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Type MG and 3PG Stainless Steel Resistor Technology

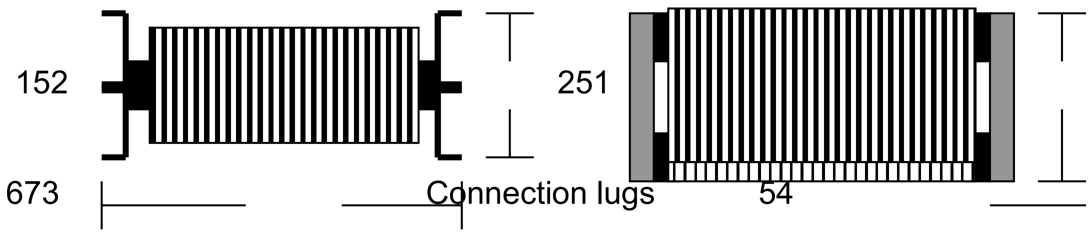
1.0 Introduction

The MG and 3PG range of resistor banks have set the standard for dependability and quality for several decades. The grid material is Carpenter 316 stainless steel; with a temperature coefficient of just 5% between ambient and 400^0C – the nominal operating temperature. The resistance parameter remains solid; regardless of the operating condition. They are impervious to rust; and adjacent grids on a bank are argon welded together to render them totally independent of rod pressure.

An MG resistor bank – tap points on alternate grids.

A high impedance to earth is ensured by double insulation; with epoxy glass tubes between tie rods and grids, and then heavy duty ceramic insulators at grid ends, and at end plates. The bank assembly is built to ensure durable operation; in tough steel-making conditions.

Ratings and dimensions conform to NEMA standards. Continuous and intermittent ratings are stated overleaf.



HPRC specialises in all aspects of power resistors. The scope includes ac and dc motor control; frequency inverter discharge circuits, and neutral earth fault limiting.

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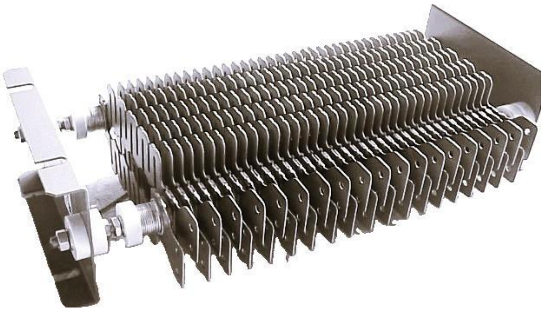
1.1 Type MG Resistor Banks

An MG resistor bank conforms to the NEMA dimensions (P1); with each grid on the bank identical, and a continuous connection along the assembly.



MG resistor bank

Ordering Information: **Ampere rating per NEMA Class numbers**

Bank	Ohms	90	170	160	150	140	130	List No
MG3×2	0.0465	350	440	513	575	680	792	40601
MG4×2	0.06	310	383	448	507	577	665	40602
MG5×2	0.075	280	319	410	456	537	598	40603
MG6×2	0.09	250	309	362	412	476	551	40604
MG3	0.156	185	232	270	303	358	417	40606
MG4	0.216	162	202	236	267	304	350	40607
MG5	0.25	147	184	216	240	283	315	40608
MG6	0.325	136	163	191	217	252	290	40609
MG8	0.544	109	137	159	178	205	238	40610
MG10	0.72	96	121	140	157	182	209	40611
MG12	0.9	85	107	123	136	160	182	40612
MG16	0.96	80	99	117	130	152	179	40613
MG20	1.52	66	83	96	108	128	149	40614
MG25	2.1	58	74	85	95	111	128	40615
MG31	2.85	51	65	75	83	98	110	40616
MG40	3.92	44	55	64	72	83	95	40617
MG50	7.6	34	42	49	54	64	74	40618
MG62	10.0	29	37	42	47	54	60	40619
MG80	11.2	26	32	36	41	46	53	40620
MG150	20.3	17	18	21	24	27	31	40621
MG200	25.9	10	12	14	16	18	20	40622

Time ON		Cont	15	15	15	15	10	Seconds
Time OFF		Cont	15	30	45	75	70	Seconds

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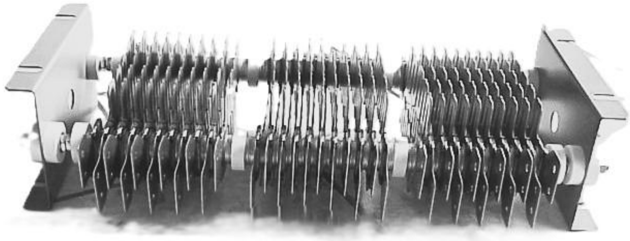
1.2 Type 3PG Resistor Banks

A 3PG resistor bank also conforms to NEMA dimensions; and all grids on it are identical, but split into three separate phases:



3PG resistor bank

Ordering Information:

		Ampere rating per NEMA Class numbers						
Bank	Ohms/Ph	90	170	160	150	140	130	List No
3PG3	0.044	185	232	270	303	358	417	40636
3PG4	0.056	162	202	236	267	304	350	40637
3PG5	0.070	147	184	216	240	283	315	40638
3PG6	0.088	136	163	191	217	252	290	40639
3PG8	0.144	109	137	159	178	205	238	40640
3PG10	0.20	96	121	140	157	182	209	40641
3PG12	0.25	85	107	123	136	160	182	40642
3PG16	0.26	80	99	117	130	152	179	40643
3PG20	0.40	66	83	96	108	128	149	40644
3PG25	0.50	58	74	85	95	111	128	40645
3PG31	0.75	51	65	75	83	98	110	40646
3PG40	1.12	44	55	64	72	83	95	40647
3PG50	2.0	34	42	49	54	64	74	40648
3PG62	2.25	29	37	42	47	54	60	40649
3PG80	2.56	26	32	36	41	46	53	40650
3PG150	4.64	17	18	21	24	27	31	40651
3PG200	5.92	10	12	14	16	18	20	40652

Time ON	Cont	15	15	15	15	10	Seconds
Time OFF	Cont	15	30	45	75	70	Seconds

Type 3PG resistor banks are ideal slip resistors for small to medium slip-ring motors; with closed-loop thyristor control, such as AC10. A NEMA 90 continuous thermal rating would be standard for this class of control; for which stability of resistance is the essential property.

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1.3 Enclosed Resistors

In line with the heavy-duty aspect of the resistor product; the proprietary enclosure is both rugged and versatile. It is quality jig-fabricated; and can be stacked in practical configurations to accommodate any number of resistor banks:

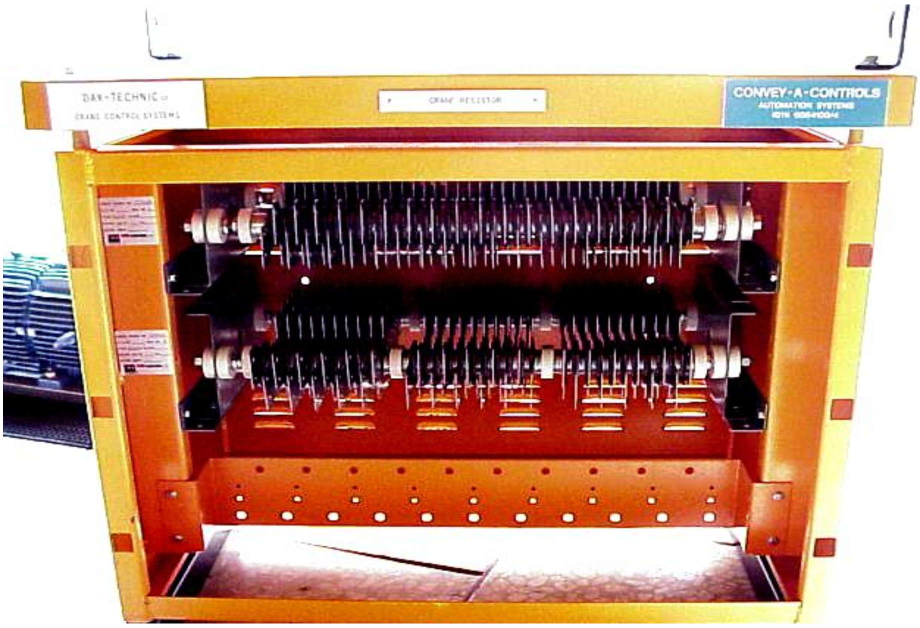
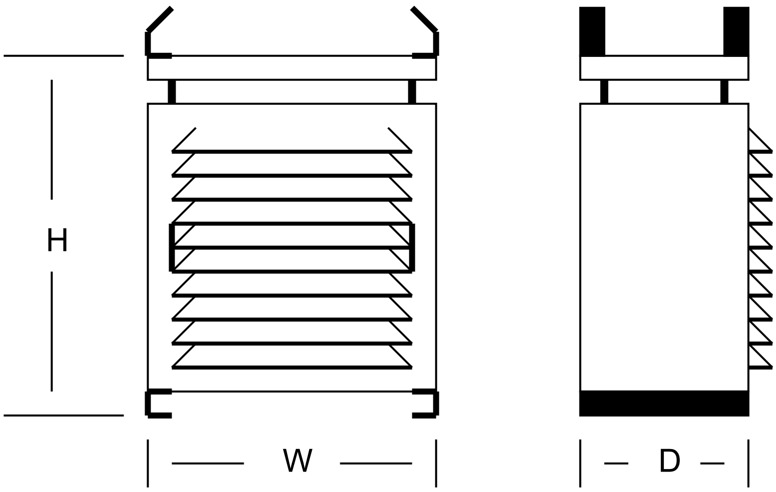


Fig 2 resistor enclosure – without wiring or terminals

The louvered front covers have two handles: they are of the lift-off design, for ease of inspection and practical function. Standard termination plates accommodate a wide variety of terminals. Each vertical assembly stands on side channel sections.



Enclosure Fig 1	1 bank + term’	H = 587	W = 832	D = 406
Enclosure Fig 2	2 bank + term’	H = 777	W = 832	D = 406
Enclosure Fig 3	3 bank + term’	H = 1019	W = 832	D = 406

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2.0 Resistor Applications

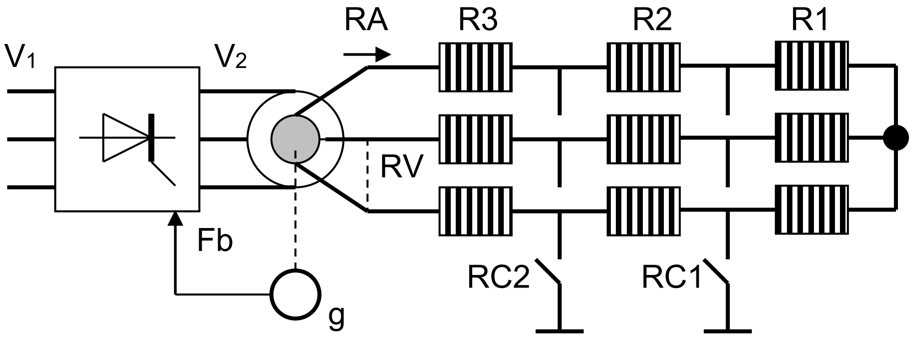
The two engineering properties of a resistor are it's *grading* and *thermal capacity.* Grading is the electrical resistance; expressed as an ohm value. In a motor set-up; grading determines the outer limit of the control function. The drive duty can be continuous; so stability is a vital property.

Thermal capacity is expressed in watts (one watt = one joule per second). Thermal capacity determines the ability of the resistor to absorb electrical energy and convert it into heat energy: this is then radiated into the atmosphere. Other heat absorption methods (oil and force cooling) are available. The volume of grid material (hence it's size and cost), are directly linked to the wattage of the resistor.

A correctly engineered resistor will optimise the grading for control; and minimise the thermal capacity to fulfil the application without overheating. The result will be the right control; at the minimum capital cost.

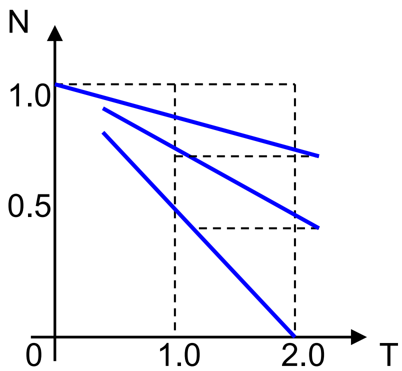
2.1 Rotor Resistors for Slip-ring Motors.

The principal need is to set an outer limit for the motor at each motor slip point.



Information needed (1-6):

1 Motor frame and speed – rpm.
2 Motor electrical rating – kW.
3 Rotor RV and RA.
4 Quantity of RC's in circuit.
5 Application – hoist, travel, conveyor, etc.
6 Duty cycle - number and duration of starts.
7 If hoist; speed in m/s and load in t or kg.
8 If hoist; mechanical efficiency of system - η.
9 Environment – indoor; outdoor, etc,



1-Q curve

A full continuous rating (NEMA 90), is a recommendation for thyristor control systems. If the system is full voltage PRP; then intermediate NEMA 170 and 160 ratings can be considered, depending on the machine duty cycle.

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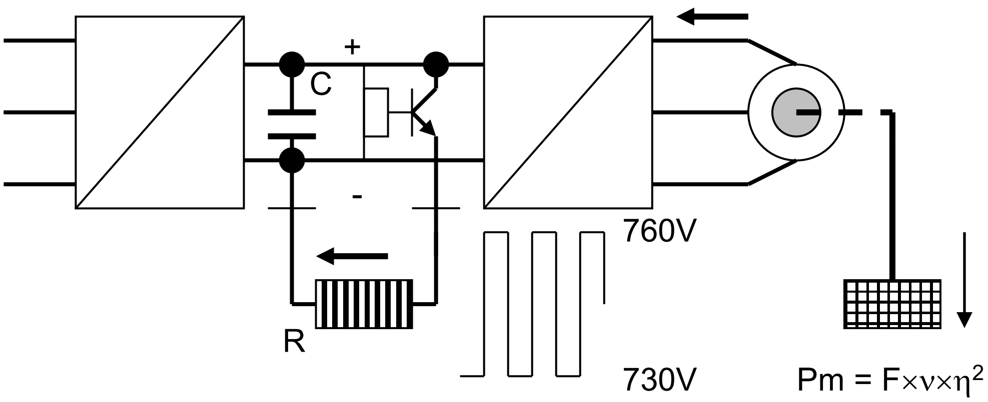
2.2 Discharge Resistors for Frequency Controllers

The majority of frequency controllers have what is called a passive (un-controlled) front end. This means the controller can pass forward power only: it cannot return regenerated power to the mains system. The implication is that negative power (power developed by the load), must be dissipated within the control system.

A standard feature or option in a frequency controller is a braking chopper – a device to turn dc current ON and OFF. In the ON state; the current is diverted into and dissipated by a discharge resistor.



In a situation where, as result of gravity, the load overhauls the ac motor, then the net energy *must* be dissipated by the control system. If the load is 50t and hoisting speed 20 m/m with $\eta = 0.85$, then:

$$\text{Pm hoisting} = \frac{F\times\nu}{\eta} = \frac{50\times10^3\times9.81\times20}{0.85\times60} = 192352\text{ W} = 193\text{ kW}$$

$$\text{Pm lowering} = F\times\nu\times\eta^2 = \frac{50\times10^3\times9.81\times20\times0.85^2}{60} = 118128\text{ W} = 119\text{ kW}$$

The thermal capacity of resistor R will be 119 kW; but the ON period must be specified. When lowering a full load at rated speed; the resistor will dissipate 119 kW. The grading of the resistor will be such that torque in the order of 1.5×Pm (lowering), can be developed for stopping or manipulation to a slower notch.

Manufacturers normally state a grading value (x-ohms) and a per-unit thermal capacity (40%), for each size of frequency controller. This can eliminate design problems; but a more engineering approach can be preferred:

Information needed:

1 Values of Pe and Pm – kW.
2 System ON and OFF voltages.
3 Duty cycle for the drive.

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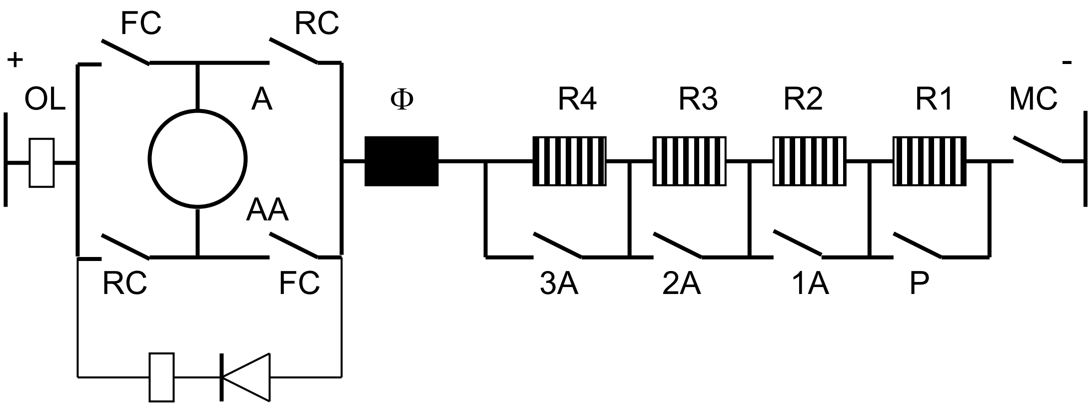
2.3 DC Crane Resistors

Conventional *fixed voltage* 230 and 440V dc technology places heavy emphasis on power resistors for starting and control. For hoist motions in particular; the inherent design necessitate bulk resistors to control the armature and field circuits; in particular during lowering.

Fixed voltage dc control systems are resistance intensive; with an associated high cost. The thermal capacity for them will be specified as NEMA 170 (15/15), or NEMA 160 (15/30). The choice is a function of the crane duty cycle.

For a crane travel system; the power circuit will be of the form:

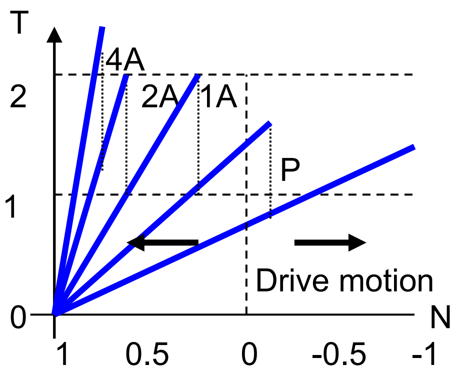


This circuit is called plain series acceleration and plug-retardation. The plug-retard function operates when contactors FC and RC are reversed via the master controller. Full resistance R1-R4 *must* be held in circuit during retardation.

During motoring: $V = E + Ia \times \Sigma R$
During retardation: $E = V + Ia \times \Sigma R$

Information needed:

1 Supply volts dc.
2 Drive power – kW.
3 Application – CT, LT, hoist, etc.
4 Crane class – ladle, slab-handling, etc.
5 Hoist system – HWR, 14115, etc.
6 Indoor – outdoor.



2-Q curve

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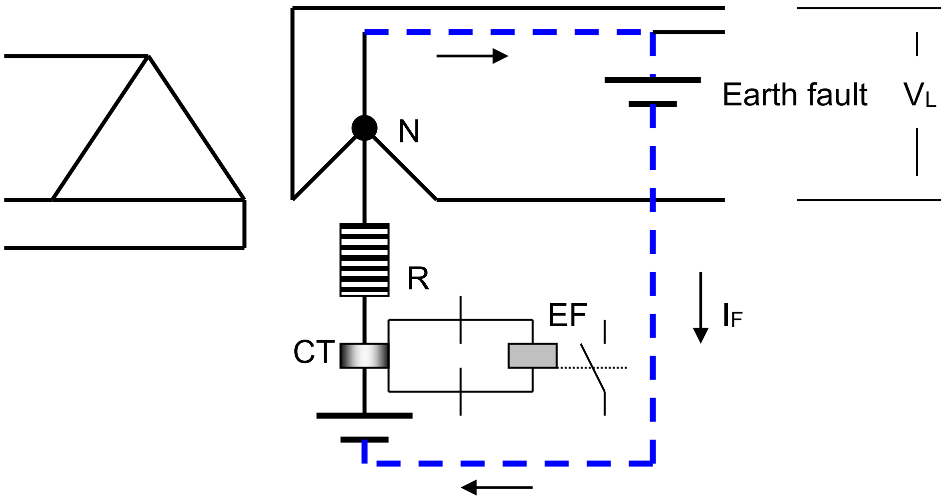
2.4 Neutral Earthing Resistors

The term *high resistance earthing* pertains to the addition of a resistor into the neutral point of a distribution system; for the purpose of limiting earth fault currents to a controlled pre-determined level.



Resistance earthing has been determined to offer the best compromise between current and voltage stresses; in a phase to neutral fault situation. The base benefit is protection of plant and personnel.

Resistor R will be rated for 10-30 seconds; with an ultimate temperature rise of the grid material of 400^0 or 500^0C. The resistance value of resistor R will be determined by:

$$R = \frac{V_L}{\sqrt{3} \times I_F} \quad \Omega$$

The metering CT is an optional item: it enables the earth fault to be relayed OFF. Medium voltage applications (3.3 and 6.6 kV), will be accommodated in suitable outdoor type enclosures; with appropriate insulation.

Information needed:

1 Supply volts.
2 Phase to neutral fault current.
3 Duration of fault – 10, 20, 30 sec.
4 Instrumentation CT needed?
5 Indoor – outdoor.
6 Enclosure colour preference.