

Information on characteristic diagram calculation FSE motor typ A2370DD

There are 3 different diagrams available. Because the magnet properties and losses of the motor change depending on the motor temperature.

Base: 80° motor temperature

Excel-File: A2370DD_T80C.xlsx

Matlab-File: A2370DD_T80C.mat

Base: 100° motor temperature

Excel-File: A2370DD_T100C.xlsx

Matlab-File: A2370DD_T100C.mat

Base: 120° motor temperature

Excel-File: A2370DD_T120C.xlsx

Matlab-File: A2370DD_T120C.mat

Base values for calculation:

- The diagram is based on a DC bus voltage of 600 VDC.
- The diagram is calculated from 0 rpm to 20.000 rpm in 100 rpm steps (see worksheet <Speed>).
- For each speed, the motor current is varied from 0 A to 105 A in 20 steps (each 5.25 A). The variation of the motor current, suitable for the speeds, can be seen in the worksheet <Stator_Current_Line_RMS>.

In all other worksheets you can see the result of the calculation with the respective motor current and speed.




The following applies to these worksheets:

- Columns A - U correspond to the current variation from 0 A - 105 A in 5.25 A steps.
- Lines 1 - 201 correspond to the speed variation from 0 rpm – 20.000 rpm in 100 rpm steps.

Example:

What torque is set at 900 rpm and 47.25 A?

The value in J10 (12.045 Nm) in the worksheet <Shaft_Torque> is the torque that occurs at 900 rpm (worksheet <Speed> line 10) and 47.25A (worksheet <Stator_Current_Line_RMS> column J).

J10 :    12,0451036370466

| | | 0,00 A | 5,25 A | 10,5 A | 15,75 A | 21,00 A | 26,25 A | 31,50 A | 36,75 A | 42,00 A | 47,25 A | 52,50 A | 57,75 A |
|----------|----|-------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| | | A | B | C | D | E | F | G | H | I | J | K | L |
| 0 rpm | 1 | 0 | 1,4974235 | 2,99644502 | 4,47889175 | 5,92935328 | 7,33505861 | 8,68575318 | 9,97357583 | 11,1929358 | 12,3405008 | 13,4179345 | 14,4337598 |
| 100 rpm | 2 | -0,17053581 | 1,32462369 | 2,81899105 | 4,29468774 | 5,73659771 | 7,13224427 | 8,47166717 | 9,74729957 | 10,9538451 | 12,0888833 | 13,1562165 | 14,1644452 |
| 200 rpm | 3 | -0,17394646 | 1,32116039 | 2,81541987 | 4,29095799 | 5,73266322 | 7,12806342 | 8,46720287 | 9,74251926 | 10,9487207 | 12,0834058 | 13,1504232 | 14,1583706 |
| 300 rpm | 4 | -0,177357 | 1,31769727 | 2,81184895 | 4,28722863 | 5,72872929 | 7,12388336 | 8,46273964 | 9,73774039 | 10,9435983 | 12,0779307 | 13,1446331 | 14,1523 |
| 400 rpm | 5 | -0,18076747 | 1,31423425 | 2,80827821 | 4,28349951 | 5,72479572 | 7,1197038 | 8,45827711 | 9,73296245 | 10,938477 | 12,0724572 | 13,138845 | 14,146232 |
| 500 rpm | 6 | -0,1841779 | 1,31077132 | 2,80470759 | 4,27977059 | 5,72086242 | 7,11552461 | 8,45381509 | 9,7281852 | 10,9333567 | 12,0669849 | 13,1330585 | 14,1401659 |
| 600 rpm | 7 | -0,18758829 | 1,30730845 | 2,80113707 | 4,2760418 | 5,71692933 | 7,11134572 | 8,44935347 | 9,72340849 | 10,9282371 | 12,0615136 | 13,1272731 | 14,1341014 |
| 700 rpm | 8 | -0,19099864 | 1,30384564 | 2,79756663 | 4,27231315 | 5,71299641 | 7,10716708 | 8,44489219 | 9,71863223 | 10,9231181 | 12,056043 | 13,1214888 | 14,1280381 |
| 800 rpm | 9 | -0,19440897 | 1,30038287 | 2,79399626 | 4,26858459 | 5,70906365 | 7,10298864 | 8,4404312 | 9,71385635 | 10,9179996 | 12,050573 | 13,1157052 | 14,1219759 |
| 900 rpm | 10 | -0,19781927 | 1,29692014 | 2,79042596 | 4,26485612 | 5,70513101 | 7,09881039 | 8,43597045 | 9,70908081 | 10,9128815 | 12,0451036 | 13,1099225 | 14,1159146 |
| 1000 rpm | 11 | -0,20122956 | 1,29345745 | 2,7868557 | 4,26112774 | 5,70119849 | 7,09463229 | 8,43150993 | 9,70430557 | 10,9077638 | 12,0396348 | 13,1041403 | 14,1098541 |
| 1100 rpm | 12 | -0,20463982 | 1,28999478 | 2,7832855 | 4,25739943 | 5,69726607 | 7,09045435 | 8,42704961 | 9,6995306 | 10,9026465 | 12,0341664 | 13,0983588 | 14,1037944 |
| 1200 rpm | 13 | -0,20805007 | 1,28653215 | 2,77971534 | 4,25367118 | 5,69333374 | 7,08627653 | 8,42258946 | 9,69475586 | 10,8975295 | 12,0286984 | 13,0925778 | 14,0977354 |
| 1300 rpm | 14 | -0,2114603 | 1,28306955 | 2,77614523 | 4,24994299 | 5,6894015 | 7,08209883 | 8,41812948 | 9,68998135 | 10,8924128 | 12,0232307 | 13,0867972 | 14,0916769 |

Variable DC bus voltage

The diagram is based on a DC bus voltage of 600 VDC.

If a lower DC bus voltage is available, not all calculated operating points can be approached.

Which working points can still be reached, can be seen in the worksheets with the voltage that is set depending on the current and the speed.

Example:

With a DC bus voltage of 500 VDC ($500 \text{ VDC} / \sqrt{2}$), a maximum of 354 VAC motor voltage is available. Accordingly, the maximum torque generating motor current up to 13,000 rpm is available (example a). At a maximum speed of 20,000 rpm, the torque generating motor current is reduced to 10.5 A (example b).

Example a:

<Voltage_Phase_RMS> (line 137) 13.000 rpm at (column U) 105 A.

U137

Example b:

<Voltage_Phase_RMS> (line 201) 20.000 rpm but only (column C) 10.5 A.

C201

:

✕
✓
 f_x

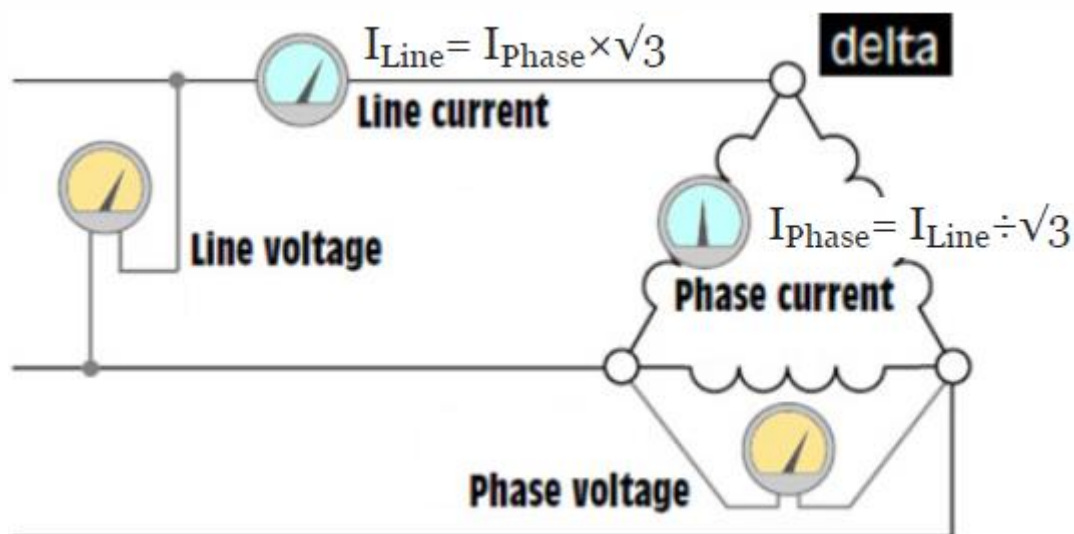
35

| | A | B | 10.5 A |
|------------|------------|------------|------------|
| | | | C |
| 181 | 308,833379 | 312,95776 | 318,943071 |
| 182 | 310,54912 | 314,692735 | 320,707876 |
| 183 | 312,264861 | 316,427714 | 322,472691 |
| 184 | 313,980602 | 318,162697 | 324,237516 |
| 185 | 315,696343 | 319,897684 | 326,00235 |
| 186 | 317,412084 | 321,632675 | 327,767194 |
| 187 | 319,127825 | 323,367671 | 329,532047 |
| 188 | 320,843566 | 325,10267 | 331,29691 |
| 189 | 322,559307 | 326,837673 | 333,061782 |
| 190 | 324,275048 | 328,572681 | 334,826664 |
| 191 | 325,990789 | 330,307692 | 336,591556 |
| 192 | 327,70653 | 332,042708 | 338,356457 |
| 193 | 329,422271 | 333,777727 | 340,121368 |
| 194 | 331,138012 | 335,512751 | 341,886288 |
| 195 | 332,853753 | 337,247779 | 343,651218 |
| 196 | 334,569494 | 338,98281 | 345,416157 |
| 197 | 336,285235 | 340,717846 | 347,181106 |
| 198 | 338,000976 | 342,452886 | 348,946064 |
| 199 | 339,716717 | 344,18793 | 350,711032 |
| 200 | 341,432458 | 345,922978 | 352,47601 |
| 20.000 rpm | 201 | 343,148199 | 347,65803 |
| 202 | | | |

Available values

| Worksheet | Description | Unit |
|-----------------------------|-------------------------|--------|
| <Speed> | Speed | rpm |
| <Shaft_Torque> | Torque on the shaft | Nm |
| <Stator_Current_Phase_Peak> | Amplitude phase current | Ampere |
| <Stator_Current_Phase_RMS> | RMS value phase current | Ampere |
| <Stator_Current_Line_Peak> | Amplitude line current | Ampere |
| <Stator_Current_Line_RMS> | RMS value line current | Ampere |
| <Voltage_Phase_Peak> | = Voltage_Line_Peak | Volt |
| <Voltage_Phase_RMS> | = Voltage_Line_RMS | Volt |

| | | |
|--------------------------|---|--------|
| <Voltage_Line_Peak> | = Voltage_Line_RMS | Volt |
| <Voltage_Line_RMS> | = Voltage_Line_Peak | Volt |
| <Id_Peak> | Amplitude field weakening current | Ampere |
| <Id_RMS> | RMS field weakening current | Ampere |
| <Iq_Peak> | Amplitude of torque generating current | Ampere |
| <Iq_RMS> | RMS value torque generating current | Ampere |
| <Vd_Peak> | Amplitude field weakening voltage | Volt |
| <Vd_RMS> | RMS field weakening voltage | Volt |
| <Vq_Peak> | Amplitude of torque generating voltage | Volt |
| <Vq_RMS> | RMS torque generating voltage | Volt |
| <Frequency> | Frequency | Hz |
| <Total_Loss> | Sum of: Stator_Copper_Loss Iron_Loss Magnet_Loss Mechanical_Loss | Watt |
| <Stator_Copper_Loss> | Copper losses in the stator | Watt |
| <Iron_Loss> | Iron losses | Watt |
| <Magnet_Loss> | Magnetic losses | Watt |
| <Mechanical_Loss> | Mechanical losses | Watt |
| <Power_Factor> | Power factor | |
| <Electromagnetic_Torque> | Electromagnetic torque is the internal torque of the motor, which results from the simulation. From this the iron losses, magnet losses and mechanical losses are subtracted in order to obtain the mechanical torque on the shaft. | Nm |



| Term | Description |
|------------------------------|---|
| Line voltage / Phase voltage | In the case of a delta connection, the line voltage and the phase voltage are the voltages measured between any two conductors. |
| Line current | The line current, is the current flowing through any line between the inverter and the motor connection. |
| Phase current | The phase current, is the current that flows through the motor winding. |
| RMS | RMS value Root Mean Square The effective value for sine waves is: RMS value = amplitude / $\sqrt{2}$ |
| Peak | Peak value or amplitude (not peak / peak) |