.384	0.824	88.86
5.1948	164	40	4.10	0.067	2239	3.363	1.377	0.832	88.47
5.2108	160	40	4.00	0.071	2230	3.423	1.383	0.842	87.94
5.1829	161	35	4.60	0.060	1974	3.185	1.204	0.782	89.01
5.1879	157.5	35	4.50	0.063	1968	3.215	1.206	0.794	88.64
5.1759	154	35	4.40	0.066	1961	3.241	1.204	0.805	88.27

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
5.2155	150.5	35	4.30	0.070	1953	3.295	1.215	0.817	87.86
5.1686	147	35	4.20	0.073	1947	3.314	1.206	0.825	87.38
5.2280	143.5	35	4.10	0.078	1936	3.391	1.222	0.837	86.74
5.2033	140	35	4.00	0.082	1928	3.341	1.218	0.846	86.21
5.1939	138	30	4.60	0.071	1672	3.196	1.043	0.789	87.17
5.2243	135	30	4.50	0.075	1665	3.238	1.051	0.801	86.68
5.1749	132	30	4.40	0.078	1660	3.249	1.042	0.810	86.31
5.2260	129	30	4.30	0.083	1651	3.311	1.054	0.823	85.69
5.1995	126	30	4.20	0.087	1643	3.342	1.050	0.832	85.19
5.2062	123	30	4.10	0.092	1634	3.394	1.054	0.842	84.55
5.1911	120	30	4.00	0.097	1625	3.440	1.053	0.850	83.91
5.0475	230	50	4.60	0.040	2880	3.119	1.647	0.765	92.43
4.9443	225	50	4.50	0.041	2877	3.099	1.614	0.772	92.30
5.0517	220	50	4.40	0.044	2868	3.171	1.650	0.789	91.93
5.0297	215	50	4.30	0.046	2862	3.192	1.644	0.799	91.68
4.9928	210	50	4.20	0.048	2856	3.209	1.633	0.808	91.42
5.0334	205	50	4.10	0.051	2847	3.269	1.649	0.820	91.03
4.9642	200	50	4.00	0.053	2841	3.278	1.627	0.827	90.76
4.9759	207	45	4.60	0.044	2581	3.093	1.467	0.764	91.67
4.9649	202.5	45	4.50	0.046	2576	3.110	1.465	0.775	91.43
5.0356	198	45	4.40	0.049	2568	3.167	1.487	0.791	91.06
4.9918	193.5	45	4.30	0.051	2562	3.178	1.475	0.800	90.81
5.0215	189	45	4.20	0.054	2554	3.227	1.485	0.812	90.42
5.0299	184.5	45	4.10	0.057	2546	3.272	1.490	0.823	90.03
5.0181	180	45	4.00	0.060	2538	3.312	1.488	0.832	89.63
4.9929	184	40	4.60	0.050	2280	3.102	1.316	0.768	90.62

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
4.9562	180	40	4.50	0.052	2275	3.110	1.307	0.778	90.38
4.9918	176	40	4.40	0.055	2268	3.152	1.317	0.792	90.01
5.0074	172	40	4.30	0.058	2261	3.190	1.323	0.803	89.63
5.0040	168	40	4.20	0.061	2254	3.225	1.323	0.814	89.25
4.9827	164	40	4.10	0.064	2246	3.255	1.319	0.824	88.86
5.0114	160	40	4.00	0.068	2237	3.317	1.329	0.835	88.34
5.0230	161	35	4.60	0.058	1978	3.119	1.166	0.774	89.25
5.0362	157.5	35	4.50	0.061	1972	3.149	1.170	0.786	88.89
5.0321	154	35	4.40	0.064	1966	3.175	1.170	0.798	88.52
5.0117	150.5	35	4.30	0.067	1959	3.199	1.167	0.808	88.14
4.9758	147	35	4.20	0.070	1953	3.219	1.160	0.817	87.76
4.9863	143.5	35	4.10	0.074	1945	3.266	1.164	0.828	87.25
5.0331	140	35	4.00	0.079	1934	3.339	1.177	0.839	86.61
5.0602	138	30	4.60	0.069	1676	3.140	1.016	0.782	87.41
4.9705	135	30	4.50	0.071	1672	3.127	0.999	0.789	87.17
4.9947	132	30	4.40	0.075	1665	3.166	1.005	0.801	86.68
4.9994	129	30	4.30	0.079	1658	3.202	1.007	0.813	86.19
4.9858	126	30	4.20	0.083	1651	3.234	1.006	0.823	85.69
5.0054	123	30	4.10	0.088	1642	3.288	1.012	0.834	85.06
5.0028	120	30	4.00	0.093	1633	3.337	1.013	0.843	84.42
4.8084	230	50	4.60	0.038	2886	3.024	1.568	0.752	92.67
4.8305	225	50	4.50	0.040	2880	3.052	1.576	0.765	92.43
4.8356	220	50	4.40	0.042	2874	3.077	1.579	0.778	92.18
4.8247	215	50	4.30	0.044	2868	3.099	1.576	0.789	91.93
4.7985	210	50	4.20	0.046	2862	3.117	1.569	0.799	91.68
4.7579	205	50	4.10	0.048	2856	3.133	1.557	0.808	91.42

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
4.7909	200	50	4.00	0.051	2847	3.189	1.569	0.820	91.03
4.7625	207	45	4.60	0.042	2587	3.007	1.404	0.752	91.91
4.7619	202.5	45	4.50	0.044	2581	3.025	1.404	0.764	91.67
4.8433	198	45	4.40	0.047	2573	3.083	1.429	0.781	91.31
4.8093	193.5	45	4.30	0.049	2568	3.095	1.420	0.791	91.06
4.7624	189	45	4.20	0.051	2562	3.104	1.407	0.800	90.81
4.7853	184.5	45	4.10	0.054	2554	3.151	1.416	0.816	90.42
4.7875	180	45	4.00	0.057	2546	3.192	1.418	0.823	90.03
4.8057	184	40	4.60	0.048	2285	3.027	1.266	0.757	90.86
4.7781	180	40	4.50	0.050	2280	3.035	1.259	0.768	90.62
4.8231	176	40	4.40	0.053	2273	3.078	1.272	0.783	90.26
4.7675	172	40	4.30	0.055	2268	3.080	1.258	0.792	90.01
4.7772	168	40	4.20	0.058	2261	3.116	1.262	0.803	89.63
4.7685	164	40	4.10	0.061	2254	3.148	1.261	0.814	89.25
4.8101	160	40	4.00	0.065	2244	3.211	1.274	0.827	88.73
4.7815	161	35	4.60	0.055	1985	3.020	1.109	0.760	89.60
4.8070	157.5	35	4.50	0.058	1978	3.051	1.116	0.774	89.25
4.8149	154	35	4.40	0.061	1972	3.079	1.119	0.786	88.89
4.8060	150.5	35	4.30	0.064	1966	3.103	1.118	0.798	88.52
4.7813	147	35	4.20	0.067	1959	3.125	1.113	0.808	88.14
4.8031	143.5	35	4.10	0.071	1951	3.173	1.120	0.820	87.64
4.8038	140	35	4.00	0.075	1943	3.217	1.122	0.830	87.12
4.7906	138	30	4.60	0.065	1683	3.028	0.961	0.766	87.88
4.7783	135	30	4.50	0.068	1678	3.044	0.959	0.778	87.53
4.8130	132	30	4.40	0.072	1670	3.084	0.967	0.792	87.05
4.8278	129	30	4.30	0.076	1663	3.121	0.971	0.804	86.56

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
4.8239	126	30	4.20	0.080	1656	3.154	0.972	0.815	86.07
4.8023	123	30	4.10	0.084	1649	3.183	0.969	0.825	85.57
4.8122	120	30	4.00	0.089	1640	3.234	0.973	0.836	84.93
4.5677	230	50	4.60	0.036	2892	2.930	1.489	0.737	92.90
4.6016	225	50	4.50	0.038	2886	2.958	1.501	0.752	92.67
4.6182	220	50	4.40	0.040	2880	2.984	1.507	0.765	92.43
4.6183	215	50	4.30	0.042	2874	3.007	1.508	0.778	92.18
4.6029	210	50	4.20	0.044	2868	3.027	1.504	0.789	91.93
4.5727	205	50	4.10	0.046	2862	3.043	1.495	0.799	91.68
4.6163	200	50	4.00	0.049	2853	3.100	1.511	0.812	91.29
4.5478	207	45	4.60	0.040	2592	2.923	1.340	0.738	92.14
4.5577	202.5	45	4.50	0.042	2587	2.942	1.343	0.752	91.91
4.5526	198	45	4.40	0.044	2581	2.958	1.342	0.764	91.67
4.6256	193.5	45	4.30	0.047	2573	3.013	1.365	0.781	91.31
4.5882	189	45	4.20	0.049	2568	3.023	1.355	0.791	91.06
4.6209	184.5	45	4.10	0.052	2560	3.070	1.366	0.804	90.68
4.6325	180	45	4.00	0.055	2552	3.113	1.371	0.816	90.29
4.6175	184	40	4.60	0.046	2290	2.952	1.215	0.746	91.09
4.5991	180	40	4.50	0.048	2285	2.961	1.211	0.757	90.86
4.5681	176	40	4.40	0.050	2280	2.968	1.204	0.768	90.62
4.6063	172	40	4.30	0.053	2273	3.008	1.215	0.783	90.26
4.6248	168	40	4.20	0.056	2266	3.044	1.221	0.796	89.89
4.6247	164	40	4.10	0.059	2258	3.077	1.222	0.807	89.51
4.6069	160	40	4.00	0.062	2251	3.106	1.219	0.817	89.12
4.6193	161	35	4.60	0.053	1989	2.956	1.071	0.750	89.83
4.5759	157.5	35	4.50	0.055	1984	2.955	1.061	0.760	89.60

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
4.5957	154	35	4.40	0.058	1978	2.983	1.067	0.774	89.25
4.5985	150.5	35	4.30	0.061	1972	3.009	1.068	0.786	88.89
4.5850	147	35	4.20	0.064	1966	3.031	1.066	0.798	88.52
4.6183	143.5	35	4.10	0.068	1957	3.081	1.075	0.811	88.02
4.5716	140	35	4.00	0.071	1951	3.096	1.066	0.820	87.64
4.5864	138	30	4.60	0.062	1688	2.946	0.919	0.754	88.22
4.5846	135	30	4.50	0.065	1683	2.962	0.919	0.766	87.88
4.6297	132	30	4.40	0.069	1676	3.003	0.930	0.782	87.41
4.5967	129	30	4.30	0.072	1670	3.014	0.924	0.792	87.05
4.6058	126	30	4.20	0.076	1663	3.049	0.927	0.804	86.56
4.5969	123	30	4.10	0.080	1656	3.079	0.926	0.815	86.07
4.6194	120	30	4.00	0.085	1647	3.131	0.933	0.827	85.44
4.4469	230	50	4.60	0.035	2895	2.884	1.449	0.729	93.01
4.3713	225	50	4.50	0.036	2892	2.866	1.425	0.737	92.90
4.3993	220	50	4.40	0.038	2886	2.892	1.435	0.752	92.67
4.4106	215	50	4.30	0.040	2880	2.916	1.439	0.765	92.43
4.4060	210	50	4.20	0.042	2874	2.937	1.439	0.778	92.18
4.3863	205	50	4.10	0.044	2868	2.955	1.433	0.789	91.93
4.4406	200	50	4.00	0.047	2859	3.013	1.452	0.803	91.55
4.4400	207	45	4.60	0.039	2595	2.882	1.308	0.731	92.25
4.3522	202.5	45	4.50	0.040	2592	2.860	1.282	0.738	92.14
4.3574	198	45	4.40	0.042	2587	2.877	1.284	0.752	91.91
4.4408	193.5	45	4.30	0.045	2579	2.931	1.310	0.770	91.55
4.4130	189	45	4.20	0.047	2573	2.943	1.302	0.781	91.31
4.3723	184.5	45	4.10	0.049	2568	2.951	1.291	0.791	91.06
4.3982	180	45	4.00	0.052	2560	2.995	1.300	0.804	90.68

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
4.4282	184	40	4.60	0.044	2294	2.879	1.165	0.733	91.32
4.4189	180	40	4.50	0.046	2290	2.888	1.163	0.746	91.09
4.3969	176	40	4.40	0.048	2285	2.895	1.158	0.757	90.86
4.3629	172	40	4.30	0.050	2280	2.900	1.150	0.768	90.62
4.3946	168	40	4.20	0.053	2273	2.938	1.159	0.783	90.26
4.4072	164	40	4.10	0.056	2266	2.972	1.163	0.769	89.89
4.4018	160	40	4.00	0.059	2258	3.002	1.163	0.807	89.51
4.3744	161	35	4.60	0.050	1995	2.860	1.014	0.734	90.17
4.4207	157.5	35	4.50	0.053	1989	2.891	1.025	0.750	89.83
4.3748	154	35	4.40	0.055	1985	2.889	1.015	0.760	89.60
4.3892	150.5	35	4.30	0.058	1978	2.915	1.019	0.774	89.25
4.3871	147	35	4.20	0.061	1972	2.939	1.019	0.786	88.89
4.3693	143.5	35	4.10	0.064	1966	2.959	1.016	0.798	88.52
4.3957	140	35	4.00	0.068	1957	3.006	1.024	0.811	88.02
4.3807	138	30	4.60	0.059	1694	2.865	0.877	0.740	88.56
4.3892	135	30	4.50	0.062	1688	2.882	0.880	0.754	88.22
4.3831	132	30	4.40	0.065	1683	2.897	0.879	0.766	87.88
4.4217	129	30	4.30	0.069	1676	2.935	0.888	0.782	87.41
4.3854	126	30	4.20	0.072	1670	2.944	0.881	0.792	87.05
4.3891	123	30	4.10	0.076	1663	2.976	0.883	0.804	86.56
4.4245	120	30	4.00	0.081	1654	3.030	0.892	0.818	85.94
4.2041	230	50	4.60	0.033	2901	2.793	1.370	0.711	93.23
4.2556	225	50	4.50	0.035	2895	2.821	1.387	0.729	93.01
4.1792	220	50	4.40	0.036	2892	2.802	1.362	0.737	92.90
4.2016	215	50	4.30	0.038	2886	2.827	1.370	0.752	92.67
4.2079	210	50	4.20	0.040	2880	2.848	1.373	0.765	92.43

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
4.1987	205	50	4.10	0.042	2874	2.867	1.371	0.778	92.18
4.1749	200	50	4.00	0.044	2868	2.882	1.364	0.789	91.93
4.2234	207	45	4.60	0.037	2600	2.800	1.244	0.715	92.47
4.2490	202.5	45	4.50	0.039	2595	2.819	1.252	0.731	92.25
4.1609	198	45	4.40	0.040	2592	2.796	1.226	0.738	92.14
4.1615	193.5	45	4.30	0.042	2584	2.851	1.254	0.758	91.79
4.2367	189	45	4.20	0.045	2579	2.863	1.250	0.770	91.55
4.2054	184.5	45	4.10	0.047	2573	2.873	1.241	0.781	91.31
4.1617	180	45	4.00	0.049	2568	2.879	1.229	0.791	91.06
4.2378	184	40	4.60	0.042	2299	2.807	1.115	0.720	91.53
4.2378	180	40	4.50	0.044	2294	2.816	1.115	0.733	91.32
4.2247	176	40	4.40	0.046	2290	2.824	1.112	0.746	91.09
4.1993	172	40	4.30	0.048	2285	2.829	1.106	0.757	90.86
4.1623	168	40	4.20	0.050	2280	2.833	1.097	0.768	90.62
4.1878	164	40	4.10	0.053	2273	2.868	1.104	0.783	90.26
4.1949	160	40	4.00	0.056	2266	2.899	1.107	0.796	89.89
4.2100	161	35	4.60	0.048	1999	2.797	0.975	0.722	90.39
4.1863	157.5	35	4.50	0.050	1995	2.798	0.970	0.734	90.17
4.2264	154	35	4.40	0.053	1989	2.827	0.980	0.750	89.83
4.1782	150.5	35	4.30	0.055	1985	2.823	0.969	0.760	89.60
4.1874	147	35	4.20	0.058	1978	2.848	0.972	0.774	89.25
4.1807	143.5	35	4.10	0.061	1972	2.869	0.971	0.786	88.89
4.2183	140	35	4.00	0.065	1964	2.916	0.981	0.801	88.39
4.1732	138	30	4.60	0.056	1699	2.785	0.836	0.725	88.88
4.1923	135	30	4.50	0.059	1694	2.803	0.840	0.740	88.56
4.1963	132	30	4.40	0.062	1688	2.818	0.841	0.754	88.22

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
4.1861	129	30	4.30	0.065	1683	2.831	0.840	0.766	87.88
4.2184	126	30	4.20	0.069	1676	2.867	0.847	0.782	87.41
4.1790	123	30	4.10	0.072	1670	2.874	0.840	0.792	87.05
4.1776	120	30	4.00	0.076	1663	2.904	0.841	0.804	86.56
3.9598	230	50	4.60	0.031	2907	2.704	1.290	0.692	93.44
4.0233	225	50	4.50	0.033	2901	2.732	1.311	0.712	93.23
3.9577	220	50	4.40	0.034	2898	2.714	1.290	0.720	93.12
3.9914	215	50	4.30	0.036	2892	2.739	1.301	0.737	92.90
4.0085	210	50	4.20	0.038	2886	2.761	1.307	0.752	92.67
4.0099	205	50	4.10	0.040	2880	2.780	1.308	0.765	92.43
3.9964	200	50	4.00	0.042	2874	2.797	1.305	0.778	92.18
4.0055	207	45	4.60	0.035	2606	2.701	1.179	0.698	92.68
4.0418	202.5	45	4.50	0.037	2600	2.740	1.190	0.715	92.47
3.9633	198	45	4.40	0.038	2597	2.717	1.167	0.723	92.37
3.9739	193.5	45	4.30	0.040	2592	2.733	1.171	0.738	92.14
3.9702	189	45	4.20	0.042	2587	2.746	1.170	0.752	91.91
4.0374	184.5	45	4.10	0.045	2576	2.795	1.191	0.770	91.55
4.0027	180	45	4.00	0.047	2573	2.803	1.181	0.781	91.31
4.0464	184	40	4.60	0.040	2304	2.736	1.064	0.705	91.75
3.9641	180	40	4.50	0.041	2302	2.711	1.043	0.712	91.64
3.9645	176	40	4.40	0.043	2297	2.719	1.043	0.727	91.43
4.0349	172	40	4.30	0.046	2290	2.760	1.062	0.746	91.09
4.0063	168	40	4.20	0.048	2285	2.764	1.055	0.757	90.86
3.9664	164	40	4.10	0.050	2280	2.765	1.045	0.768	90.62
3.9860	160	40	4.00	0.053	2273	2.798	1.051	0.783	90.26
3.9617	161	35	4.60	0.045	2006	2.706	0.917	0.702	90.70

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
4.0289	157.5	35	4.50	0.048	1999	2.737	0.933	0.722	90.39
4.0023	154	35	4.40	0.050	1995	2.736	0.927	0.734	90.17
3.9653	150.5	35	4.30	0.052	1991	2.733	0.919	0.745	89.95
3.9861	147	35	4.20	0.055	1985	2.758	0.924	0.760	89.60
3.9904	143.5	35	4.10	0.058	1978	2.780	0.926	0.774	89.25
3.9792	140	35	4.00	0.061	1972	2.799	0.924	0.786	88.89
4.0340	138	30	4.60	0.054	1703	2.733	0.807	0.714	89.09
3.9937	135	30	4.50	0.056	1699	2.725	0.800	0.725	88.88
4.0080	132	30	4.40	0.059	1694	2.740	0.803	0.740	88.56
4.0077	129	30	4.30	0.062	1688	2.754	0.803	0.754	88.22
3.9937	126	30	4.20	0.065	1683	2.765	0.801	0.766	87.88
4.0199	123	30	4.10	0.069	1676	2.799	0.807	0.782	87.41
3.9777	120	30	4.00	0.072	1670	2.804	0.799	0.792	87.05
3.8371	230	50	4.60	0.030	2910	2.660	1.250	0.681	93.54
3.7895	225	50	4.50	0.031	2907	2.645	1.235	0.692	93.44
3.8464	220	50	4.40	0.033	2901	2.671	1.253	0.711	93.23
3.7798	215	50	4.30	0.034	2898	2.653	1.232	0.720	93.12
3.8079	210	50	4.20	0.036	2892	2.675	1.241	0.737	92.90
3.8199	205	50	4.10	0.038	2886	2.695	1.246	0.752	92.67
3.8167	200	50	4.00	0.040	2880	2.713	1.245	0.765	92.43
3.7865	207	45	4.60	0.033	2611	2.643	1.115	0.679	92.88
3.8333	202.5	45	4.50	0.035	2606	2.661	1.129	0.698	92.63
3.7646	198	45	4.40	0.036	2603	2.640	1.108	0.707	92.58
3.7852	193.5	45	4.30	0.038	2597	2.656	1.115	0.723	92.37
3.7913	189	45	4.20	0.040	2592	2.669	1.117	0.738	92.14
3.7834	184.5	45	4.10	0.042	2587	2.681	1.115	0.752	91.91

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
3.7625	180	45	4.00	0.044	2581	2.689	1.109	0.764	91.67
3.7572	184	40	4.60	0.037	2311	2.632	0.988	0.680	92.04
3.7803	180	40	4.50	0.039	2306	2.642	0.994	0.697	91.85
3.7899	176	40	4.40	0.041	2302	2.651	0.997	0.712	91.64
3.7864	172	40	4.30	0.043	2297	2.657	0.996	0.727	91.43
3.7706	168	40	4.20	0.045	2292	2.662	0.992	0.740	91.20
3.8178	164	40	4.10	0.048	2285	2.698	1.005	0.757	90.86
3.7753	160	40	4.00	0.050	2280	2.698	0.995	0.768	90.62
3.7950	161	35	4.60	0.043	2010	2.646	0.879	0.688	90.90
3.7913	157.5	35	4.50	0.045	2006	2.647	0.878	0.702	90.70
3.7763	154	35	4.40	0.047	2001	2.646	0.875	0.715	90.49
3.8224	150.5	35	4.30	0.050	1995	2.673	0.886	0.734	90.17
3.7830	147	35	4.20	0.052	1991	2.669	0.877	0.745	89.95
3.7985	143.5	35	4.10	0.055	1985	2.692	0.881	0.760	89.60
3.7981	140	35	4.00	0.058	1978	2.712	0.882	0.774	89.25
3.8238	138	30	4.60	0.051	1708	2.656	0.765	0.696	89.39
3.7936	135	30	4.50	0.053	1705	2.648	0.759	0.708	89.19
3.8182	132	30	4.40	0.056	1699	2.664	0.764	0.725	88.88
3.8279	129	30	4.30	0.059	1694	2.678	0.767	0.740	88.56
3.8235	126	30	4.20	0.062	1688	2.690	0.766	0.754	88.22
3.8057	123	30	4.10	0.065	1683	2.699	0.763	0.766	87.88
3.7755	120	30	4.00	0.068	1678	2.706	0.758	0.778	87.53
3.5907	230	50	4.60	0.028	2916	2.576	1.170	0.658	93.73
3.5544	225	50	4.50	0.029	2913	2.561	1.158	0.670	93.64
3.6230	220	50	4.40	0.031	2907	2.586	1.180	0.692	93.44
3.5670	215	50	4.30	0.032	2904	2.569	1.162	0.702	93.34

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
3.5047	210	50	4.20	0.033	2901	2.550	1.142	0.711	93.23
3.6287	205	50	4.10	0.036	2892	2.611	1.183	0.737	92.90
3.6358	200	50	4.00	0.038	2886	2.629	1.186	0.752	92.67
3.5661	207	45	4.60	0.031	1616	2.567	1.050	0.659	93.07
3.6236	202.5	45	4.50	0.033	2611	2.585	1.067	0.679	92.88
3.5647	198	45	4.40	0.034	2608	2.565	1.049	0.689	92.79
3.5954	193.5	45	4.30	0.036	2603	2.580	1.059	0.707	92.58
3.6112	189	45	4.20	0.038	2597	2.594	1.063	0.723	92.37
3.6129	184.5	45	4.10	0.040	2592	2.606	1.064	0.738	92.14
3.6011	180	45	4.00	0.042	2587	2.615	1.061	0.752	91.91
3.5630	184	40	4.60	0.035	2316	2.566	0.937	0.662	92.23
3.5956	180	40	4.50	0.037	2311	2.575	0.945	0.680	92.04
3.6142	176	40	4.40	0.039	2306	2.584	0.950	0.697	91.85
3.6195	172	40	4.30	0.041	2302	2.590	0.952	0.712	91.64
3.6123	168	40	4.20	0.043	2297	2.595	0.950	0.727	91.43
3.5932	164	40	4.10	0.045	2292	2.599	0.946	0.740	91.20
3.6338	160	40	4.00	0.048	2285	2.632	0.957	0.757	90.86
3.6275	161	35	4.60	0.041	2014	2.587	0.840	0.672	91.08
3.6318	157.5	35	4.50	0.043	2010	2.588	0.841	0.688	90.90
3.6247	154	35	4.40	0.045	2006	2.588	0.839	0.702	90.70
3.6006	150.5	35	4.30	0.047	2001	2.586	0.835	0.715	90.49
3.5783	147	35	4.20	0.049	1997	2.583	0.829	0.728	90.28
3.6050	143.5	35	4.10	0.052	1991	2.606	0.836	0.745	89.95
3.6155	140	35	4.00	0.055	1985	2.626	0.839	0.760	89.60
3.6120	138	30	4.60	0.048	1714	2.582	0.723	0.676	89.67
3.5920	135	30	4.50	0.050	1710	2.574	0.719	0.690	89.48

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
3.6269	132	30	4.40	0.053	1705	2.590	0.726	0.708	89.19
3.5859	129	30	4.30	0.055	1701	2.579	0.718	0.719	88.98
3.5944	126	30	4.20	0.058	1696	2.591	0.720	0.735	88.66
3.5892	123	30	4.10	0.061	1690	2.601	0.719	0.749	88.33
3.6332	120	30	4.00	0.065	1683	2.633	0.726	0.766	87.83
3.3429	230	50	4.60	0.026	2922	2.494	1.089	0.633	93.90
3.4363	225	50	4.50	0.028	2916	2.520	1.120	0.658	93.73
3.3982	220	50	4.40	0.029	2913	2.504	1.107	0.670	93.64
3.3530	215	50	4.30	0.030	2910	2.487	1.092	0.681	93.54
3.4031	210	50	4.20	0.032	2904	2.509	1.109	0.702	93.34
3.4364	205	50	4.10	0.034	2898	2.529	1.120	0.720	93.12
3.3625	200	50	4.00	0.035	2895	2.507	1.096	0.729	93.01
3.3446	207	45	4.60	0.029	2622	2.494	0.985	0.636	93.24
3.4128	202.5	45	4.50	0.031	2616	2.511	1.005	0.659	93.07
3.3637	198	45	4.40	0.032	2614	2.491	0.990	0.669	92.98
3.4045	193.5	45	4.30	0.034	2608	2.506	1.002	0.689	92.79
3.4302	189	45	4.20	0.036	2603	2.520	1.010	0.707	92.58
3.4413	184.5	45	4.10	0.038	2597	2.532	1.013	0.723	92.37
3.4388	180	45	4.00	0.040	2592	2.542	1.013	0.738	92.14
3.3678	184	40	4.60	0.033	2321	2.501	0.886	0.642	92.40
3.4098	180	40	4.50	0.035	2316	2.510	0.897	0.662	92.23
3.4376	176	40	4.40	0.037	2311	2.518	0.904	0.680	92.04
3.3675	172	40	4.30	0.038	2309	2.493	0.885	0.689	91.95
3.3732	168	40	4.20	0.040	2304	2.498	0.887	0.705	91.75
3.3666	164	40	4.10	0.042	2299	2.502	0.886	0.720	91.53
3.4200	160	40	4.00	0.045	2292	2.535	0.900	0.740	91.20

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
3.3745	161	35	4.60	0.038	2020	2.502	0.782	0.647	91.35
3.3910	157.5	35	4.50	0.040	2016	2.503	0.785	0.664	91.17
3.3956	154	35	4.40	0.042	2012	2.503	0.786	0.680	90.99
3.3891	150.5	35	4.30	0.044	2008	2.501	0.785	0.695	90.80
3.3718	147	35	4.20	0.046	2003	2.498	0.781	0.709	90.60
3.4099	143.5	35	4.10	0.049	1997	2.521	0.790	0.728	90.28
3.3696	140	35	4.00	0.051	1993	2.514	0.781	0.739	90.06
3.3985	138	30	4.60	0.045	1719	2.509	0.680	0.655	89.93
3.3887	135	30	4.50	0.047	1715	2.502	0.678	0.669	89.76
3.3695	132	30	4.40	0.049	1712	2.493	0.674	0.683	89.58
3.4027	129	30	4.30	0.052	1706	2.507	0.681	0.702	89.29
3.4210	126	30	4.20	0.055	1701	2.519	0.685	0.719	88.98
3.4253	123	30	4.10	0.058	1696	2.530	0.686	0.735	88.66
3.4163	120	30	4.00	0.061	1690	2.538	0.685	0.749	88.33
2.9686	230	50	4.60	0.023	2931	2.377	0.968	0.590	94.11
2.9607	225	50	4.50	0.024	2928	2.363	0.965	0.605	94.04
2.9447	220	50	4.40	0.025	2925	2.347	0.960	0.620	93.97
3.0295	215	50	4.30	0.027	2919	2.369	0.987	0.646	93.82
2.9934	210	50	4.20	0.028	2916	2.352	0.975	0.658	93.73
3.0483	205	50	4.10	0.030	2910	2.371	0.993	0.681	93.54
2.9942	200	50	4.00	0.031	2907	2.351	0.975	0.692	93.44
3.0099	207	45	4.60	0.026	2630	2.389	0.887	0.598	93.45
2.9875	202.5	45	4.50	0.027	2627	2.371	0.880	0.611	93.39
2.9583	198	45	4.40	0.028	2624	2.351	0.871	0.624	93.31
3.0195	193.5	45	4.30	0.030	2619	2.365	0.889	0.648	93.16
2.9729	189	45	4.20	0.031	2616	2.344	0.875	0.659	93.07

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
3.0080	184.5	45	4.10	0.033	2611	2.355	0.885	0.679	92.88
3.0288	180	45	4.00	0.035	2606	2.366	0.892	0.698	92.68
2.9743	184	40	4.60	0.029	2330	2.377	0.783	0.597	92.69
3.0352	180	40	4.50	0.031	2326	2.385	0.799	0.620	92.55
2.9917	176	40	4.40	0.032	2323	2.362	0.787	0.631	92.48
3.0283	172	40	4.30	0.034	2318	2.368	0.796	0.652	92.32
2.9703	168	40	4.20	0.035	2316	2.343	0.781	0.662	92.23
2.9848	164	40	4.10	0.037	2311	2.346	0.785	0.680	92.04
2.9868	160	40	4.00	0.039	2306	2.349	0.785	0.697	91.85
3.0340	161	35	4.60	0.034	2029	2.394	0.703	0.608	91.64
2.9853	157.5	35	4.50	0.035	2027	2.368	0.692	0.618	91.57
3.0098	154	35	4.40	0.037	2022	2.367	0.697	0.638	91.43
3.0226	150.5	35	4.30	0.039	2018	2.365	0.700	0.656	91.26
3.0240	147	35	4.20	0.041	2014	2.362	0.700	0.672	91.08
3.0149	143.5	35	4.10	0.043	2010	2.358	0.698	0.688	90.90
2.9956	140	35	4.00	0.045	2006	2.353	0.694	0.702	90.70
2.9665	138	30	4.60	0.039	1730	2.372	0.595	0.606	90.37
2.9774	135	30	4.50	0.041	1726	2.364	0.596	0.623	90.24
2.9783	132	30	4.40	0.043	1723	2.355	0.596	0.640	90.09
2.9696	129	30	4.30	0.045	1719	2.345	0.594	0.655	89.93
3.0111	126	30	4.20	0.048	1714	2.357	0.603	0.676	89.67
2.9818	123	30	4.10	0.050	1710	2.345	0.597	0.690	89.48
2.9974	120	30	4.00	0.053	1705	2.354	0.600	0.708	89.19
1.9554	230	50	4.60	0.015	2955	2.116	0.642	0.440	94.18
1.9936	225	50	4.50	0.016	2952	2.097	0.654	0.462	94.23
2.0226	220	50	4.40	0.017	2949	2.079	0.663	0.483	94.26

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
2.0428	215	50	4.30	0.018	2946	2.061	0.669	0.503	94.27
1.9489	210	50	4.20	0.018	2946	2.013	0.638	0.503	94.27
1.9580	205	50	4.10	0.019	2943	1.994	0.640	0.522	94.26
1.9593	200	50	4.00	0.020	2940	1.974	0.640	0.540	94.24
1.9899	207	45	4.60	0.017	2654	2.122	0.591	0.449	93.58
2.0139	202.5	45	4.50	0.018	2651	2.101	0.597	0.468	93.63
2.0299	198	45	4.40	0.019	2649	2.080	0.601	0.487	93.65
2.0382	193.5	45	4.30	0.020	2646	2.058	0.603	0.505	93.66
2.0393	189	45	4.20	0.021	2643	2.037	0.603	0.522	93.65
2.0334	184.5	45	4.10	0.022	2641	2.015	0.600	0.539	93.63
2.0209	180	45	4.00	0.023	2638	1.993	0.596	0.554	93.60
1.9724	184	40	4.60	0.019	2354	2.117	0.524	0.449	92.82
1.9846	180	40	4.50	0.020	2352	2.093	0.526	0.466	92.86
1.9898	176	40	4.40	0.021	2350	2.068	0.527	0.483	92.89
1.9885	172	40	4.30	0.022	2347	2.044	0.526	0.499	92.91
1.9810	168	40	4.20	0.023	2345	2.019	0.524	0.515	92.91
1.9674	164	40	4.10	0.024	2342	1.994	0.520	0.530	92.89
2.0238	160	40	4.00	0.026	2338	1.992	0.534	0.558	92.84
1.9915	161	35	4.60	0.022	2054	2.119	0.466	0.456	91.87
1.9901	157.5	35	4.50	0.023	2052	2.092	0.465	0.471	91.91
1.9831	154	35	4.40	0.024	2050	2.065	0.463	0.485	91.94
1.9705	150.5	35	4.30	0.025	2048	2.037	0.459	0.500	91.95
2.0255	147	35	4.20	0.027	2043	2.030	0.471	0.527	91.94
1.9993	143.5	35	4.10	0.028	2041	2.002	0.465	0.540	91.92
1.9686	140	35	4.00	0.029	2039	1.973	0.457	0.552	91.89
2.0081	138	30	4.60	0.026	1753	2.120	0.407	0.464	90.62

load torque (N-m)	phase voltage (V)	frequency (Hz)	ratio (V/f)	slip	speed (rpm)	current (A)	power (kW)	PF	efficiency (%)
1.9934	135	30	4.50	0.027	1751	2.090	0.403	0.476	90.66
1.9740	132	30	4.40	0.028	1750	2.060	0.399	0.489	90.68
2.0153	129	30	4.30	0.030	1746	2.047	0.406	0.513	90.70
1.9844	126	30	4.20	0.031	1744	2.016	0.400	0.524	90.69
2.0083	123	30	4.10	0.033	1741	2.002	0.404	0.547	90.65
2.0226	120	30	4.00	0.035	1737	1.989	0.406	0.567	90.58

ก.2 ข้อมูลที่ใช้สอนโครงข่ายประสาทเทียม

การสอนโครงข่ายประสาทเทียมให้สามารถรับรู้ปริมาณโหลดภาระโดยการนำผลการ Simulation การทำงานของมอเตอร์ที่สภาวะการทำงานต่าง ๆ มาปรับค่าตัวเลข ข้อมูลที่นำมาใช้สอนโครงข่ายประสาทเทียมแสดงดังตารางที่ ก-2

ตารางที่ ก-2 ข้อมูลที่ใช้สอนโครงข่ายประสาทเทียมเพื่อรับรู้ปริมาณโหลดภาระ

ข้อมูลของมอเตอร์				ข้อมูลที่ใช้สอนโครงข่ายประสาท			
Input			Output	Input			Output
V	F	I	T	p1	p2	p3	a^2_1
230	50	3.977	7.0191	1.000000	1.000000	0.795400	1.002729
225	50	4.043	7.0391	0.978261	1.000000	0.808600	1.005586
220	50	4.103	7.0341	0.956522	1.000000	0.820600	1.004871
215	50	4.158	7.0056	0.934783	1.000000	0.831600	1.000800
210	50	4.205	6.9550	0.913043	1.000000	0.841000	0.993571
205	50	4.293	6.9681	0.891304	1.000000	0.858600	0.995443
200	50	4.373	6.9513	0.869565	1.000000	0.874600	0.993043
207	45	3.948	6.9384	0.900000	0.900000	0.789600	0.991200
202.5	45	3.998	6.9261	0.880435	0.900000	0.799600	0.989443

ข้อมูลของมอเตอร์				ข้อมูลที่ใช้สอนโครงข่ายประสาท			
Input			Output	Input			Output
V	F	I	T	p1	p2	p3	a^2_1
198	45	4.088	6.9820	0.860870	0.900000	0.817600	0.997429
193.5	45	4.127	6.9233	0.841304	0.900000	0.825400	0.989043
189	45	4.203	6.9255	0.821739	0.900000	0.840600	0.989357
184.5	45	4.313	6.9752	0.802174	0.900000	0.862600	0.996457
180	45	4.412	6.9901	0.782609	0.900000	0.882400	0.998586
184	40	3.977	6.9786	0.800000	0.800000	0.795400	0.996943
180	40	4.011	6.9276	0.782609	0.800000	0.802200	0.989657
176	40	4.079	6.9371	0.765217	0.800000	0.815800	0.991014
172	40	4.141	6.9213	0.747826	0.800000	0.828200	0.988757
168	40	4.233	6.9507	0.730435	0.800000	0.846600	0.992957
164	40	4.317	6.9493	0.713043	0.800000	0.863400	0.992757
160	40	4.428	6.9793	0.695652	0.800000	0.885600	0.997043
161	35	3.981	6.9560	0.700000	0.700000	0.796200	0.993714
157.5	35	4.033	6.9401	0.684783	0.700000	0.806600	0.991443
154	35	4.113	6.9688	0.669565	0.700000	0.822600	0.995543
150.5	35	4.187	6.9694	0.654348	0.700000	0.837400	0.995629
147	35	4.252	6.9436	0.639130	0.700000	0.850400	0.991943
143.5	35	4.342	6.9478	0.623913	0.700000	0.868400	0.992543
140	35	4.453	6.9725	0.608696	0.700000	0.890600	0.996071
138	30	4.016	6.9887	0.600000	0.600000	0.803200	0.998386
135	30	4.075	6.9804	0.586957	0.600000	0.815000	0.997200
132	30	4.128	6.9460	0.573913	0.600000	0.825600	0.992286
129	30	4.203	6.9470	0.560870	0.600000	0.840600	0.992429
126	30	4.270	6.9183	0.547826	0.600000	0.854000	0.988329

ข้อมูลของมอเตอร์				ข้อมูลที่ใช้สอนโครงข่ายประสาท			
Input			Output	Input			Output
V	F	I	T	p1	p2	p3	a^2_1
123	30	4.355	6.9095	0.534783	0.600000	0.871000	0.987071
120	30	4.457	6.9131	0.521739	0.600000	0.891400	0.987586
230	50	3.515	5.9891	1.000000	1.000000	0.703000	0.855586
225	50	3.538	5.9532	0.978261	1.000000	0.707600	0.850457
220	50	3.606	6.0067	0.956522	1.000000	0.721200	0.858100
215	50	3.669	6.0348	0.934783	1.000000	0.733800	0.862114
210	50	3.726	6.0387	0.913043	1.000000	0.745200	0.862671
205	50	3.777	6.0198	0.891304	1.000000	0.755400	0.859971
200	50	3.822	5.9796	0.869565	1.000000	0.764400	0.854229
207	45	3.535	6.0236	0.900000	0.900000	0.707000	0.860514
202.5	45	3.547	5.9613	0.880435	0.900000	0.709400	0.851614
198	45	3.599	5.9792	0.860870	0.900000	0.719800	0.854171
193.5	45	3.647	5.9752	0.841304	0.900000	0.729400	0.853600
189	45	3.732	6.0334	0.821739	0.900000	0.746400	0.861914
184.5	45	3.768	5.9846	0.802174	0.900000	0.753600	0.854943
180	45	3.839	5.9910	0.782609	0.900000	0.767800	0.855857
184	40	3.532	6.0025	0.800000	0.800000	0.706400	0.857500
180	40	3.573	6.0023	0.782609	0.800000	0.714600	0.857471
176	40	3.609	5.9828	0.765217	0.800000	0.721800	0.854686
172	40	3.679	6.0217	0.747826	0.800000	0.735800	0.860243
168	40	3.743	6.0347	0.730435	0.800000	0.748600	0.862100
164	40	3.801	6.0234	0.713043	0.800000	0.760200	0.860486
160	40	3.852	5.9892	0.695652	0.800000	0.770400	0.855600
161	35	3.525	5.9687	0.700000	0.700000	0.705000	0.852671

ข้อมูลของมอเตอร์				ข้อมูลที่ใช้สอนโครงข่ายประสาท			
Input			Output	Input			Output
V	F	I	T	p1	p2	p3	a^2_1
157.5	35	3.585	6.0067	0.684783	0.700000	0.717000	0.858100
154	35	3.639	6.0210	0.669565	0.700000	0.727800	0.860143
150.5	35	3.688	6.0131	0.654348	0.700000	0.737600	0.859014
147	35	3.732	5.9842	0.639130	0.700000	0.746400	0.854886
143.5	35	3.801	5.9933	0.623913	0.700000	0.760200	0.856186
140	35	3.863	5.9769	0.608696	0.700000	0.772600	0.853843
138	30	3.542	5.9807	0.600000	0.600000	0.708400	0.854386
135	30	3.609	6.0297	0.586957	0.600000	0.721800	0.861386
132	30	3.642	5.9959	0.573913	0.600000	0.728400	0.856557
129	30	3.699	5.9990	0.560870	0.600000	0.739800	0.857000
126	30	3.749	5.9793	0.547826	0.600000	0.749800	0.854186
123	30	3.820	5.9861	0.534783	0.600000	0.764000	0.855157
120	30	3.910	6.0115	0.521739	0.600000	0.782000	0.858786
230	50	3.119	5.0475	1.000000	1.000000	0.623800	0.721071
225	50	3.099	4.9443	0.978261	1.000000	0.619800	0.706329
220	50	3.171	5.0517	0.956522	1.000000	0.634200	0.721671
215	50	3.192	5.0297	0.934783	1.000000	0.638400	0.718529
210	50	3.209	4.9928	0.913043	1.000000	0.641800	0.713257
205	50	3.269	5.0334	0.891304	1.000000	0.653800	0.719057
200	50	3.278	4.9642	0.869565	1.000000	0.655600	0.709171
207	45	3.093	4.9759	0.900000	0.900000	0.618600	0.710843
202.5	45	3.110	4.9649	0.880435	0.900000	0.622000	0.709271
198	45	3.167	5.0356	0.860870	0.900000	0.633400	0.719371
193.5	45	3.178	4.9918	0.841304	0.900000	0.635600	0.713114

ข้อมูลของมอเตอร์				ข้อมูลที่ใช้สอนโครงข่ายประสาท			
Input			Output	Input			Output
V	F	I	T	p1	p2	p3	a^2_1
189	45	3.227	5.0215	0.821739	0.900000	0.645400	0.717357
184.5	45	3.272	5.0299	0.802174	0.900000	0.654400	0.718557
180	45	3.312	5.0181	0.782609	0.900000	0.662400	0.716871
184	40	3.102	4.9929	0.800000	0.800000	0.620400	0.713271
180	40	3.110	4.9562	0.782609	0.800000	0.622000	0.708029
176	40	3.152	4.9918	0.765217	0.800000	0.630400	0.713114
172	40	3.190	5.0074	0.747826	0.800000	0.638000	0.715343
168	40	3.225	5.0040	0.730435	0.800000	0.645000	0.714857
164	40	3.255	4.9827	0.713043	0.800000	0.651000	0.711814
160	40	3.317	5.0114	0.695652	0.800000	0.663400	0.715914
161	35	3.119	5.0230	0.700000	0.700000	0.623800	0.717571
157.5	35	3.149	5.0362	0.684783	0.700000	0.629800	0.719457
154	35	3.175	5.0321	0.669565	0.700000	0.635000	0.718871
150.5	35	3.199	5.0117	0.654348	0.700000	0.639800	0.715957
147	35	3.219	4.9758	0.639130	0.700000	0.643800	0.710829
143.5	35	3.266	4.9863	0.623913	0.700000	0.653200	0.712329
140	35	3.339	5.0331	0.608696	0.700000	0.667800	0.719014
138	30	3.140	5.0602	0.600000	0.600000	0.628000	0.722886
135	30	3.127	4.9705	0.586957	0.600000	0.625400	0.710071
132	30	3.166	4.9947	0.573913	0.600000	0.633200	0.713529
129	30	3.202	4.9994	0.560870	0.600000	0.640400	0.714200
126	30	3.234	4.9858	0.547826	0.600000	0.646800	0.712257
123	30	3.288	5.0054	0.534783	0.600000	0.657600	0.715057
120	30	3.337	5.0028	0.521739	0.600000	0.667400	0.714686

ข้อมูลของมอเตอร์				ข้อมูลที่ใช้สอนโครงข่ายประสาท			
Input			Output	Input			Output
V	F	I	T	p1	p2	p3	a^2_1
230	50	2.704	3.9598	1.000000	1.000000	0.540800	0.565686
225	50	2.732	4.0233	0.978261	1.000000	0.546400	0.574757
220	50	2.714	3.9577	0.956522	1.000000	0.542800	0.565386
215	50	2.739	3.9914	0.934783	1.000000	0.547800	0.570200
210	50	2.761	4.0085	0.913043	1.000000	0.552200	0.572643
205	50	2.780	4.0099	0.891304	1.000000	0.556000	0.572843
200	50	2.797	3.9964	0.869565	1.000000	0.559400	0.570914
207	45	2.701	4.0055	0.900000	0.900000	0.540200	0.572214
202.5	45	2.740	4.0418	0.880435	0.900000	0.548000	0.577400
198	45	2.717	3.9633	0.860870	0.900000	0.543400	0.566186
193.5	45	2.733	3.9739	0.841304	0.900000	0.546600	0.567700
189	45	2.746	3.9702	0.821739	0.900000	0.549200	0.567171
184.5	45	2.795	4.0374	0.802174	0.900000	0.559000	0.576771
180	45	2.803	4.0027	0.782609	0.900000	0.560600	0.571814
184	40	2.736	4.0464	0.800000	0.800000	0.547200	0.578057
180	40	2.711	3.9641	0.782609	0.800000	0.542200	0.566300
176	40	2.719	3.9645	0.765217	0.800000	0.543800	0.566357
172	40	2.760	4.0349	0.747826	0.800000	0.552000	0.576414
168	40	2.764	4.0063	0.730435	0.800000	0.552800	0.572329
164	40	2.765	3.9664	0.713043	0.800000	0.553000	0.566629
160	40	2.798	3.9860	0.695652	0.800000	0.559600	0.569429
161	35	2.706	3.9617	0.700000	0.700000	0.541200	0.565957
157.5	35	2.737	4.0289	0.684783	0.700000	0.547400	0.575557
154	35	2.736	4.0023	0.669565	0.700000	0.547200	0.571757

ข้อมูลของมอเตอร์				ข้อมูลที่ใช้สอนโครงข่ายประสาท			
Input			Output	Input			Output
V	F	I	T	p1	p2	p3	a^2_1
150.5	35	2.733	3.9653	0.654348	0.700000	0.546600	0.566471
147	35	2.758	3.9861	0.639130	0.700000	0.551600	0.569443
143.5	35	2.780	3.9904	0.623913	0.700000	0.556000	0.570057
140	35	2.799	3.9792	0.608696	0.700000	0.559800	0.568457
138	30	2.733	4.0340	0.600000	0.600000	0.546600	0.576286
135	30	2.725	3.9937	0.586957	0.600000	0.545000	0.570529
132	30	2.740	4.0080	0.573913	0.600000	0.548000	0.572571
129	30	2.754	4.0077	0.560870	0.600000	0.550800	0.572529
126	30	2.765	3.9937	0.547826	0.600000	0.553000	0.570529
123	30	2.799	4.0199	0.534783	0.600000	0.559800	0.574271
120	30	2.804	3.9777	0.521739	0.600000	0.560800	0.568243
230	50	2.377	2.9686	1.000000	1.000000	0.475400	0.424086
225	50	2.363	2.9607	0.978261	1.000000	0.472600	0.422957
220	50	2.347	2.9447	0.956522	1.000000	0.469400	0.420671
215	50	2.369	3.0295	0.934783	1.000000	0.473800	0.432786
210	50	2.352	2.9934	0.913043	1.000000	0.470400	0.427629
205	50	2.371	3.0483	0.891304	1.000000	0.474200	0.435471
200	50	2.351	2.9942	0.869565	1.000000	0.470200	0.427743
207	45	2.389	3.0099	0.900000	0.900000	0.477800	0.429986
202.5	45	2.371	2.9875	0.880435	0.900000	0.474200	0.426786
198	45	2.351	2.9583	0.860870	0.900000	0.470200	0.422614
193.5	45	2.365	3.0195	0.841304	0.900000	0.473000	0.431357
189	45	2.344	2.9729	0.821739	0.900000	0.468800	0.424700
184.5	45	2.355	3.0080	0.802174	0.900000	0.471000	0.429714

ข้อมูลของมอเตอร์				ข้อมูลที่ใช้สอนโครงข่ายประสาท			
Input			Output	Input			Output
V	F	I	T	p1	p2	p3	a^2_1
180	45	2.366	3.0288	0.782609	0.900000	0.473200	0.432686
184	40	2.377	2.9743	0.800000	0.800000	0.475400	0.424900
180	40	2.385	3.0352	0.782609	0.800000	0.477000	0.433600
176	40	2.362	2.9917	0.765217	0.800000	0.472400	0.427386
172	40	2.368	3.0283	0.747826	0.800000	0.473600	0.432614
168	40	2.343	2.9703	0.730435	0.800000	0.468600	0.424329
164	40	2.346	2.9848	0.713043	0.800000	0.469200	0.426400
160	40	2.349	2.9868	0.695652	0.800000	0.469800	0.426686
161	35	2.394	3.0340	0.700000	0.700000	0.478800	0.433429
157.5	35	2.368	2.9853	0.684783	0.700000	0.473600	0.426471
154	35	2.367	3.0098	0.669565	0.700000	0.473400	0.429971
150.5	35	2.365	3.0226	0.654348	0.700000	0.473000	0.431800
147	35	2.362	3.0240	0.639130	0.700000	0.472400	0.432000
143.5	35	2.358	3.0149	0.623913	0.700000	0.471600	0.430700
140	35	2.353	2.9956	0.608696	0.700000	0.470600	0.427943
138	30	2.372	2.9665	0.600000	0.600000	0.474400	0.423786
135	30	2.364	2.9774	0.586957	0.600000	0.472800	0.425343
132	30	2.355	2.9783	0.573913	0.600000	0.471000	0.425471
129	30	2.345	2.9696	0.560870	0.600000	0.469000	0.424229
126	30	2.357	3.0111	0.547826	0.600000	0.471400	0.430157
123	30	2.345	2.9818	0.534783	0.600000	0.469000	0.425971
120	30	2.354	2.9974	0.521739	0.600000	0.470800	0.428200
230	50	2.116	1.9554	1.000000	1.000000	0.423200	0.279343
225	50	2.097	1.9936	0.978261	1.000000	0.419400	0.284800

ข้อมูลของมอเตอร์				ข้อมูลที่ใช้สอนโครงข่ายประสาท			
Input			Output	Input			Output
V	F	I	T	p1	p2	p3	a_1^2
220	50	2.079	2.0226	0.956522	1.000000	0.415800	0.288943
215	50	2.061	2.0428	0.934783	1.000000	0.412200	0.291829
210	50	2.013	1.9489	0.913043	1.000000	0.402600	0.278414
205	50	1.994	1.9580	0.891304	1.000000	0.398800	0.279714
200	50	1.974	1.9593	0.869565	1.000000	0.394800	0.279900
207	45	2.122	1.9899	0.900000	0.900000	0.424400	0.284271
202.5	45	2.101	2.0139	0.880435	0.900000	0.420200	0.287700
198	45	2.080	2.0299	0.860870	0.900000	0.416000	0.289986
193.5	45	2.058	2.0382	0.841304	0.900000	0.411600	0.291171
189	45	2.037	2.0393	0.821739	0.900000	0.407400	0.291329
184.5	45	2.015	2.0334	0.802174	0.900000	0.403000	0.290486
180	45	1.993	2.0209	0.782609	0.900000	0.398600	0.288700
184	40	2.117	1.9724	0.800000	0.800000	0.423400	0.281771
180	40	2.093	1.9846	0.782609	0.800000	0.418600	0.283514
176	40	2.068	1.9898	0.765217	0.800000	0.413600	0.284257
172	40	2.044	1.9885	0.747826	0.800000	0.408800	0.284071
168	40	2.019	1.9810	0.730435	0.800000	0.403800	0.283000
164	40	1.994	1.9674	0.713043	0.800000	0.398800	0.281057
160	40	1.992	2.0238	0.695652	0.800000	0.398400	0.289114
161	35	2.119	1.9915	0.700000	0.700000	0.423800	0.284500
157.5	35	2.092	1.9901	0.684783	0.700000	0.418400	0.284300
154	35	2.065	1.9831	0.669565	0.700000	0.413000	0.283300
150.5	35	2.037	1.9705	0.654348	0.700000	0.407400	0.281500
147	35	2.030	2.0255	0.639130	0.700000	0.406000	0.289357

ข้อมูลของมอเตอร์				ข้อมูลที่ใช้สอนโครงข่ายประสาท			
Input			Output	Input			Output
V	F	I	T	p1	p2	p3	a^2_1
143.5	35	2.002	1.9993	0.623913	0.700000	0.400400	0.285614
140	35	1.973	1.9686	0.608696	0.700000	0.394600	0.281229
138	30	2.120	2.0081	0.600000	0.600000	0.424000	0.286871
135	30	2.090	1.9934	0.586957	0.600000	0.418000	0.284771
132	30	2.060	1.9740	0.573913	0.600000	0.412000	0.282000
129	30	2.047	2.0153	0.560870	0.600000	0.409400	0.287900
126	30	2.016	1.9844	0.547826	0.600000	0.403200	0.283486
123	30	2.002	2.0083	0.534783	0.600000	0.400400	0.286900
120	30	1.989	2.0226	0.521739	0.600000	0.397800	0.288943

ภาคผนวก ข รายละเอียดและคุณสมบัติของบอร์ด ET-ARM7 STAMP LPC2119

ภาคผนวก ข

รายละเอียดและคุณสมบัติของบอร์ด ET-ARM7 STAMP LPC2119

ET-ARM7 STAMP LPC2119 เป็นบอร์ดไมโครคอนโทรเลอร์ในตระกูล ARM 7 TDMI-S Core เลือกใช้ไมโครคอนโทรเลอร์ 16/32 บิตขนาด 64 ขาแบบใช้พลังงานต่ำ เลือกใช้ MCU เบอร์ LPC2119 ของ Philips โดยการออกแบบโครงสร้างของบอร์ดนั้นจะเน้นเรื่องการจัดวางให้มีขนาดเล็กเพื่อให้ง่ายต่อการนำไปประยุกต์ใช้งาน

การจัดวางโครงสร้างของบอร์ดนำ MCU มาจัดวงจรร่วมกับอุปกรณ์พื้นฐานที่จำเป็นและจัดขาออกมาให้ใช้งานภายนอก ซึ่งการจัดเรียงขาสัญญาณจะทำการจัดเรียงอย่างเป็นระเบียบเพื่อให้สามารถต่อใช้งานได้โดยสะดวก ตัวบอร์ดใช้ไฟ +3.3V สามารถรองรับ I/O ที่เป็นสัญญาณ 5V ได้ ตัวบอร์ดมี Connector UART0 (RS-232) จำนวน 1 พอร์ตสำหรับทำการ Download Hex File หรือใช้งานในการสื่อสารผ่านพอร์ตอนุกรม (RS232)

คุณสมบัติของบอร์ด

1) ใช้ MCU ตระกูล ARM7TDMI-S เบอร์ LPC2119 ของ Philips มีขนาด 16/32 บิต

2) ใช้ Crystal 19.6608 MHz โดย MCU สามารถประมวลผลด้วยความเร็วสูงสุดที่ 58.9824 MHz เมื่อใช้งานร่วมกับ Phase-Locked Loop (PLL) ภายในตัว MCU เอง

3) รองรับการโปรแกรมแบบ In-System Programming (ISP) และ In-Application Programming (IAP) ผ่านทาง On-Chip Boot-Loader Software ผ่านทาง UART0 (RS232)

4) ใช้แรงดันไฟฟ้า +3.3V เท่านั้น (3.0V – 3.6V + 10% Error)

5) ภายใน MCU มีหน่วยความจำโปรแกรมแบบ Flash ขนาด 128 KB, หน่วยความจำข้อมูล Static RAM ขนาด 16 KB

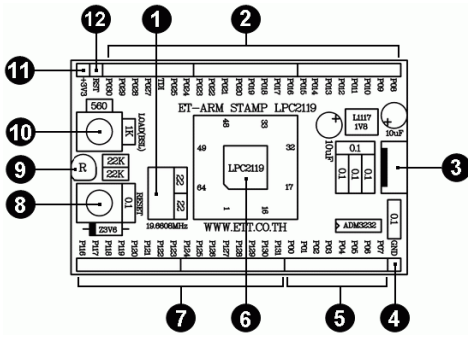
6) จำนวน GPIO สูงสุดถึง 46 I/O ขาสามารถเชื่อมต่อกับระบบ I/O ที่เป็นสัญญาณ 5V ได้ ซึ่งขาสัญญาณ GPIO จะมีการใช้งานร่วมกันของ Function อื่นๆอีก

7) ทนอุณหภูมิใช้งานระหว่าง -40 ถึง +85°C

8) ขนาดดังนี้

- PCB ขนาด 40 x 65 มิลลิเมตร
- ระยะขาความกว้าง 38.1 มิลลิเมตร ความยาว 63.5 มิลลิเมตร
- ระยะระหว่างขา 2 x 25 ขา I/O Connector 2.54 มิลลิเมตร

โครงสร้างบอร์ด ET-ARM7 STAMP LPC2119 แสดงดังภาพประกอบ ค-1



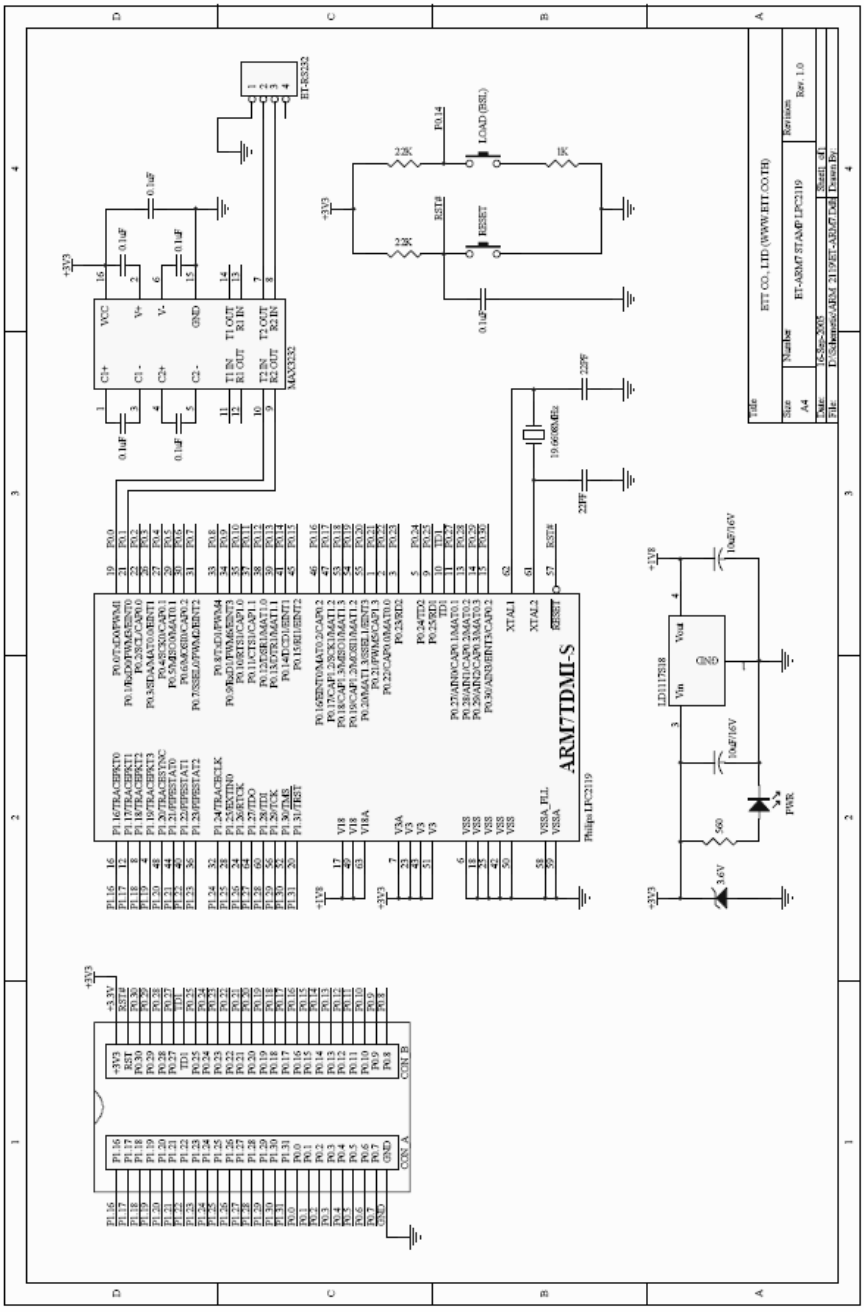
ภาพประกอบ ข-1 โครงสร้างบอร์ด ET-ARM7 STAMP LPC2119

(ที่มา : http://www.ett.co.th)

โดย

- หมายเลข 1 คือ คริสตอล 19.6608 MHz
- หมายเลข 6 คือ CPU ARM7 LPC2119 ของ Philips
- หมายเลข 2/5 คือ GPIO 0 ตั้งแต่ P0.0 – P0.25 และ P0.27 – P0.30 จำนวนทั้งหมด 30 ขาสามารถรองรับอุปกรณ์ที่มีสัญญาณ I/O เป็น 3.3V และ 5V ได้
- หมายเลข 3 คือ คือ UART 0 หรือพอร์ตอนุกรม (Serial Port) สำหรับติดต่อกับอุปกรณ์มาตรฐาน RS232 และเป็น ISP Download Connector สำหรับโปรแกรม Hex file ลงบอร์ด
- หมายเลข 4 คือ จุดต่อกราวด์ (GND)
- หมายเลข 11 คือ จุดต่อแรงดัน+3.3V ของบอร์ด
- หมายเลข 7 คือ GPIO 1 ตั้งแต่ P1.16 – P1.31 จำนวนทั้งหมด 16 ขาสามารถรองรับอุปกรณ์ที่มีสัญญาณ I/O เป็น 3.3V และ 5V ได้
- หมายเลข 8 คือ สวิตช์ RESET ส่วน หมายเลข 10 คือ สวิตช์ LOAD (BSL)
- หมายเลข 9 คือ LED สีแดง แสดงสถานการณ์ทำงานของแหล่งจ่ายไฟ
- หมายเลข 12 คือ จุดต่อสัญญาณ RESET สำหรับ Reset อุปกรณ์ภายนอก

รายละเอียดของบอร์ด ET-ARM7 STAMP LPC2119 แสดงดังภาพประกอบ ข-2



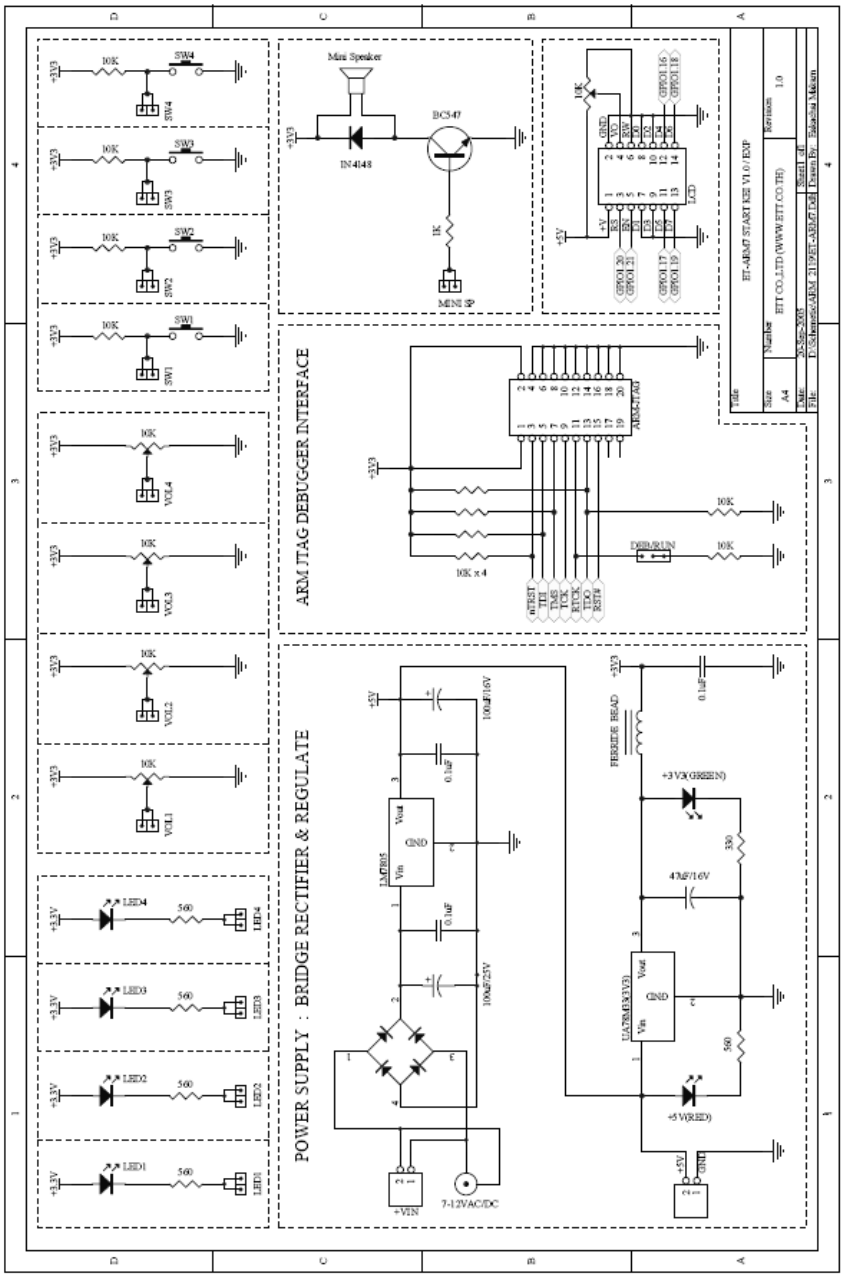
ภาพประกอบ ข-2 รายละเอียดของบอร์ด ET-ARM7 STAMP LPC2119

(ที่มา : http://www.ett.co.th)

เพื่อความสะดวกในการใช้งานบอร์ด ET ARM STAMP LPC2119 นั้นสามารถเลือกใช้ ET-ARM7 START KIT V1.0 / EXP เป็นชุด “ARM Base Socket” โดยในส่วนของชุด “ARM Base Socket” หรือ ET-ARM7 START KIT V1.0 และ ET-ARM7 START KEI V1.0 EXP ประกอบไปด้วย วงจรพื้นฐานที่จำเป็นสำหรับการศึกษาเรียนรู้และทดลองใช้งานทรัพยากรต่างๆ ของ MCUตระกูล ARM โดยภายในบอร์ดได้จัดเตรียมวงจรใช้งานที่จำเป็นไว้ให้ใช้งานอย่างครบถ้วนได้แก่

- วงจรแหล่งจ่ายไฟ แบบ Bridge Rectifier ขนาด 1A พร้อมวงจร Filter สามารถใช้กับแหล่งจ่ายไฟได้ทั้ง AC และ DC ขนาด 7-12V
- วงจร Regulate ขนาด +3.3V / 500mA สำหรับใช้งานเป็นแหล่งจ่ายไฟเลี้ยงวงจรให้กับโมดูล “ET-ARM STAMP LPC2119” และวงจร I/O ต่างๆที่ใช้กับแหล่งจ่ายขนาด 3.3V พร้อม LED แสดงสถานะสีเขียว และจุด Connector เชื่อมต่อใช้งาน ทั้งตัวผู้และตัวเมีย
- วงจร Regulate ขนาด +5V / 1A สำหรับใช้งานเป็นแหล่งจ่ายไฟเลี้ยงวงจรให้กับจอแสดงผล LCD และอุปกรณ์ I/O ต่างๆที่ใช้กับแหล่งจ่ายขนาดขนาด +5V พร้อม LED แสดงสถานะสีแดง และจุด Connector เชื่อมต่อใช้งาน ทั้งตัวผู้และตัวเมีย
- วงจรเชื่อมต่อจอแสดงผล LCD แบบ Character พร้อม VR ปรับความสว่าง โดยใช้สัญญาณ GPIO1[16..21] ในการเชื่อมต่อวงจรกับ LCD แบบ 4 Bit Interface
- วงจร LED แสดงผลแบบ Sink Current ใช้ไฟเลี้ยง 3.3V โดยใช้ LED สีแดงขนาด 3 mm. จำนวน 4 ชุด สำหรับใช้ในการทดสอบการทำงานของ Output ต่างๆ
- วงจรปรับแรงดัน 0-3.3V โดยใช้ตัวต้านทานปรับค่าได้แบบเกือกม้าแบบมีแกนปรับ จำนวน 4 ชุด สำหรับใช้ในการทดสอบการทำงานของ A/D
- วงจร Push Button Switch จำนวน 4 ชุด สำหรับใช้ทดสอบการทำงานของ Input ต่างๆ
- วงจร Mini Speaker สำหรับใช้ทดสอบการกำเนิดเสียง Beep หรือเสียงอื่นๆ
- พื้นที่สำหรับบัดกรีวงจรเพิ่มเติมขนาด 8cm x 4.5cm หรือใช้เป็นพื้นที่ติดตั้ง Photo Board รุ่น AD100 ขนาด 360 จุด
- ขั้วต่อ Header สำหรับรองรับโมดูล “ET-ARM STAMP LPC2119” หรือโมดูลอื่นๆที่มีขนาดเท่ากันพร้อม Connector สำหรับต่อไปยังวงจรทดลองต่างๆทั้งแบบตัวผู้และตัวเมีย

รายละเอียดของบอร์ด ET-ARM7 START KIT V1.0 / EXP แสดงดังภาพประกอบ ข-3



ภาพประกอบ ข-3 รายละเอียดของบอร์ด ET-ARM7 START KIT V1.0 / EXP

(ที่มา : http://www.ett.co.th)

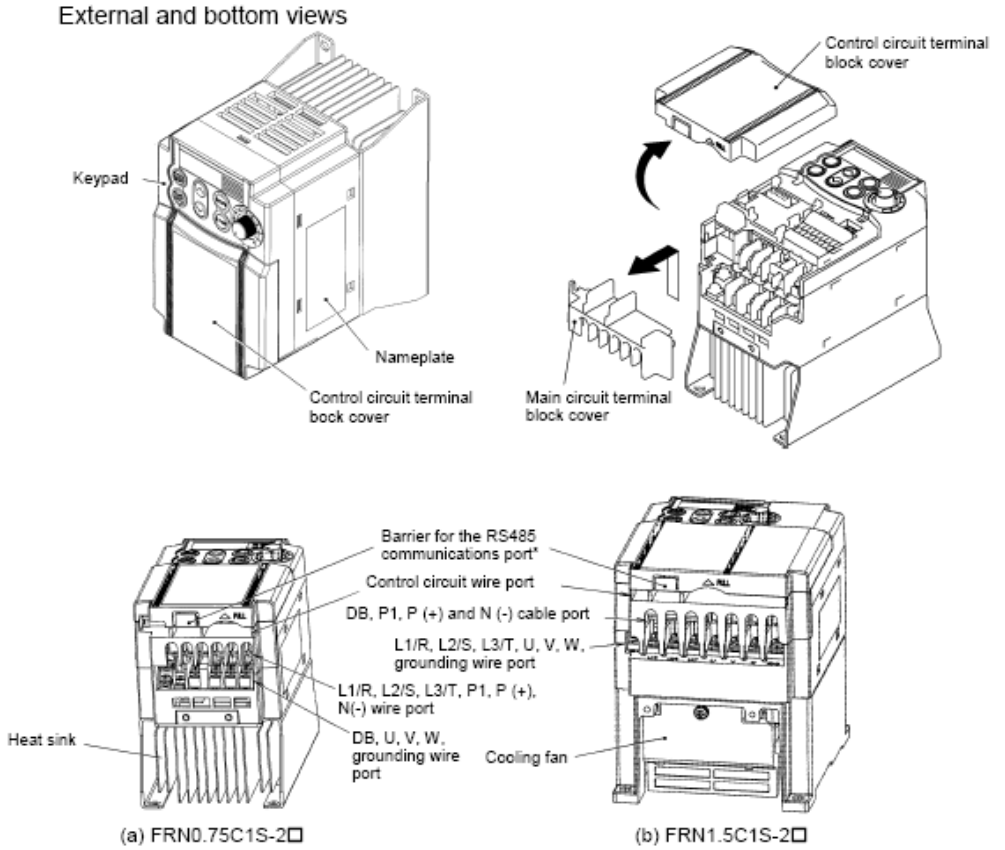
ภาคผนวก ค รายละเอียดและคุณสมบัติของอินเวอร์เตอร์ FUJI รุ่น FRENIC-Mini Model:FRN3. 7C1S-4A

ภาคผนวก ค

รายละเอียดและคุณสมบัติของอินเวอร์เตอร์

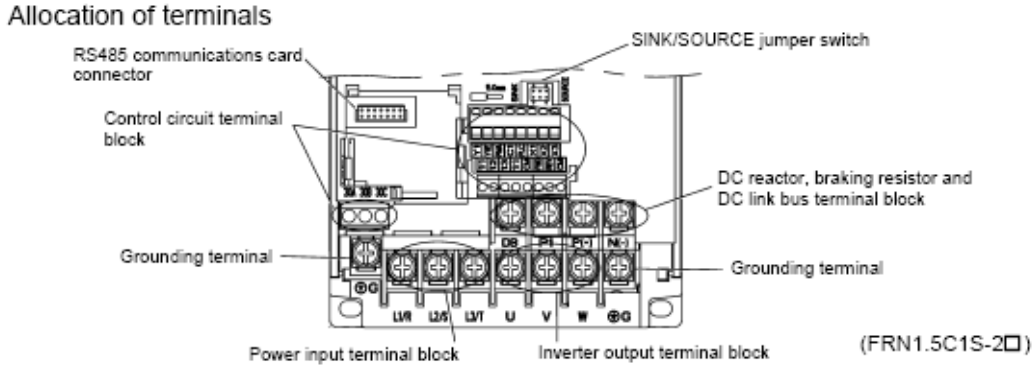
FUJI รุ่น FRENIC-Mini Model:FRN3. 7C1S-4A

ค.1 องค์ประกอบของอินเวอร์เตอร์ FUJI รุ่น FRENIC-Mini Model:FRN3. 7C1S-4A



(*When connecting the RS485 communications cable, remove the control circuit terminal block cover and snip off the barrier provided in it using nippers.)

Note: A box (□) in model names replaces A, C, E, or J depending on shipping destination.



LED Monitor, Potentiometer and Keys on the Keypad

As shown at the right, the keypad consists of a 7-segment LED monitor, a potentiometer (POT), and six keys.

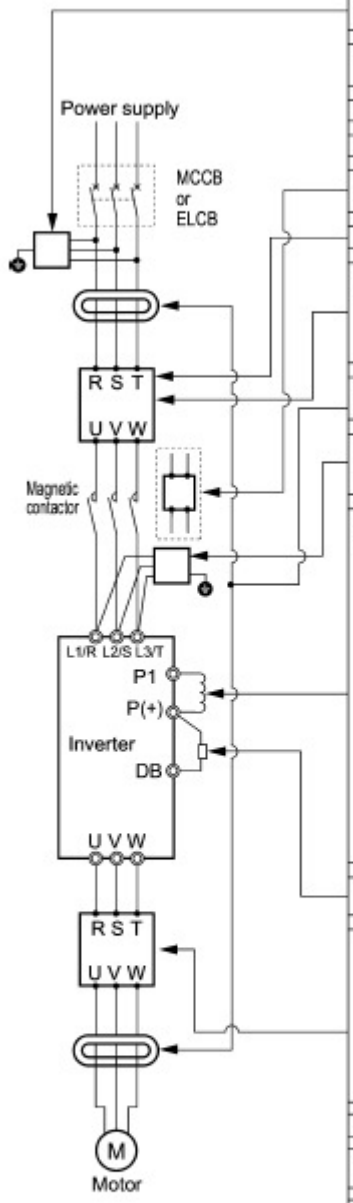
The keypad allows you to run and stop the motor, monitor running status, and switch to the menu mode. In the menu mode, you can set the function code data to match your operating requirements and monitor I/O signal states, maintenance information, and alarm information.

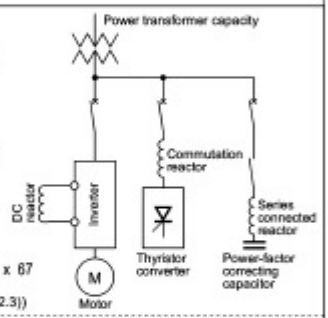
Keypad

Overview of Keypad Functions

Monitor, Potentiometer and Keys	Functions
	Four-digit, 7-segment LED monitor which displays the running status, data settings, and alarm status of the inverter according to the operation modes*. In Running mode, the monitor displays running status information (e.g., output frequency, current, and voltage). In Programming mode, it displays menus, function codes and their data. In Alarm mode, it displays an alarm code which identifies the error factor if the protective function is activated.
	Potentiometer (POT) which is used to manually set frequency, auxiliary frequencies 1 and 2 or PID process command.
	RUN key. Press this key to run the motor.
	STOP key. Press this key to stop the motor.
	UP/DOWN keys. Press these keys to select the setting items and change the function data displayed on the LED monitor.
	Program/Reset key. Press this key to switch the operation modes* of the inverter. Pressing this key in Running mode switches the inverter to Programming mode and vice versa. In Alarm mode, pressing this key after removing the error factor will switch the inverter to Running mode.
	Function/Data key. Pressing this key in Running mode switches the information displayed (output frequency (Hz), current (Amps) or voltage (V)). Pressing this key in Programming mode displays the function code and sets the data entered using ⌃ / ⌄ keys or the POT. Pressing this key in Alarm mode displays information concerning the alarm code currently displayed on the LED monitor.

ค.2 องค์ประกอบเพิ่มเติมของอินเวอร์เตอร์ FUJI รุ่น FRENIC-Mini Model:FRN3. 7C1S-4A



Name	Function
Surge absorber	Suppresses surges or noise invading from an external source, preventing malfunction from magnetic contactors, control relays and timers, etc.
Arrester	Suppresses induced lightning surges from power source, thus protecting all equipment connected to the power source.
Surge killer	Absorbs surges or noise invading from an external source, preventing malfunction of electronic equipment used in the switchboard.
Frequency setting device	Frequency setting potentiometer (mounted externally)
Frequency meter	Displays the frequency in accordance with signals output from the inverter.
Option for single-phase 100V input	This is used in cases where a single-phase 100V power supply is used to feed a three-phase 200V inverter. (It can be applied to the inverter of 0.75kW or less.)
EMC compliance filter	This is a dedicated filter which complies with the European EMC (Emission) Directive.
AC REACTOR (ACR)	Used for power factor improvement and power supply coordination. However, it is recommended that a DC REACTOR with a higher efficiency and which is more compact and lightweight be used. Use a DC REACTOR (DCR) as a countermeasure for harmonics. If it is necessary to supply a stabilized power supply, such as a DC bus system and running from that (PN connection operation), please use such a reactor.
Ferrite ring reactor for reducing radio noise	Reduces radio frequency noise. If the wiring between motor and inverter is shorter than 20m, use the ferrite ring reactor in the power supply side. If longer than 20m, use it in the output side.
Filter capacitor for reducing radio interference	Reduces noise. For frequencies in the AM radio frequency band of 1MHz or less, a noise reduction effect can be obtained. Absolutely never connect this device to the inverter's output side.
DC REACTOR (DCR)	[Use the DCR to normalize the power supply in the following cases.] 1. The power transformer capacity is 500kVA or over and exceeds the inverter rated capacity by 10 times. 2. The inverter and a thyristor converter are connected with the same transformer. *Check if the thyristor converter uses a commutation reactor. If not, AC reactor must be connected to the power supply side. 3. Overvoltage trip occurs due to open/close of the phase-advancing capacitor for the power supply lines. 4. The voltage unbalance exceeds 2%. Voltage unbalance (%) = $\frac{\text{Max. voltage (V)– Min. voltage (V)}}{\text{Three-phase average voltage (V)}} \times 67$ (IEC 61800-3 (5.2.3))  [For improving input power-factor, reducing harmonics] • Used to reduce input harmonic current (correcting power-factor)
Braking resistor	Used to increase the braking capability when the motor needs to start and stop frequently or when the moment of inertia is large.
Output circuit filter	This filter is connected to the output circuit of inverters, and has the following functions: 1. Suppressing fluctuation of motor terminal voltage Protects the motor insulation from being damaged by surge voltage. 2. Suppressing leakage current from output side wiring Reduces the leakage current caused when several motors are operated in parallel or connected with long wiring. 3. Suppressing radiation noise or inductive noise from output side wiring Effective noise suppression device for long wiring applications such as plant * There are two kinds of filters for 400V series. Choose a desired one according to the purpose of use.
RS485 communications card	This makes communication to a PLC or personal computer system easy.
Remote operation extension cable	Used to connect the RS485 communications card with the remote keypad, USB-RS485 converter, etc.
Remote keypad	Used when performing inverter remote operations with the remote keypad.
Copy adaptor	Allows copying data to multiple inverters with easy connection to the inverter body.
Connector adaptor	Used for the connector replacement of the copy adaptor.
Inverter support loader software	Inverter support loader software, Windows based, that makes setting of function codes easy.
USB-RS485 converter	Used to connect the RS485 communications card with a USB port of your personal computer. Manufacturer: System Sacom Sales Corp. Phone: +81-3-5623-5933 Web site: http://www.sacom.co.jp
NEMA1 kit	NEMA1 kit protects the inverter body with the structure that conforms to the NEMA1 standard (approved as UL TYPE1).
Attachments	Permit change of protective structure, replacement of Fuji's previous inverter model and installation on the DIN rails, etc.

ค.3 คุณสมบัติของอินเวอร์เตอร์ FUJI รุ่น FRENIC-Mini Model:FRN3. 7C1S-4A

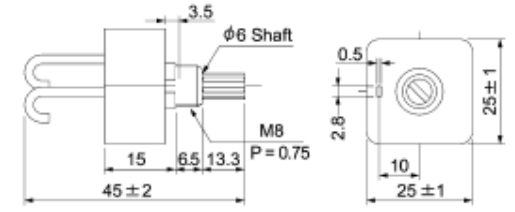
Currents Flowing through Inverter

Power supply voltage	Applicable motor rating (kW)	200 V/400 V (380 V), 50 Hz				220 V (200 V)/440 V (380 V), 60 Hz			
		Input RMS current (A) DC reactor (DCR)		DC link bus current (A)	Braking resistor circuit current (A)	Input RMS current (A) DC reactor (DCR)		DC link bus current (A)	Braking resistor circuit current (A)
		w/ DCR	w/o DCR			w/ DCR	w/o DCR		
Three-phase 200 V	0.1	0.57	1.1	0.70	-	0.51 (0.55)	1.1 (1.1)	0.62 (0.67)	-
	0.2	0.93	1.7	1.1	-	0.85 (0.92)	1.7 (1.8)	1.0 (1.1)	-
	0.4	1.6	3.0	2.0	1.2	1.5 (1.6)	3.0 (3.0)	1.8 (2.0)	1.2
	0.75	3.0	5.1	3.7	1.6	2.8 (3.0)	5.0 (5.3)	3.4 (3.7)	1.6
	1.5	5.7	9.4	7.0	3.6	5.2 (5.6)	9.0 (9.5)	6.3 (6.9)	3.6
	2.2	8.3	13.0	10.2	3.5	7.6 (8.3)	12.3 (13.2)	9.3 (10.1)	3.5
	3.7, 4.0	14.0	22.2	17.2	4.1	12.7 (13.9)	20.6 (22.2)	15.6 (17.0)	4.1
Three-phase 400 V	0.4	0.81 (0.85)	1.6 (1.7)	0.99 (1.0)	0.8	0.74 (0.85)	1.7 (1.7)	0.91 (1.0)	0.8
	0.75	1.5 (1.6)	2.9 (3.0)	1.8 (1.9)	1.1	1.4 (1.6)	3.0 (3.0)	1.7 (2.0)	1.1
	1.5	2.9 (3.0)	5.7 (5.7)	3.5 (3.6)	1.8	2.6 (3.0)	5.1 (5.9)	3.2 (3.6)	1.8
	2.2	4.2 (4.4)	7.9 (7.9)	5.1 (5.3)	1.8	3.8 (4.3)	7.1 (8.2)	4.6 (5.3)	1.8
	3.7, 4.0	7.0 (7.3)	12.5 (13.0)	8.6 (9.0)	2.1	6.4 (7.3)	11.1 (12.9)	7.8 (8.9)	2.1
Single-phase 200 V	0.1	1.1	1.8	1.1	-	1.0 (1.1)	1.8 (1.8)	1.0 (1.1)	-
	0.2	2.0	3.2	2.0	-	1.8 (1.9)	3.1 (3.2)	1.8 (1.9)	-
	0.4	3.5	5.2	3.5	0.82	3.1 (3.4)	5.0 (5.4)	3.1 (3.4)	0.82
	0.75	6.4	9.5	6.4	1.4	5.8 (6.3)	9.1 (9.7)	5.8 (6.3)	1.4
	1.5	11.7	16.0	11.7	1.4	10.5 (11.3)	15.5 (16.4)	10.5 (11.3)	1.4
	2.2	17.5	24.2	17.5	1.7	15.8 (17.0)	23.4 (24.8)	15.8 (17.0)	1.7

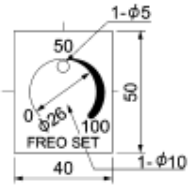
External potentiometer for frequency setting

An external potentiometer may be used to set the drive frequency. Connect the potentiometer to control signal terminals [11] to [13] of the inverter

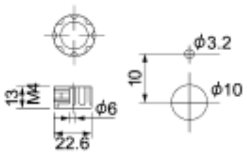
Model: RJ-13 (BA-2 B-characteristics, 1 kΩ)



Dial plate type: YS549810-0

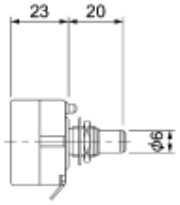


Knob type: MSS-2SB

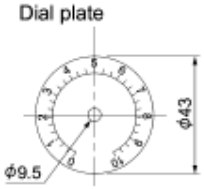


Note: The dial plate and knob must be ordered as separated items.
Available from Fuji Electric Technica Co., Ltd.

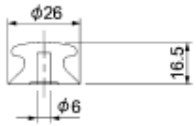
Model: WAR3W (3W B-characteristics, 1 kΩ)



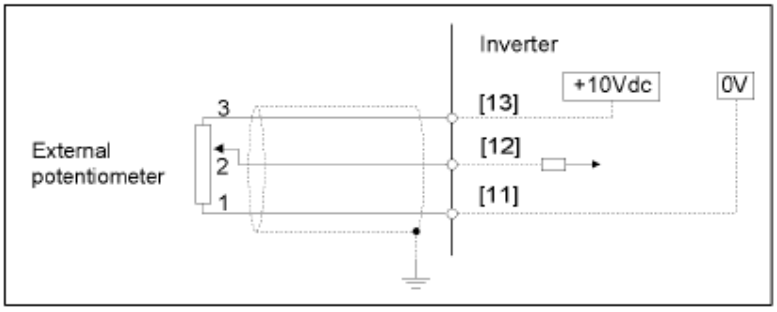
Dial plate



Knob



Note: The dial plate and knob are supplied together with the external potentiometer WAR3W.
Available from Fuji Electric Technica Co., Ltd.

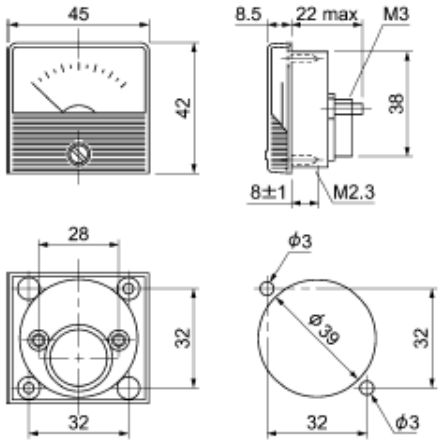


External Potentiometer Dimensions and Connection Example

Frequency meters

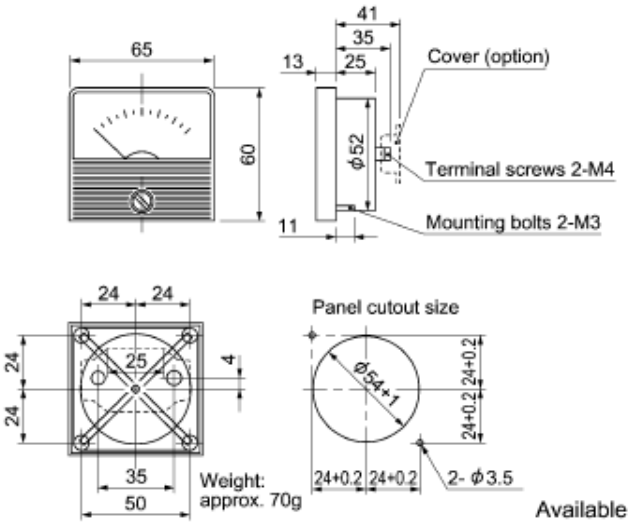
Connect a frequency meter to analog signal output terminals [FMA] (+) and [11] (-) of the inverter to measure the frequency component selected by function code F31

Model: TRM-45 (10 VDC, 1 mA)

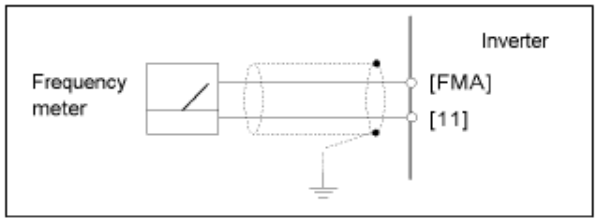


Available from Fuji Electric Technica Co., Ltd.

Model: FM-60 (10 VDC, 1 mA)



Available from Fuji Electric Technica Co., Ltd.



Frequency Meter Dimensions and Connection Example

Standard Models

In the European version, these models listed in Section 8.1 are available on order.

Three-phase 200 V series

Item			Specifications						
Power supply voltage			Three-phase 200 V						
Type (FRN _ _ _ C1S-2□)			0.1	0.2	0.4	0.75	1.5	2.2	3.7
Applicable motor rating (kW)		*1	0.1	0.2	0.4	0.75	1.5	2.2	3.7, 4.0
Output Ratings	Rated capacity (kVA)	*2	0.3	0.57	1.1	1.9	3.0	4.1	6.4
	Rated voltage (V)	*3	Three-phase, 200 V/50 Hz, 200 V, 220 V, 230 V/60 Hz						
	Rated current (A)	*4	0.8 (0.7)	1.5 (1.4)	3.0 (2.5)	5.0 (4.2)	8.0 (7.0)	11.0 (10.0)	17.0 (16.5)
	Overload capability		150 % of rated output current for 1 min. 200 % of rated output current for 0.5 s						
	Rated frequency (Hz)		50, 60 Hz						
Input Ratings	Phases, voltage, frequency		Three-phase, 200 to 240 V, 50/60 Hz						
	Voltage and frequency variations		Voltage : +10 to -15 % (Interphase voltage unbalance*10: 2 % or less) Frequency: +5 to -5 %						
	Momentary voltage dip capability	*5	When the input voltage is 165 V or more, the inverter may keep running. Even if it drops below 165 V, the inverter may keep running for 15 ms.						
	Rated current (A)	(w/ DCR) *6	0.57	0.93	1.6	3.0	5.7	8.3	14.0
		(w/o DCR) *6	1.1	1.8	3.1	5.3	9.5	13.2	22.2
	Required power supply capacity (kVA)	*7	0.2	0.3	0.6	1.1	2.0	2.9	4.9
Braking	Torque (%)	*8	150		100		50	30	
	Torque (%)	*9	-		150				
	DC injection braking		Starting frequency: 0.0 to 60.0 Hz Braking time: 0.0 to 30.0 s Braking level: 0 to 100 % of rated current						
Enclosure (IEC60529)			IP20, UL open type*11						
Cooling method			Natural cooling				Fan cooling		
Mass (kg)			0.6	0.6	0.6	0.7	1.7	1.7	2.3

*1 Fuji 4-pole standard motors

*2 The rated capacity is for 220 V output voltage.

*3 Output voltages cannot exceed the power supply voltage.

*4 Use the inverter at the current given in ( ) or below when the carrier frequency is higher than 4 kHz (*F 26 =4 to 15*) or the ambient temperature is 40°C or higher.

*5 Tested under the standard load condition (85% load for applicable motor rating).

*6 Calculated under Fuji-specified conditions.

*7 Indicates the value when using a DC reactor (option).

*8 Average braking torque obtained with the AVR control off (*F 05 =0*). (Varies according to the efficiency of the motor.)

*9 Average braking torque obtained by use of an external braking resistor (standard type available as option).

*10 $\text{Interphase voltage unbalance (\%)} = \dfrac{\text{Max.voltage (V) - Min.voltage (V)}}{\text{3-phase average voltage (V)}} \times 67$ (Refer to IEC 61800-3 (5.2.3))

If this value is 2 to 3 %, use an AC reactor (ACR).

*11 Making FRENIC-Mini conform to category TYPE1 of the UL Standard (or NEMA1) requires an optional NEMA1 kit. Note that the TYPE1-listed FRENIC-Mini should be used in the ambient temperature range from -10 to +40°C.

Three-phase 400 V series

Item			Specifications				
Power supply voltage			Three-phase 400 V				
Type (FRN _ _ _ C1S-4□)			0.4	0.75	1.5	2.2	3.7, 4.0
Applicable motor rating (kW)		*1	0.4	0.75	1.5	2.2	3.7, 4.0
Output Ratings	Rated capacity (kVA)	*2	1.1	1.9	2.8	4.1	6.8
	Rated voltage (V)	*3	Three-phase, 380, 400, 415 V/50 Hz, 380, 400, 440, 460 V/60 Hz				
	Rated current (A)		1.5	2.5	3.7	5.5	9.0
	Overload capability		150 % of rated output current for 1 min. 200 % of rated output current for 0.5 s				
	Rated frequency (Hz)		50, 60 Hz				
Input Ratings	Phases, voltage, frequency		Three-phase, 380 to 480 V, 50/60 Hz				
	Voltage and frequency variations		Voltage : +10 to -15 % (Interphase voltage unbalance*9: 2 % or less) Frequency: +5 to -5 %				
	Momentary voltage dip capability	*4	When the input voltage is 300 V or more, the inverter may keep running. Even if it drops below 300 V, the inverter may keep running for 15 ms.				
	Rated current (A)	(w/ DCR)	0.85	1.6	3.0	4.4	7.3
		*5 (w/o DCR)	1.7	3.1	5.9	8.2	13.0
	Required power supply capacity (kVA)	*6	0.6	1.1	2.0	2.9	4.9
Braking	Torque (%)	*7	100		50	30	
	Torque (%)	*8	150				
	DC injection braking		Starting frequency: 0.0 to 60.0 Hz Braking time: 0.0 to 30.0 s Braking level: 0 to 100 % of rated current				
Enclosure (IEC60529)			IP20, UL open type*10				
Cooling method			Natural cooling		Fan cooling		
Mass (kg)			1.1	1.2	1.7	1.7	2.3

*1 Fuji 4-pole standard motors

*2 The rated capacity is for 440 V output voltage.

*3 Output voltages cannot exceed the power supply voltage.

*4 Tested under the standard load condition (85% load for applicable motor rating).

*5 Calculated under Fuji-specified conditions.

*6 Indicates the value when using a DC reactor (option).

*7 Average braking torque obtained with the AVR control off (*F 05 =0*). (Varies according to the efficiency of the motor.)

*8 Average braking torque obtained by use of an external braking resistor (standard type available as option).

*9 $$\text{Interphase voltage unbalance (\%)} = \frac{\text{Max.voltage (V) - Min.voltage (V)}}{\text{3-phase average voltage (V)}} \times 67$$ (Refer to IEC 61800-3 (5.2.3))

If this value is 2 to 3 %, use an AC reactor (ACR).

*10 Making FRENIC-Mini conform to category TYPE1 of the UL Standard (or NEMA1) requires an optional NEMA1 kit. Note that the TYPE1-listed FRENIC-Mini should be used in the ambient temperature range from -10 to +40°C.

Single-phase 200 V series

Item			Specifications					
Power supply voltage			Single-phase 200 V					
Type (FRN _ _ _C1S-7□)			0.1	0.2	0.4	0.75	1.5	2.2
Applicable motor rating (kW)		*1	0.1	0.2	0.4	0.75	1.5	2.2
Output Ratings	Rated capacity (kVA)	*2	0.3	0.57	1.1	1.9	3.0	4.1
	Rated voltage (V)	*3	Three-phase, 200 V/50 Hz, 200 V, 220 V, 230 V/60 Hz					
	Rated current (A)	*4	0.8 (0.7)	1.5 (1.4)	3.0 (2.5)	5.0 (4.2)	8.0 (7.0)	11.0 (10.0)
	Overload capability		150 % of rated output current for 1 min. 200 % of rated output current for 0.5 s					
	Rated frequency (Hz)		50, 60 Hz					
Input Ratings	Phases, voltage, frequency		Single-phase, 200 to 240 V, 50/60 Hz					
	Voltage and frequency variations		Voltage : +10 to -10 % Frequency: +5 to -5 %					
	Momentary voltage dip capability	*5	When the input voltage is 165 V or more, the inverter may keep running. Even if it drops below 165 V, the inverter may keep running for 15 ms.					
	Rated current (A)	*6 (w/ DCR)	1.1	2.0	3.5	6.4	11.6	17.5
		*6 (w/o DCR)	1.8	3.3	5.4	9.7	16.4	24.8
	Required power supply capacity (kVA)	*7	0.3	0.4	0.7	1.3	2.4	3.5
Braking	Torque (%)	*8	150		100		50	30
	Torque (%)	*9	-		150			
	DC injection braking		Starting frequency: 0.0 to 60.0 Hz Braking time: 0.0 to 30.0 s Braking level: 0 to 100 % of rated current					
Enclosure (IEC60529)			IP20, UL open type*10					
Cooling method			Natural cooling				Fan cooling	
Mass (kg)			0.6	0.6	0.6	0.8	1.6	2.3

*1 Fuji 4-pole standard motors

*2 The rated capacity is for 220 V output voltage.

*3 Output voltages cannot exceed the power supply voltage.

*4 Use the inverter at the current given in ( ) or below when the carrier frequency is higher than 4 kHz (*F 26 =4 to 15*) or the ambient temperature is 40°C or higher.

*5 Tested under the standard load condition (85% load for applicable motor rating).

*6 Calculated under Fuji-specified conditions.

*7 Indicates the value when using a DC reactor (option).

*8 Average braking torque obtained with the AVR control off (*F 05 =0*). (Varies according to the efficiency of the motor.)

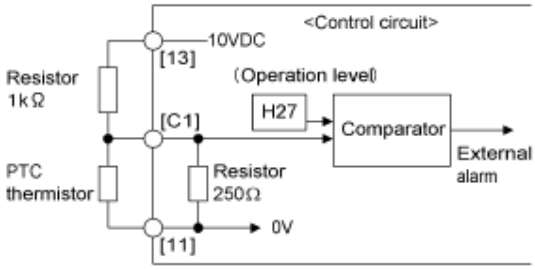
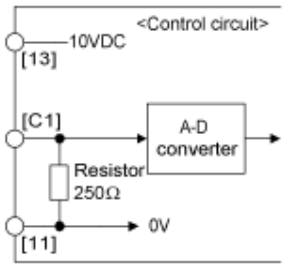
*9 Average braking torque obtained by use of an external braking resistor (standard type available as option).

*10 Making FRENIC-Mini conform to category TYPE1 of the UL Standard (or NEMA1) requires an optional NEMA1 kit. Note that the TYPE1-listed FRENIC-Mini should be used in the ambient temperature range from -10 to +40°C.

Terminal functions

Main circuit and analog input terminals

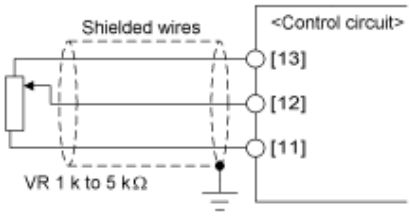
Classification	Symbol	Name	Functions	Related function codes
Main circuit	L1/R, L2/S, L3/T	Main circuit power input	Connects a three-phase power supply. (three-phase 200V, 400V series)	
	L1/L, □, L2/N		Connects a single-phase power supply. □ indicates the no connection terminal. (Single-phase 200V series)	
	U, V, W	Inverter output	Connects a three-phase induction motor.	
	P1, P(+)	For DC reactor	Connects a DC reactor.	
	P(+), N(-)	DC link bus	Connects a DC power device.	
	P(+), DB	For braking resistor	Used for connection of the optional external braking resistor. (Wiring is required even for the braking resistor built-in type.)	
	⏚ G	Grounding	Grounding terminal for inverter chassis (Two terminals are provided.)	
Analog input	[13]	Potentiometer power supply	Power supply (+10 VDC) for frequency command potentiometer (Potentiometer: 1 to 5 kΩ) Allowable maximum output current: 10 mA	
	[12]	Voltage input (Normal operation) (Inverse operation)	The frequency is set according to the external analog input voltage. 0 to +10 VDC/0 to 100 % 0 to +5 VDC/0 to 100 % or +1 to +5 VDC/0 to 100 % can be selected by function code setting. +10 to 0 VDC/0 to 100 % (switchable by digital input signal)	F18, C32 to C34
		(PID control)	Used for reference signal (PID process command) or PID feedback signal.	E61
		(Frequency auxiliary setting)	Used as additional auxiliary setting to various main settings of frequency.	E61
		Electric characteristics of terminal [12] • Input impedance: 22 kΩ • Allowable maximum input voltage: 15 VDC (If the input voltage is +10 VDC or over, the inverter assumes it to be +10 VDC.)		
	[C1]	Current input (Normal operation) (Inverse operation)	The frequency is set according to the external analog input current command. +4 to +20 mADC/0 to 100% +20 to +4 mADC/0 to 100 % (switchable by digital input signal)	F18, C37 to C39
		(PID control)	Used for reference signal (PID process command) or PID feedback signal.	E62

<table>
<tr><th>Classification</th><th>Symbol</th><th>Name</th><th>Functions</th><th>Related function codes</th></tr>
<tr><td rowspan="4">Analog input</td><td rowspan="3">[C1]</td><td>(For PTC thermistor)</td><td>Connects a PTC thermistor for motor protection.
(Connect an 1 kΩ external resistor to terminal [13] - [C1].)
 
</td><td>H26, H27</td></tr>
<tr><td>(Frequency auxiliary setting)</td><td>Used as additional auxiliary setting to various main settings of frequency.</td><td>E62</td></tr>
<tr><td colspan="2">Electric characteristics of terminal [C1]
• Input impedance: 250 Ω
• Allowable maximum input current: +30 mADC
(If the input current exceeds +20 mADC, the inverter will limit it at +20 mADC.)
 
</td><td></td></tr>
<tr><td>[11]</td><td>Analog common</td><td>Common for analog input signals ([13], [12], [C1])
(Isolated from terminals [CM] and [Y1E].)</td><td></td></tr>
</table>

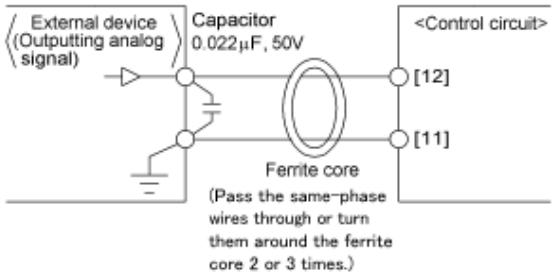
Classification	Symbol	Name	Functions	Related function codes
Analog input				

Note

- Since weak analog signals are handled, these signals are especially susceptible to the external noise effects. Route the wiring as short as possible (within 20 m) and use shielded wires. In principle, ground the shielding layer of the shielded wires; if effects of external inductive noises are considerable, connection to terminal [11] may be effective. As shown in Figure 8.1, ground the single end of the shield to enhance the shielding effect.
- Use a twin contact relay for weak signals if the relay is used in the control circuit. Do not connect the relay's contact to terminal [11].
- When the inverter is connected to an external device outputting the analog signal, a malfunction may be caused by electric noise generated by the inverter. If this happens, according to the circumstances, connect a ferrite core (a toroidal core or an equivalent) to the device outputting the analog signal and/or connect a capacitor having the good cut-off characteristics for high frequency between control signal wires as shown in Figure 8.2.
- Do not apply a voltage of +7.5 VDC or higher to terminal [C1]. Doing so could damage the internal control circuit.

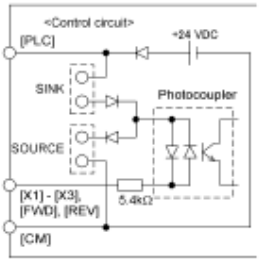


Connection of Shielded Wire



Example of Electric Noise Prevention

Digital input terminals

<table>
<tr><th>Classification</th><th>Symbol</th><th>Name</th><th>Functions</th><th>Related function codes</th></tr>
<tr><td rowspan="6">Digital input</td><td>[X1]</td><td>Digital input 1</td><td rowspan="5">The following features can be set to terminals [X1] - [X3], [FWD] and [REV] and the commands function according to the input signals at the terminals.
The commands (FWD) and (REV) are factory setting assigned at terminals [FWD] and [REV], respectively.
Common features
• Sink/Source switching feature:
Sink and source can be switched by using the built-in jumper switch.
• Normal/negative logic input switching feature:
Switches the logic value (1/0) for ON/OFF of terminals between [X1] to [X3], [FWD] or [REV], and [CM]. If the logic value for ON between [X1] and [CM] is 1 in the normal logic system, for example, OFF is 1 in the negative logic system.
Digital input circuit specifications
 

<table>
<tr><th colspan="2">Item</th><th>Min.</th><th>Max.</th></tr>
<tr><td rowspan="2">Operation voltage (SINK)</td><td>ON level</td><td>0V</td><td>2V</td></tr>
<tr><td>OFF level</td><td>22V</td><td>27V</td></tr>
<tr><td rowspan="2">Operation voltage (SOURCE)</td><td>ON level</td><td>22V</td><td>27V</td></tr>
<tr><td>OFF level</td><td>0V</td><td>2V</td></tr>
<tr><td colspan="2">Operation current at ON (Input voltage at 0 V)</td><td>2.5mA</td><td>5mA</td></tr>
<tr><td colspan="2">Allowable leakage current at OFF</td><td>-</td><td>0.5mA</td></tr>
</table></td><td rowspan="4">E01 to E03

E98, E99</td></tr>
<tr><td>[X2]</td><td>Digital input 2</td></tr>
<tr><td>[X3]</td><td>Digital input 3</td></tr>
<tr><td>[FWD]</td><td>Forward operation command</td></tr>
<tr><td>[REV]</td><td>Reverse operation command</td></tr>
<tr><td>[PLC]</td><td>PLC signal power</td><td>Connects to PLC output signal power supply.
(Rated voltage: +24 VDC, Maximum output current: 50 mA)</td><td></td></tr>
<tr><td>[CM]</td><td>Digital common</td><td>Common for digital input signals
(Isolated from terminals [11] and [Y1E].)</td><td></td></tr>
</table>

Classification	Symbol	Name	Functions	Related function codes

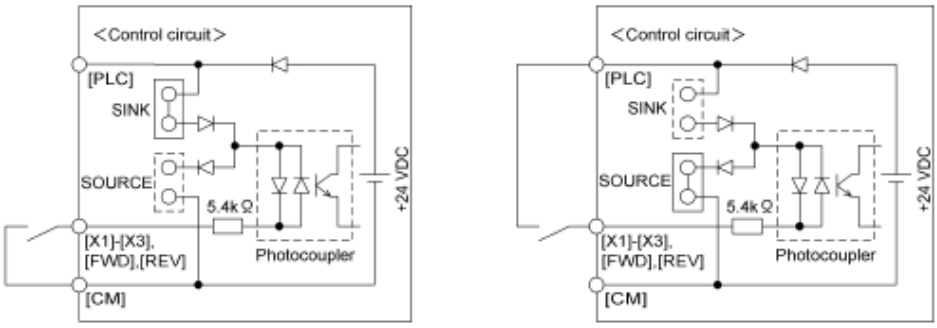
Digital input

Tip

■ **Turning ON or OFF [X1], [X2], [X3], [FWD], or [REV] using a relay contact**

Figure 8.3 shows two examples of a circuit that turns ON or OFF control signal input [X1], [X2], [X3], [FWD], or [REV] using a relay contact. Circuit (a) has a connecting jumper applied to SINK, whereas circuit (b) has it applied to SOURCE.

NOTE: To configure this kind of circuit, use a highly reliable relay (Recommended product: Fuji control relay Model HH54PW.)



(a) With a jumper applied to SINK (b) With a jumper applied to SOURCE

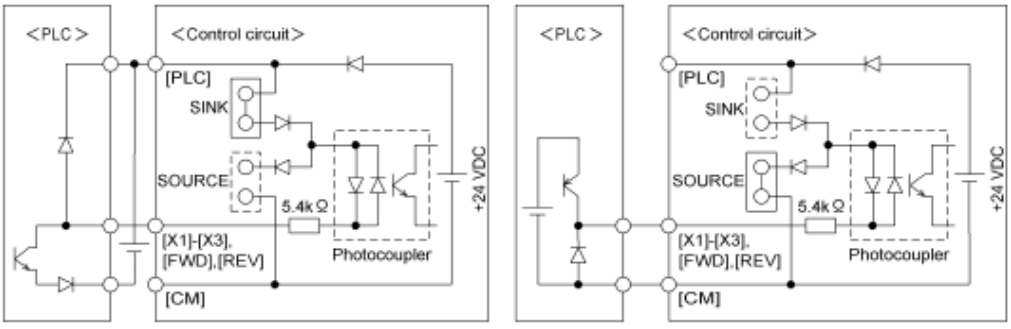
Circuit Configuration Using a Relay Contact

■ **Turning ON or OFF [X1], [X2], [X3], [FWD], or [REV] using a programmable logic controller (PLC)**

Figure 8.4 shows two examples of a circuit that turns ON or OFF control signal input [X1], [X2], [X3], [FWD], or [REV] using a programmable logic controller (PLC). Circuit (a) has a connecting jumper applied to SINK, whereas circuit (b) has it applied to SOURCE.

In circuit (a) below, short-circuiting or opening the transistor's open collector circuit in the PLC using an external power source turns ON or OFF control signal [X1], [X2], [X3], [FWD], or [REV]. When using this type of circuit, observe the following:

- Connect the + node of the external power source (which should be isolated from the PLC's power) to terminal [PLC] of the inverter.
- Do not connect terminal [CM] of the inverter to the common terminal of the PLC.



(a) With a jumper applied to SINK (b) With a jumper applied to SOURCE

Circuit Configuration Using a PLC

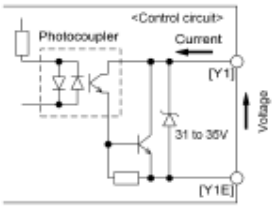
■ Commands assigned at digital input terminals

<table>
<tr><th>Classification</th><th>Command</th><th>Command name</th><th>Functions</th><th>Related function codes</th></tr>
<tr><td rowspan="5">Commands assigned on digital input terminals</td><td>(FWD)</td><td>Run forward command</td><td>[FWD] - [CM] ON: The motor runs forward.
[FWD] - [CM] OFF: The motor decelerates and stops.
When the [FWD] - [CM] and [REV] - [CM] are simultaneously ON, the inverter immediately decelerates and stops the motor. This command can be set only for terminals [FWD] and [REV].</td><td>E98 = 98</td></tr>
<tr><td>(REV)</td><td>Run reverse command</td><td>[REV] - [CM] ON: The motor runs reverse.
[REV] - [CM] OFF: The motor decelerates and stops.
When [FWD] - [CM] and [REV] - [CM] are simultaneously ON, the inverter immediately decelerates and stops the motor. This command can be set only for terminals [FWD] and [REV].</td><td>E99 = 99</td></tr>
<tr><td>(SS1)
(SS2)
(SS4)</td><td>Multistep frequency selection</td><td>Select 2 (0 and 1) step multi frequency running.
Select 4 (0 to 3) step multi frequency running.
Select 8 (0 to 7) step multi frequency running.
Multistep frequency 0 indicates the frequency set by the keypad, built-in potentiometer or analog signal.
<table><tr><th rowspan="2">Digital input</th><th colspan="8">Multistep frequency</th></tr><tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th></tr><tr><td>(SS1)</td><td>–</td><td>ON</td><td>–</td><td>ON</td><td>–</td><td>ON</td><td>–</td><td>ON</td></tr><tr><td>(SS2)</td><td>–</td><td>–</td><td>ON</td><td>ON</td><td>–</td><td>–</td><td>ON</td><td>ON</td></tr><tr><td>(SS4)</td><td>–</td><td>–</td><td>–</td><td>–</td><td>ON</td><td>ON</td><td>ON</td><td>ON</td></tr></table>Assigns the commands (SS1), (SS2), and (SS4) to terminals [X1], [X2], and [X3], respectively.</td><td>E01 = 0
E02 = 1
E03 = 2
C05 to C11 = 0.00 to 400.0 Hz</td></tr>
<tr><td>(RT1)</td><td>ACC/DEC time selection</td><td>[X1] - [CM]: ON Acceleration and deceleration time 2 is effective.
[X1] - [CM]:OFF Acceleration and deceleration time 1 is effective. (Acceleration and deceleration time by link operation is effective.)
(e.g.) Assigns the command (RT1) to terminal [X1].
Note Switchable during the acceleration or deceleration operation</td><td>E01 = 4
E10, E11 = 0.00 to 3600 s
S08, S09 = 0.00 to 3600 s</td></tr>
<tr><td>(HLD)</td><td>3-wire operation stop command</td><td>Used for 3-wire operation.
[X2] - [CM] ON: The inverter self-holds the command (FWD) or (REV).
[X2] - [CM] OFF: The inverter releases self-holding.
(e.g.) Assigns the command (HLD) to terminal [X2].</td><td>E02 = 6</td></tr>
</table>

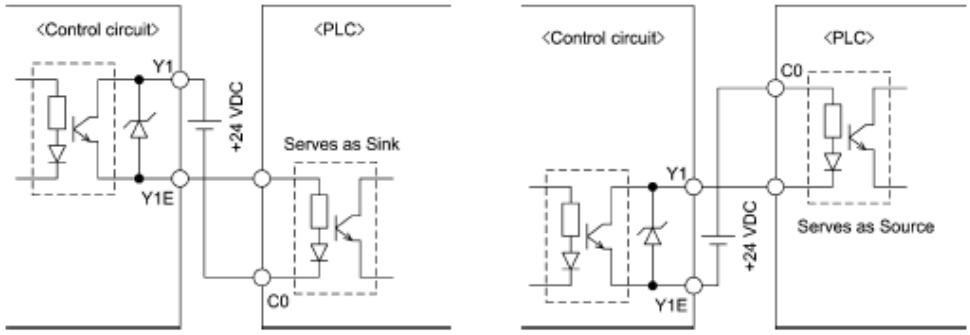
Classification	Command	Command name	Functions	Related function codes
Commands assigned on digital input terminals	(BX)	Coast-to-stop command	[X3] - [CM] ON: The inverter output is stopped immediately and the motor will coast-to-stop. (No alarm signal will be output.) (e.g.) Assigns the command (BX) to terminal [X3].	E03 = 7
	(RST)	Alarm reset	[X1] - [CM] ON: Alarm status is reset. (ON signal should be held for 0.1 s or longer.) (e.g.) Assigns the command (RST) to terminal [X1].	E01 = 8
	(THR)	Alarm from external equipment	[X2] - [CM] OFF: The inverter output is stopped and the motor coasts-to-stop. Alarm signal for the alarm code *OH2* will be output. (e.g.) Assigns the command (THR) to terminal [X2].	E02 = 9
	(JOG)	Jogging operation	[X3] - [CM] ON: Jogging operation is effective. (FWD) or (REV) ON: The inverter runs the motor with jogging frequency. (e.g.) Assigns the command (JOG) to terminal [X3].	E03 = 10 C20 = 0.00 to 400.0 Hz H54 = 0.00 to 3600 s
	(Hz2/Hz1)	Freq. set2/ Freq. set1	[X1] - [CM] ON: Frequency command source 2 is effective. (e.g.) Assigns the command (Hz2/Hz1) to terminal [X1].	E01 = 11 F01 = 0 to 4 C30 = 0 to 4
	(WE-KP)	Write enable for keypad	[X2] - [CM] ON: The function code data can be changed from the keypad. (Data can be changed when this function is not allocated.) (e.g.) Assigns the command (WE-KP) to terminal [X2].	E02 = 19
	(Hz/PID)	PID control cancel	[X3] - [CM] ON: The PID control is cancelled, and the set frequency is set by the Multistep frequency, keypad or analog input. (e.g.) Assigns the command (Hz/PID) to terminal [X3]. For details about J01 to J06 data, refer to Chapter 9, "FUNCTION CODES."	E03 = 20 J01 to J06 F01 = 0 to 4 C30 = 0 to 4
	(IVS)	Inverse mode changeover	[X1] - [CM] ON: Normal mode operation or inverse mode operation can be changed in the frequency command and PID control. (e.g.) Assigns the command (IVS) to terminal [X1].	E01 = 21

Classification	Command	Command name	Functions	Related function codes
Commands assigned on digital input terminals	(LE)	Link enable	[X2] - [CM] ON: The link operation is effective. (RS485 communications card (option) or models available on order) (e.g.) Assigns the command (LE) to terminal [X2].	E02 = 24 H30 = 3 y99 = 1
	(PID-RST)	PID integral/ differential reset	[X3] - [CM] ON: PID integration and differentiation are reset. (e.g.) Assigns the command (PID-RST) to terminal [X3].	E03 = 33
	(PID-HLD)	PID integral hold	[X1] - [CM] ON: PID integration is temporarily stopped. (e.g.) Assigns the command (PID-HLD) to terminal [X1].	E01 = 34

Analog output, transistor output, and relay output terminals

<table>
<tr><th>Classification</th><th>Symbol</th><th>Name</th><th>Functions</th><th>Related function codes</th></tr>
<tr><td rowspan="2">Analog output</td><td>[FMA]</td><td>Analog monitor</td><td>The monitor signal for analog DC voltage (0 to +10 VDC) is output. The signal functions can be selected with the function code F31 from the following.
• Output frequency (before slip compensation)
• Output frequency (after slip compensation)
• Output current • Output voltage
• Input power • PID feedback value
• DC link bus voltage
• Analog output test (+)
(Output voltage: 0 to +10 VDC,
maximum current: 2 mA
Up to two analog voltmeters can be connected.)</td><td>F30, F31</td></tr>
<tr><td>[11]</td><td>Analog common</td><td>Common for analog output signal ([FMA])
This terminal is electrically isolated from terminals [CM] and [Y1E].</td><td></td></tr>
<tr><td rowspan="2">Transistor output</td><td>[Y1]</td><td>Transistor output</td><td>Commands listed below can be assigned to terminal [Y1] and the signal is output according to the command.
Normal/negative logic output switching feature:
Switches the logic value (1/0) for ON/OFF of the terminals between [Y1] and [Y1E]. If the logic value for ON between [Y1] and [Y1E] is 1 in the normal logic system, for example, OFF is 1 in the negative logic system.
Digital output circuit specification
 

<table>
<tr><th colspan="2">Item</th><th>Max.</th></tr>
<tr><td rowspan="2">Operation voltage</td><td>ON level</td><td>2V</td></tr>
<tr><td>OFF level</td><td>27V</td></tr>
<tr><td colspan="2">Maximum load current at ON</td><td>50mA</td></tr>
<tr><td colspan="2">Leakage current at OFF</td><td>0.1mA</td></tr>
</table>
) shows examples of connection between the control circuit and a PLC.
Note • Check the polarity of an external power input.
• To connect a control relay, connect a surge absorbing diode across the coil of the relay.</td><td>E20</td></tr>
<tr><td>[Y1E]</td><td>Transistor output common</td><td>Common for transistor output signal
(Isolated from terminals [CM] and [11].)</td><td></td></tr>
</table>

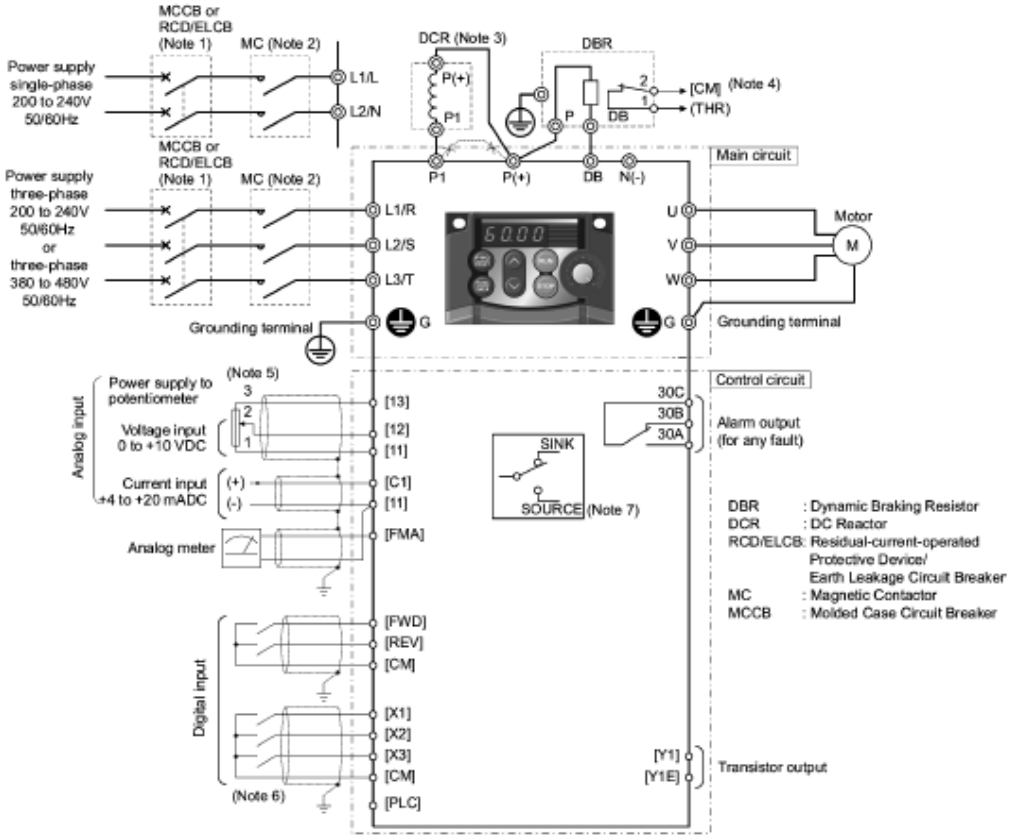
Classification	Symbol	Name	Functions	Related function codes
Transistor output			**■ Connecting Programmable Controller (PLC) to Terminal [Y1]** Figure 8.5 shows two examples of circuit connection between the transistor output of the inverter's control circuit and a PLC. In example (a), the input circuit of the PLC serves as the sink for the control circuit, whereas in example (b), it serves as the source for the control circuit.  (a) PLC serving as Sink (b) PLC serving as Source Connecting PLC to Control Circuit	
Relay output	[30A], [30B], [30C]	Alarm relay output (for any fault)	(1) Outputs a contact signal (SPDT) when a protective function is activated to stop the motor. Contact rating: 250 VAC 0.3A cosϕ = 0.3 +48 VDC, 0.5A (2) Possible to select a command similar to terminal [Y1] for transistor output signal and use it for signal output. (3) The normal/negative logic output changeover is applicable to these contact outputs: "Terminals [30A] and [30C] are short-circuited for ON signal output" or "terminals [30B] and [30C] are short-circuited (non-excite) for ON signal output"	E27

■ Signals assigned at transistor output terminal

Classification	Signal	Signal name	Functions	Related function codes
Signals assigned at transistor output terminal	(RUN)	Inverter running	Comes ON when the output frequency is higher than start frequency.	E20 = 0
	(RUN2)	Inverter output on	Comes ON when the main circuit (gate) is turned ON.	E20 = 35
	(FAR)	Speed/freq. arrival	Comes ON when the motor speed reaches the set frequency. (Condition: Run command is ON.) (Hysteresis width (fixed): 2.5 Hz)	E20 = 1
	(FDT)	Speed/freq. detection	Comes ON when the output frequency is above the detection level and goes OFF when below the detection level. (Hysteresis width (fixed): 1.0 Hz)	E20 = 2 E31
	(LU)	undervoltage detection	Comes ON when the inverter stops its output because of undervoltage while the run command is ON.	E20 = 3
	(IOL)	Inverter output limit (limit on current)	Comes ON when the inverter is limiting the current.	E20 = 5 F43, F44
	(IPF)	Auto-restarting	Comes ON during auto-restarting operation (after instantaneous power failure and until completion of restart).	E20 = 6 F14
	(OL)	Overload early warning (for motor)	Comes ON when the calculated value of electronic thermal relay is higher than the preset alarm level.	E20 = 7 F10 to F12
	(TRY)	Auto-resetting	Comes ON during auto-resetting mode.	E20 = 26 H04, H05
	(LIFE)	Lifetime alarm	Outputs alarm signal according to the preset lifetime level.	E20 = 30 H42, H43
	(OLP)	Overload preventive control	Comes ON during inverter control for avoiding overload.	E20 = 36 H70
	(ID)	Current detection	Comes ON when a current larger than the set value has been detected for the timer-set time.	E20 = 37 E34, E35
	(IDL)	Small current detection	Comes ON when a current smaller than the set value has been detected for the timer-set time.	E20 = 41 E34, E35
	(ALM)	Alarm relay (for any fault)	Alarm signal is output as the transistor output signal.	E20 = 99

Operation by external signal inputs

The basic connection diagram below shows an example for operation by external input signals.



(Note 1) Install a recommended molded case circuit breaker (MCCB) or a residual-current-operated protective device (RCD)/earth leakage circuit breaker (ELCB) (with overcurrent protection) in the primary circuit of the inverter to protect wiring. At this time, ensure that the circuit breaker capacity is equivalent to or lower than the recommended capacity.

(Note 2) A magnetic contactor (MC) should, if necessary, be mounted independent of the MCCB or ELCB to cut off the power fed to the inverter. Refer to page 6-7 for details. MCs or solenoids that will be installed close to the inverter require surge absorbers to be connected in parallel to their coils.

(Note 3) When connecting a DC reactor (optional accessory), remove the jumper bar from terminals [P1] and [P+].

(Note 4) (THR) function can be used by assigning code "9" (Alarm from external equipment) to any of terminals [X1] to [X3], [FWD] or [REV] (function code E01 to E03, E98, or E99). For details, refer to Chapter 9.

(Note 5) Frequency can be set by connecting a frequency setting device (external potentiometer) between the terminals [11], [12], and [13] instead of inputting voltage signal (0 to +10 VDC or 0 to +5 VDC) between the terminals [12] and [11].

(Note 6) For the wiring of the control circuit, use shielded or twisted wires. When using shielded wires, connect the shields to earth. To prevent malfunction due to noise, keep the control circuit wiring away from the main circuit wiring as far as possible (recommended: 10 cm or longer), and never set them in the same wire duct. When crossing the control circuit wiring with the main circuit wiring, set them at right angles.

(Note 7) In the EU version except the three-phase 200 V series of inverter, the digital input terminals are switched to the SOURCE side.

F codes: Fundamental Functions

Code	Name	Data setting range	Increment	Unit	Change when running	Data copy	Default setting	Refer to:
F00	Data Protection	0: Disable data protection (Function code data can be edited.) 1: Enable data protection (Function code data cannot be edited.)	—	—	Y	N	0	9-12
F01	Frequency Command 1	0: Enable ▲ and ▼ keys on the built-in keypad 1: Enable the voltage input to terminal [12] 2: Enable the current input to terminal [C1] 3: Enable the sum of voltage and current inputs to terminals [12] and [C1] 4: Enable the built-in potentiometer (POT)	—	—	N	Y	4	9-12
F02	Running/Stopping and Rotational Direction	0: Enable RUN and STOP keys on the built-in keypad to run and stop motor (The (FWD) or (REV) command should be ON for forward or reverse rotation.) 1: Enable the external signal command (FWD) or (REV) command to run motor 2: Enable RUN and STOP keys on the built-in keypad to run/stop motor forward 3: Enable RUN and STOP keys on the built-in keypad to run/stop motor reverse	—	—	N	Y	2	9-13
F03	Maximum Frequency	25.0 to 400.0	0.1	Hz	N	Y	60.0 (50.0)*1	9-14
F04	Base Frequency	25.0 to 400.0	0.1	Hz	N	Y	60.0 (50.0)*1	9-15
F05	Rated Voltage (at Base Frequency)	0: Output a voltage in line with variance in input voltage 80 to 240: Output a voltage AVR-controlled *3 (Note 1) 160 to 500: Output a voltage AVR-controlled *3 (Note 2)	1	V	N	Y2	0	9-15
F07	Acceleration Time 1	0.00 to 3600 Note: Acceleration time is ignored at 0.00. (External gradual acceleration pattern)	0.01	s	Y	Y	6.00	9-17
F08	Deceleration Time 1	0.00 to 3600 Note: Deceleration time is ignored at 0.00. (External gradual deceleration pattern)	0.01	s	Y	Y	6.00	9-17
F09	Torque Boost	0.0 to 20.0 (The set voltage at base frequency for F05 is 100%.) Note: This setting is effective for auto torque boost/auto energy saving operations specified by function code F37 (= 0, 1, 3, or 4).	0.1	%	Y	Y	Fuji's *2 standard torque boost	9-17
F10	Electronic Thermal Overload for Motor Protection (Select motor characteristics)	1: For general-purpose motors with built-in self-cooling fan 2: For inverter-driven motors or high-speed motors with forced-ventilation fan	—	—	Y	Y	1	9-18
F11	(Overload detection level)	0.00 (Disable) 1 to 135% of rated current (allowable continuos load current) of the inverter	0.01	A	Y	Y1 Y2	Nominal *2 rated current of Fuji standard motor	

Code	Name	Data setting range	Increment	Unit	Change when running	Data copy	Default setting	Refer to:
F12	(Thermal time constant)	0.5 to 75.0	0.1	min	Y	Y	5.0	9-18
F14	Restart Mode after Instantaneous Power Failure	0: Disable (Trip immediately without restart) 1: Disable (Trip without restart after recovery of power) 4: Enable (Restart at the frequency at which the power failure occurred, for general load) 5: Enable (Restart at the start frequency, for low-inertia load)	—	—	Y	Y	1 (0)*1	9-19
F15	Frequency Limiter (High)	0.0 to 400.0	0.1	Hz	Y	Y	70.0	9-21
F16	(Low)	0.0 to 400.0	0.1	Hz	Y	Y	0.0	
F18	Bias (for frequency command 1)	-100.00 to 100.00	0.01	%	Y*	Y	0.00	9-22
F20	DC Braking (Start frequency)	0.0 to 60.0	0.1	Hz	Y	Y	0.0	9-23
F21	(Braking level)	0 to 100 (Rated output current of the inverter interpreted as 100%.)	1	%	Y	Y	0	
F22	(Braking time)	0.00 (Disable), 0.01 to 30.00	0.01	s	Y	Y	0.00	
F23	Start Frequency	0.1 to 60.0	0.1	Hz	Y	Y	1.0	9-25
F25	Stop Frequency	0.1 to 60.0	0.1	Hz	Y	Y	0.2	9-25
F26	Motor Sound (Carrier frequency)	0.75 to 15	1	kHz	Y	Y	2 (15)*1	9-25
F27	(Tone)	0: Level 0 1: Level 1 2: Level 2 3: Level 3	—	—	Y	Y	0	9-26
F30	Terminal [FMA] (Gain to output voltage)	0 to 200 If 100 is set, +10 VDC will be output from [FMA] at full scale.	1	%	Y*	Y	100	9-26
F31	Analog Output Signal Selection for [FMA] (Monitor object)	0: Output frequency 1 (before slip compensation) Maximum output frequency at full scale 1: Output frequency 2 (after slip compensation) Maximum output frequency at full scale 2: Output current Two times the inverter's rated output current at full scale 3: Output voltage 250 V (500 V) at full scale 6: Input power Two times the inverter's rated output capacity at full scale 7: PID feedback value Feedback value is 100% at full scale 9: DC link bus voltage 500 VDC (for 200 V series), 1000 VDC (for 400 V series) at full scale 14: Test analog output (+) voltage If F30 = 100, +10 VDC at full scale	—	—	Y	Y	0	9-26

Code	Name	Data setting range	Incre-ment	Unit	Change when running	Data copy	Default setting	Refer to:
F37	Load Selection/ Auto Torque Boost/ Auto Energy Saving Operation	0: Variable torque load 1: Constant torque load 2: Auto-torque boost 3: Auto-energy saving operation (Variable torque load during acceleration and deceleration) 4: Auto-energy saving operation (Constant torque load during acceleration and deceleration) 5: Auto-energy saving operation (Auto-torque boost during acceleration and deceleration)	—	—	N	Y	1	9-27
F43	Current Limiter (Operation condition)	0: Disable 1: In constant speed (Disable during acceleration and deceleration) 2: At acceleration and in constant speed (Disable during deceleration)	—	—	Y	Y	0	9-28
F44	(Limiting level)	20 to 200 (The data is interpreted as the rated output current of the inverter for 100%.)	1	%	Y	Y	200	
F50	Electronic Thermal Overload Relay (for braking resistor) (Discharging capability)	0: (To be set for braking resistor built-in type) 1 to 900 999: (Disable)	1	kWs	Y	Y	999/0 (Note)	9-28
F51	(Allowable loss)	0.000: Applied for built-in braking resistor, 0.001 to 50.000	0.001	kW	Y	Y	0.000	