1. Brake motors

Standard motors (TS, TH, TP, D) can be constructed as brake motors (TBS, TBH, TBP, DB) when the driven machine must be stopped quickly and safely. This is done without modifying the motor’s electrical or mechanical assemblies, except for the non-drive side where the brake is applied. The brake is electromagnetic in various versions for the range of possible applications.

**Brake: FM**
Power supply: DC
Action: Negative (1)
Applications: Ideal for applications which require smooth, silent and gradual operation (both in starting and braking thanks to the slower response of DC brakes), accompanied by rapid release and braking.
Typical applications: gearmotors, transfer machines, electric trucks.

**Brake: MS**
Power supply: AC
Action: Negative (1)
Applications: Ideal for applications requiring rapid and precise braking and high braking loads.
Typical applications: automation with a high number of actions, lifting and handling equipment, packaging and packing machines.

**Brake: ML**
Power supply: DC
Action: Negative (1)
Applications: Ideal for applications requiring smooth gradual braking and high loads per braking cycle (thanks to the steel or cast iron disk mounted to the motor shaft, which can dissipated high braking energies); also designed for reduced size and low cost.
Typical applications: cutting machines (e.g. wood working), safety stops (parking brakes).

(1) negative action: the brake acts without power supply.

If not otherwise specified, Motovario supplies brake motors with FM type DC brakes.
2. FM brake

Operation
The FM brake is a DC electromagnetic brake and acts with no power supply through the pressure of the springs. When the brake magnet (1) is powered, the moving coil (2) is attracted against the brake body and overcomes the spring force (7) thus leaving the shaft to which the brake disk (3) is mounted axially free on the toothed hub (4), to rotate freely. Once power is shut off, the springs press the moving coil and hence the disk mounted to the hub, against the motor shield (14) to brake the motor. Brake motors with FM brakes in the standard version have a standard protection rating of IP54.

Characteristics:
- power supply 230V±10% 50/60Hz or 400V±10% 50/60Hz; other voltages available as options. The brake's power voltage must always be specified if the brake is ordered with separate power supply (see below, “Hookup for DC brakes”).
- service S1, insulation class F;
- silent friction surfaces, with no asbestos, with double braking surface;
- steel disk brake, sliding on splined drive hub; vibration damping O-ring;
- fixed braking moment selected in relation to nominal motor torque (value given in motor technical data table). Optionally, disks can be supplied with other braking moments; see column Mb in the table “Brake characteristic values”. On request, brakes can be supplied with adjustable braking moment.

Options
- manual release lever with automatic return, hand lever can be removed; it is useful for manual operations in case of power outage or during installation; the lever is parallel to the terminal box cover; on request we can evaluate the possibility to supply the lever a different position; in case of gearmotors, the different positions available for the lever are always referred to the terminal block box position. As an option we can supply a release lever which can be locked in the released position, by screwing it in until it engages with a lug in the brake body.
- Anti-seizing stainless steel washer. This is a stainless steel washer mounted between the motor shield and brake disk to prevent the ferode from seizing to the shield, for example, during long periods of disuse.
- Brake motor with protection rating IP55. Including: a) protective boot to prevent foreign matter entering the brake (e.g.: textile flock); b) stainless steel washer between motor shield and brake disk; c) stainless steel hub and disk;
- Self-braking motor with IP65 degree of protection, in which, in addition to components for IP55 degree of protection are added: a) plastic caps to close the holes for the passage of the tie-beams of the release lever; b) brake fixing screws sealed with O-ring
- Self-braking motor with IP56 degree of protection, in which, in addition to components for IP55 degree of protection are added: a) hardware and brake fixing nuts in stainless steel; b) stainless steel springs.
- Self-braking motor with IP66 degree of protection which combines the characteristics for IP65 and for IP56.
- Motor with double FM brake. For applications in which, for instance, a redundant brake is required (e.g.: theatres) motors can be supplied with two FM brakes, each with its own rectifier. The motors are normally supplied with both brakes with separate power supply and, given the application, without ventilation, hence in duty S2 10 min or S3 10%.
- Silent brake. To ensure a lower noise level inside special environments. This is achieved by adding a O-ring between moving coil and electromagnet. This option is also available with dual brake and is therefore recom mended for theatre applications.
- Hexagonal recess on non-drive side shaft end for manual rotation with straight hex key (6 mm key for ≤ size 90, 8 mm for sizes 100-112, 10 mm for size 132/160S);
- Flywheel for gradual starting and braking. Brake motors with FM brake can be equipped with a steel hub, placed between the brake and fan, acting as a flywheel to increase the moment of inertia of the system. This is done to obtain
- starting and braking that are less sharp and more progressive to make the action smoother. Gradual starting and stopping is accomplished thanks to the increased moment of inertia, which extends the time of action for a given accelerating and braking torque. The overall length dimensions of the motor for application of the flywheel are
- unchanged with respect to the standard brake version.

Power supply
The brake is powered with direct current through a rectifier bridge, by rectifying the single-phase AC input:
- for three-phase TBS, TBH and TBP motors, the standard input voltage is 230V AC, rectified with a half-wave rectifier to obtain an output of 103V DC; the brake’s power supply may be direct (drawn from the motor’s power supply) or separate, from an external source (separate power option);
- for 2 pole three-phase DB motors, the standard input voltage is 400V AC, rectified with a half- wave rectifier to obtain an output of 178V DC; in this case the brake power supply is always separate.

Optionally, brakes are available for the following power voltages: 115V AC, 133V AC, 200V AC, 208V AC, 230V AC, 255V AC, 265V AC, 280V AC, 290V AC, 330V AC, 346V AC, 380V AC, 400V AC, 415V AC, 12V DC, 24V DC, 103V DC, 178V DC (if a voltage is requested directly in DC, it is understood that the brake motor will be supplied without rectifier). Possible rectifiers are listed below:
- half-wave rectifier with NBR filter (standard from size 63 to size 100); in special cases, to adapt the requested AC...
voltage to the brake winding’s DC voltage, a full-wave DBR rectifier is supplied instead of an NBR rectifier (e.g. 115V AC-103V DC). DBR rectifiers have comparable braking and release response times to NBR rectifiers.

b. half-wave quick detachment rectifier SBR (standard for sizes 112 and 132/160S; optional for sizes 63-100), thanks to which the brake, when release starts, is powered with full-wave rather than half-wave voltage; this results in shorter release times than standard (see “Brake characteristic values” and “Hookup for FM and ML brakes”); it is thus ideal for applications with frequent multiple braking cycles (e.g. lifting).

c. half-wave rapid braking rectifier RSD (optional for size 63 to size 100), which reduces the brake de-excitation period, thus giving braking times comparable to those obtainable by opening the DC side (see “Brake characteristic values” and “Hookup for FM and ML brakes”). This rectifier does not have a rapid braking contact (see “Hookup for FM and ML brakes”) and is only available for brake voltages 230V AC - 103V DC and 400V AC - 178V DC.

d. half-wave rectifier for quick detachment and braking RRSD (as an option on all sizes), combines type b) and c) functionality. This rectifier does not have a rapid braking contact (see “Hookup for FM and ML brakes”) and is only available for brake voltages 230V AC - 103V DC and 400V AC - 178V DC.

All rectifiers except for RRSD are also available in versions homologated to the UL/CSA standards. All rectifiers are compliant with the Low Voltage Directive 2006/95/CE; in relation to the EMC Directive 2004/108/CEE, the rectifier/coil assembly is confirming due to the use of a filter on the rectifier (NBR); for DC brakes with rapid half-wave rectifier (SBR, RSD and RRSD) the filter is implemented by connecting a capacitor (440V AC 0.22μF class X2 per EN132400) in parallel with the AC power supply (default configuration for this type of rectifier).
1. Brake magnet
2. Moving coil
3. Brake disk
4. Drive hub
5. Release lever (optional)
6. Boot (in combination with IP 55)
7. Thrust springs
8. V-ring (in combination with IP 55)
9. Mounting bolt
10. Locknuts
11. Braking torque adjuster screw (on request)
12. Key
13. Circlip
14. Cast iron shield
15. Vibration damping O-ring
16. Flywheel (optional)
17. Anti-seizing stainless steel washer (optional)
### Brake characteristic values

<table>
<thead>
<tr>
<th>T</th>
<th>S_n</th>
<th>S_max</th>
<th>X</th>
<th>J_B</th>
<th>W</th>
<th>W_1</th>
<th>t_1</th>
<th>t_11</th>
<th>t_2</th>
<th>t_22</th>
<th>m_B</th>
<th>P_a</th>
<th>M_B</th>
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<td>7.5</td>
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<td>-</td>
<td>80</td>
<td>200</td>
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<td>-</td>
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<td>77</td>
<td>-</td>
<td>80</td>
<td>200</td>
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<td>1650</td>
<td>132</td>
<td>-</td>
<td>100</td>
<td>200</td>
<td>12.3</td>
<td>65</td>
<td>50-100-150</td>
<td>6.9</td>
<td>350</td>
</tr>
</tbody>
</table>

T = Type  
S_n = nominal airgap [mm]  
S_max = maximum airgap [mm]  
X = release lever play [mm]  
J_B = brake disk moment of inertia [kg cm^2]  
W = maximum energy which can be dissipated by brake [MJ]  
W_1 = energy which can be dissipated between two successive adjustments of airgap from S_n to S_max [MJ]  
t_1(*) = brake release time with normal detachment rectifier (NBR, RSD) [ms]  
t_11(*) = brake release time with rapid detachment rectifier (SBR, RRSD) [ms]  
t_2(*) = brake response time – AC side opening [ms]  
t_22(*) = brake response time – DC side opening [ms]  
m_B = weight [kg]  
P_a = power absorption [W]  
M_B = brake moments available [Nm]  
m_F = flywheel weight [kg]  
J_F = flywheel moment of inertia [kg cm^2]  

(*) NOTE: the effective values may deviate slightly in relation to the ambient temperature and humidity, the brake temperature and wear of the friction surfaces; t_1, t_11, t_2 and t_22 refer to a brake calibrated with medium airgap, nominal voltage and separate power; as regards the braking moment, one must allow for running in to allow the ferode to adapt to the braking surface of the motor shield, for a period which depends on the actual braking loads; once running in is completed, in nominal operating conditions one can expect a deviation from the declared value of ±15%. 

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M Series / Standard / IEC

BRAKE MOTORS

TECHNICAL CATALOGUE

5
3. ML brake

Operation
The ML brake is a DC electromagnetic brake and acts with no power supply through the pressure of the springs. When the brake magnet (1) is powered, the moving coil (2) is attracted and overcomes the spring force (4) thus leaving the shaft, to which the brake disk + fan (9) are locked, to rotate freely. When power is shut off, the springs push the moving coil against the disk, thus braking the shaft. Brake motors with ML brakes in the standard version have a standard protection rating of IP54. High protection ratings are not available.

Characteristics:
- power voltage 230V±10% 50/60Hz or 400V±10% 50/60Hz;
- duty S1, insulation class F;
- silent, asbestos free friction surface;
- steel or cast iron braking flywheel;
- axial dimensions less than FM brake;
- airgap adjustable with one nut or collar;
- braking moment set for motor size (see value MB in “Brake characteristic values”);
- O-ring gasket protects airgap from dust and other external agents.

Options
- Manual release lever with automatic return, hand lever can be removed; it is useful for manual operations in case of power outage or during installation; the lever is parallel to the terminal box cover; on request we can evaluate the possibility to supply the lever a different position; in case of gearmotors, the different positions available for the lever are always referred to the terminal block box position.
- Microswitch to signal brake locking/releasing and brake ferode wear.

Braking moment
For each motor size, independently of the torque delivery, the braking moment is given by the value MB in the table; the braking moment is NOT adjustable.

Power supply
The brake is powered with direct current through a rectifier bridge, by rectifying the single-phase AC input:
- for three-phase TBS, TBH and TBP motors, the standard input voltage is 230V AC, rectified with a half-wave rectifier to obtain an output of 103V DC; the brake’s power supply may be direct (drawn from the motor’s power supply) or separate, from an external source (separate power option);
- for 2 pole three-phase DB motors, the standard input voltage is 400V AC, rectified with a half-wave rectifier to obtain an output of 178V DC; in this case the brake power supply is always separate.

Optionally, brakes can be supplied for the following voltages; 115V AC, 133V AC, 200V AC, 208V AC, 230V AC, 255V AC, 290V AC, 330V AC, 346V AC, 380V AC, 400V AC, 415V AC, 12V DC, 24V DC, 103V DC, 178V DC. If a voltage is requested directly in DC, then the brake motor will be supplied without rectifier. Possible rectifiers are listed below:

- half-wave rectifier with NBR filter (standard from size 63 to size 100); in special cases, to adapt the requested AC voltage to the brake winding’s DC voltage, a full-wave DBR rectifier is supplied instead of an NBR rectifier (e.g. 115V AC-103V DC). DBR rectifiers have comparable braking and release response times to NBR rectifiers.
- half-wave quick detachment rectifier SBR (standard for sizes 112 and 132/160S; optional for sizes 63-100), thanks to which the brake, when release starts, is powered with full-wave rather than half-wave voltage; this results in shorter release times than standard (see “Brake characteristic values”); it is thus ideal for applications with frequent multiple braking cycles (e.g. lifting).
- half-wave rapid braking rectifier RSD (optional for size 63 to size 100), which reduces the brake de-excitation period, thus giving braking times comparable to those obtainable by opening the DC side (see “Brake characteristic values”). This rectifier is only available for brake voltages 230V AC - 103V DC and 400V AC - 178V DC.
- half-wave rectifier for quick detachment and braking RRSD (optionally available for all sizes), combines type b) and c) functionality. This rectifier is only available for brake voltages 230V AC - 103V DC and 400V AC - 178V DC.

All rectifiers except for RRSD are also available in versions homologated to the UL/CSA standards. All rectifiers are compliant with the Low Voltage Directive 2006/95/CE; in relation to the EMC Directive 2004/108/CEE, the rectifier/coil assembly is conforming due to the use of a filter on the rectifier (NBR); for DC brakes with rapid half-wave rectifier (SBR, RSD and RRSD) the filter is implemented by connecting a capacitor (440V AC 0.22mF class X2 per EN132400) in parallel with the AC power supply (default configuration for this type of rectifier).
1. Brake magnet
2. Moving coil
3. O-ring
4. Thrust springs
5. Release lever (optional)
6. Mounting bolt
7. Airgap adjuster screw
8. Return spring
9. Steel/cast iron disk + fan
10. Key
11. Self-locking nut
12. Motor shield
**Brake characteristic values**

<table>
<thead>
<tr>
<th>T</th>
<th>( S_n )</th>
<th>( S_{\text{max}} )</th>
<th>( J_B )</th>
<th>( W )</th>
<th>( W_1 )</th>
<th>( t_1 )</th>
<th>( t_2 )</th>
<th>( t_{22} )</th>
<th>( m_B )</th>
<th>( P_a )</th>
<th>( M_B )</th>
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<tbody>
<tr>
<td>63</td>
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<td>3</td>
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<td>25</td>
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<tr>
<td>90S-L</td>
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<td>11</td>
<td>375</td>
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<td>25</td>
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<tr>
<td>100</td>
<td>13</td>
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<td>500</td>
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<td>150</td>
<td>400</td>
<td>40</td>
<td>7.4</td>
<td>60</td>
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</tbody>
</table>

\( T \) = Type  
\( S_n \) = nominal airgap [mm]  
\( S_{\text{max}} \) = maximum airgap [mm]  
\( J_B \) = brake disk moment of inertia [kg cm²]  
\( W \) = maximum energy which can be dissipated by brake [MJ]  
\( W_1 \) = energy which can be dissipated between two successive adjustments of airgap from \( S_n \) to \( S_{\text{max}} \) [MJ]  
\( t_1(\ast) \) = brake release time [ms]  
\( t_2(\ast) \) = brake response time - AC side opening [ms]  
\( t_{22}(\ast) \) = brake response time - DC side opening [ms]  
\( m_B \) = weight [kg]  
\( P_a \) = power absorption [W]  
\( M_B \) = brake moments available [Nm]  

(\( \ast \)) NOTE: the effective values may deviate slightly in relation to the ambient temperature and humidity, the brake temperature and wear of the friction surfaces; \( t_1, t_2 \) and \( t_{22} \) refer to a brake calibrated with medium airgap, nominal voltage and separate power; as regards the braking moment, one must allow for running in to allow the ferode to adapt to the braking surface of the motor shield, for a period which depends on the actual braking loads; once running in is completed, in nominal operating conditions one can expect a deviation from the declared value of ±10%.
4. Hookup for FM and ML brakes

If the brake power is derived directly from the motor or is independent, one speaks of direct and separate brake power respectively. In detail, with reference to the figures given below:

1. Direct brake power: supply cables on the AC side of the rectifier are connected to the motor’s power terminal board; when you power up the motor, the brake coil is automatically energised and the brake is released; when power to the motor is shut off, the brake automatically brakes the motor. During this phase, the brake response time $t_2$ has to be added to the delay $R$ generated by the inertia of the load and by the energy accumulated by the motor. $R$ changes in every motor and – as it depends on the load – cannot be previously calculated.

2. Separate brake power, brake opens only from the AC side: the brake is powered, via the rectifier, off terminals separate from those of the motor. In this case stop time $t_2$ does not depend on the characteristics of both the motor and load.

3. Direct brake power, DC side opens: connection possible on the basis of type 1, if one can cable the rectifier’s rapid braking contact (DC side opening) as shown in figure 3. Despite the direct power supply (see point 1), the braking response time is independent of the characteristics of the motor and load, and is significantly shorter than that of case 2 ($t_{22} < t_2$). This connection is thus an alternative to the use of rapid braking rectifiers (RSD and RRSD).

4. Separate brake power, AC and DC sides open: connection possible on the basis of type 2, if one can cable the rectifier’s rapid braking contact (DC side opening) as shown in figure 4. Response time equal to that of type 3, hence this connection is an alternative to the use of rapid braking rectifiers (RSD and RRSD). The advantage over the previous case is that, during braking, the energy accumulated by the motor does not discharge into the rectifier, thus safeguarding its service life.

Motovario supplies brakes connected as type 1 or 2 when ordered as “direct” or “separate” power supply respectively. Type 3 and 4 connections must be implemented by the client. If SBR rapid release rectifiers are used, the brake release time reduces from $t_1$ to $t_{11}$ (see graph below). In case of independent power supply of the brake through direct current, therefore without any rectifier (ex. 24Vdc), the supply cables of the brake are set inside the terminal box and connected in a fly terminal board mammuth type. In this case, not considering the external power supply, for the time of operations you can refer to case 4.
5. MS brake

Operation
MS brake is an a. c. electromagnetic brake and acts with no power supply through the pressure of the springs. When the brake magnet (1) is powered, the moving coil (2) is attracted against the brake body and overcomes the spring force (7) thus leaving the shaft to which the brake disk (3) is mounted axially free on the toothed hub (4), to rotate freely. Once power is shut off, the springs press the moving coil and hence the disk mounted to the hub, against the motor shield (14) to brake the motor.

Characteristics
- standard power supply voltage 230/400V±10% 50Hz 265/460V±10% 60Hz; other voltages available as options;
- duty S1, insulation class F;
- silent friction surfaces, with no asbestos, with double braking surface;
- steel brake disk sliding on the splined driving hub;
- fixed braking moment selected in relation to nominal motor torque (value given in motor technical data table). Optionally, disks can be supplied with other braking moments; see column \( M_b \) in the table “Brake characteristic values”. On request, brakes can be supplied with adjustable braking moment.

Options
- Manual release lever with automatic return, hand lever can be removed; it is useful for manual operations in case of power outage or during installation; the lever is parallel to the terminal box cover; on request we can evaluate other lever positions; in case of gearmotors, the different positions available for the lever are always referred to the terminal block box position.
- Anti-seizing stainless steel washer. This is a stainless steel washer mounted between the motor shield and brake disk to prevent the ferode from seizing to the cast iron shield, for example, during long periods of disuse.
- Brake motor with protection rating IP55 for applications in special conditions (e.g. installation outdoors) including: a) boot + O-ring to prevent foreign matter entering the brake (e.g.: textile flock); b) stainless steel washer between motor shield and brake disk; c) stainless steel hub and disk; d) V-ring on the motor shaft.
- Hexagonal recess on non-drive side shaft end for manual rotation with straight hex key (6 mm key for \( \leq \) size 90, 8 mm for sizes 100-112, 10 mm for size 132/160S).

Power supply
The brake is powered AC 230/400V±10% 50Hz.
Optionally, brakes can be supplied for the following voltages: 115/200V 50Hz, 120/208V 60Hz, 133/230V 50Hz, 208/360V 50Hz, 208/360V 60Hz, 255/440V 50Hz, 200/346-220/380V 50-60Hz, 290/500-330/575V 50-60Hz, 400/690-460/800V 50-60Hz. In three-phase TBS, TBH and TBP motors, the brake is usually powered directly from the motor’s power supply (direct power). Separate brake power is available as an option; in this case, a second terminal block is mounted in the terminal box to which are cabled the brake cables and an additional cable gland is provided to route the brake power cord into the terminal box; brake power is always separate for 2 pole three-phase DB motors.
1. Brake magnet
2. Moving coil
3. Brake disk
4. Drive hub
5. Release lever (optional)
6. Boot + O-ring (optional)
7. Thrust springs
8. V-ring (optional - in combination with protective boot + O-ring)
9. Mounting bolt
10. Locknuts
11. Braking torque adjuster screw (on request)
12. Key
13. Circlip
14. Cast iron shield
15. Vibration damping O-ring
16. Anti-seizing stainless steel washer (optional)
Brake characteristic values

<table>
<thead>
<tr>
<th>T</th>
<th>(S_n)</th>
<th>(S_{\text{max}})</th>
<th>X</th>
<th>(J_B)</th>
<th>W</th>
<th>(W_1)</th>
<th>(t_1)</th>
<th>(t_2)</th>
<th>(m_B)</th>
<th>(P_a)</th>
<th>(M_B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>0.2</td>
<td>0.5</td>
<td>0.6</td>
<td>0.6</td>
<td>260</td>
<td>15.6</td>
<td>4</td>
<td>20</td>
<td>1.3</td>
<td>60</td>
<td>1.8-3.5</td>
</tr>
<tr>
<td>71</td>
<td>0.2</td>
<td>0.5</td>
<td>0.8</td>
<td>1.1</td>
<td>370</td>
<td>22.4</td>
<td>4</td>
<td>40</td>
<td>1.9</td>
<td>80</td>
<td>2.5-7.5-10</td>
</tr>
<tr>
<td>80</td>
<td>0.3</td>
<td>0.6</td>
<td>1</td>
<td>1.6</td>
<td>500</td>
<td>30</td>
<td>6</td>
<td>60</td>
<td>3</td>
<td>110</td>
<td>5-10-15-20</td>
</tr>
<tr>
<td>90S-90L-100</td>
<td>0.3</td>
<td>0.6</td>
<td>1</td>
<td>3.5</td>
<td>750</td>
<td>45</td>
<td>8</td>
<td>90</td>
<td>5.6</td>
<td>250</td>
<td>13-26-40</td>
</tr>
<tr>
<td>112</td>
<td>0.35</td>
<td>0.7</td>
<td>1.2</td>
<td>8.8</td>
<td>1000</td>
<td>70</td>
<td>16</td>
<td>120</td>
<td>9.7</td>
<td>470</td>
<td>40-60</td>
</tr>
<tr>
<td>132S</td>
<td>0.35</td>
<td>0.7</td>
<td>1.2</td>
<td>10.3</td>
<td>1100</td>
<td>77</td>
<td>16</td>
<td>140</td>
<td>10.3</td>
<td>550</td>
<td>50-75-100</td>
</tr>
<tr>
<td>132L-M/160S</td>
<td>0.4</td>
<td>0.8</td>
<td>1.2</td>
<td>22.5</td>
<td>1650</td>
<td>132</td>
<td>16</td>
<td>180</td>
<td>14.7</td>
<td>600</td>
<td>50-100-150</td>
</tr>
</tbody>
</table>

\(T\) = Type  
\(S_n\) = nominal airgap [mm]  
\(S_{\text{max}}\) = maximum airgap [mm]  
X = release lever play [mm]  
\(J_B\) = brake disk moment of inertia \([\text{kgcm}^2]\)  
W = maximum energy which can be dissipated by brake \([\text{MJ}]\)  
\(W_1\) = energy which can be dissipated between two successive adjustments of airgap from \(S_n\) to \(S_{\text{max}}\) \([\text{MJ}]\)  
\(t_1\)\((*)\) = brake release time \([\text{ms}]\)  
\(t_2\)\((*)\) = brake response time \([\text{ms}]\)  
\(m_B\) = weight \([\text{kg}]\)  
\(P_a\) = power absorption \([\text{VA}]\)  
\(M_B\) = brake moments available \([\text{Nm}]\)  

\((*)\) NOTE: the effective values may deviate slightly in relation to the ambient temperature and humidity, the brake temperature and wear of the friction surfaces; \(t_1\) and \(t_2\) refer to a brake calibrated with medium airgap, nominal voltage and separate power; as regards the braking moment, one must allow for running in to allow the ferode to adapt to the braking surface of the motor shield, for a period which depends on the actual braking loads; once running in is completed, in nominal operating conditions one can expect a deviation from the declared value of \(\pm 10\%\).
6. Hookup for MS brakes

1. Direct brake power: the brake is powered directly off the motor’s terminal block; when the motor is powered up, the brake coil is automatically energised and the brake is released; when power to the motor is shut off, the brake coil is automatically de-energised and the brake brakes the motor. During this phase, the braking response time $t_2$ has to be added to delay $R$, generated by the inertia of the load and by the energy accumulated by the motor. $R$ changes in every motor and – as it depends on the load – cannot be previously calculated.

1. Time
2. Motor
3. Brake

A. Delta connection
B. Star connection
C. Motor terminal board
D. Brake

![Diagram of MS brakes hookup](image-url)
2. Separate brake power: the brake is powered off a terminal block separate from the motor’s block; in this case $t_1$ and $t_2$ depend only on the characteristics of the brake.

1. Time
2. Motor
3. Brake

A. Motor terminal board
B. Auxiliary terminal board
C. Brake
D. Delta connection
E. Star connection
7. Notes and calculations

Calculating the braking moment
The rating of the brake depends largely on the moment of inertia it is to brake, the number of braking cycles per hour, the severity of the duty and the required stopping times; in particular, the following must be borne in mind:

- braking moment;
- wear of friction surfaces in relation to service intervals;
- thermal load (work which can be dissipated by the brake in relation to the load's moment of inertia and the number of cycles per hour);
- special ambient conditions for which guards or corrosion proofing are required.

The calculation of the braking moment $M_B$ for a given application depends on the following design parameters:

- $J_{\text{tot}}$ = total inertia of rotating parts reduced to motor shaft [kgm$^2$]
- $n_0$ = motor shaft speed [rpm]
- $t_F$ = braking time [s]
- $M_L$ = moment of load acting on system (e.g. load to be lifted, resisting moment, etc.)

The braking moment is calculated as follows:

$$M_B = K \left[ \frac{(2\pi \times n_0 \times 60) \times J_{\text{tot}} \pm M_L}{t_F} \right]$$

where:

- $K$ = safety coefficient ($\geq 2$)
- $M_L$ takes the following sign:
  - “-“ when lifting a weight or torque opposing the motor’s direction of rotation;
  - “+“ when lowering a weight or torque in the motor’s direction of rotation.

Verification of heat which can be dissipated
In each cycle, the energy of the moving masses is transformed into heat by friction. The work done during braking is:

$$W_B = J_{\text{tot}} \times \left[ \frac{(2\pi \times n_0 \times 60)^2}{2} \times \frac{M_B}{M_B \pm M_L} \right] \quad [J]$$

When we know the work done during a braking cycle $W_B$, the application’s number of cycles per hour $Z$ must be less than the maximum number of cycles per hour permitted for the type of brake selected as shown in the graph ($W_{B_{\text{max}}}$-$Z$).

Instead, when we know the number of cycles per hour $Z$, the corresponding maximum work to be done $W_{B_{\text{max}}}$ must be greater than that of the actual application (calculation).
Braking work which can be dissipated between two adjustments
Given the moments of inertia of the moving masses reduced to the shaft to be braked, and once the work per cycle \( W_B \) has been calculated, the number of cycles per interval between two successive adjustments is:

\[
N = \frac{W_1}{W_B}
\]

\( W_1 \) is given in the table for the type of brake in question.
Starting frequency
For a given application, the maximum starting frequency $Z$ in relation to the load and the inertias can be determined as:

$$Z = K_J \cdot K_M \cdot Z_0 \text{ [h}^{-1}]$$

where:

$K_J =$ coefficient given in the table in relation to $J / J_T$

$K_M =$ coefficient given in the table in relation to $M_L / M_S$

$J_T =$ moment of inertia of the motor

$J =$ moment of inertia of the load excluding that of the motor itself

$M_S =$ motor starting torque

$M_L =$ resisting moment

$Z_0 =$ starting frequency under load and inertia except for that of the motor itself (value given in the performance data tables for each type of motor).

The resulting starting frequency $Z$ must be less than the maximum number of cycles/hour permitted for the brake; if this condition is not met, the brake is unable to dissipate the heat generated by braking, so one must either reduce the starting frequency or oversize the brake (see brake ratings paragraph). If the value of $Z$ is close to $Z_0$, it is advisable to keep the motor windings temperature under control with, for instance, a bimetal cutout.