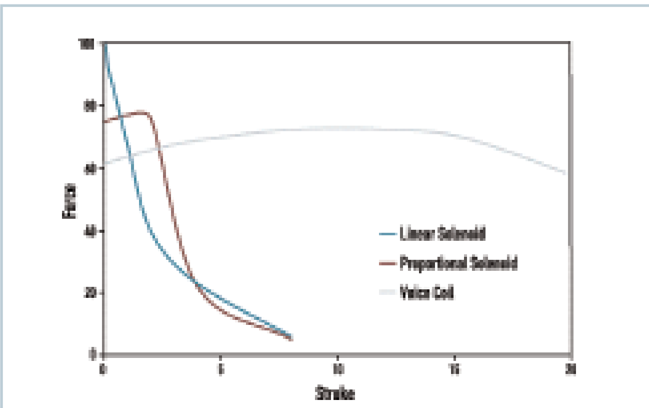
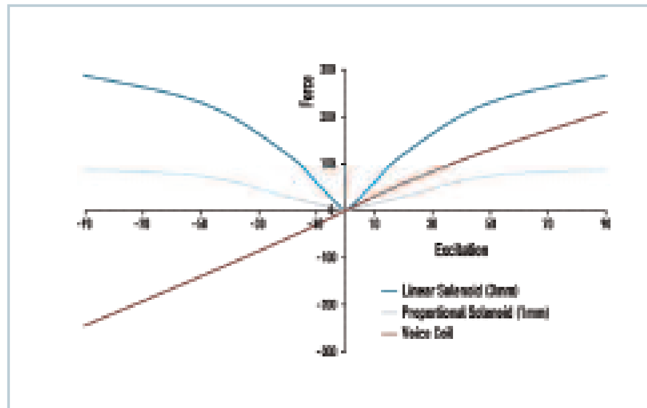
[Voice coil motors]

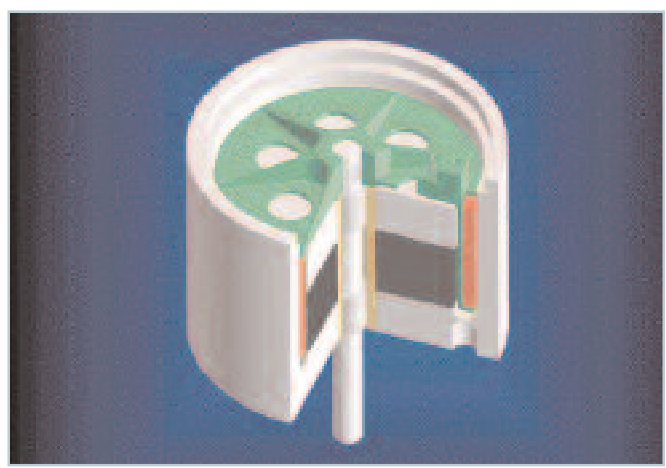
Voice coil motors offer excellent control characteristics where linear actuation is required over short distances with electronic control systems. Comparison of the force characteristics vs displacement, and vs current, for voice coil devices and solenoid actuators shows the difference between these devices. The flat force characteristic exhibited by the voice coil motor lends this to applications requiring precise control of force or position such as control valves, or lens and mirror positioning systems, whereas the sharp increase in developed force as the pole faces approach one another in a solenoid device makes these difficult to control.

The voice coil motor can develop force in either direction by reversing polarity of the excitation. In a solenoid, a spring is typically required to produce force in the return direction, this spring force subtracts from the magnetic force developed so reducing force and speed in the energised direction. Combined with low inductance this makes possible cycle times <1ms in certain cases, typically an order of magnitude faster than solenoid devices



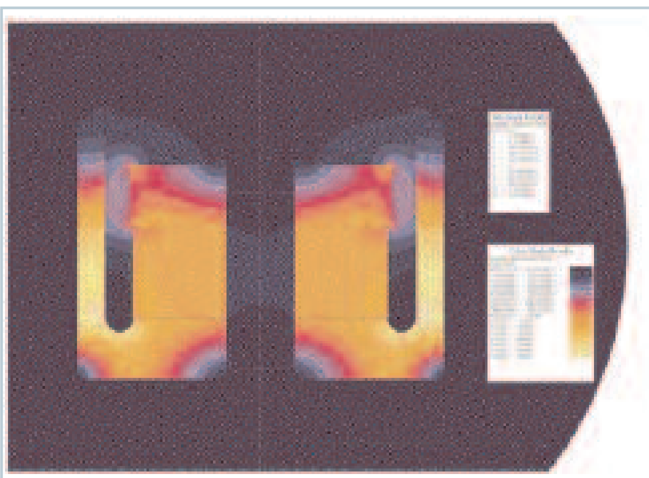


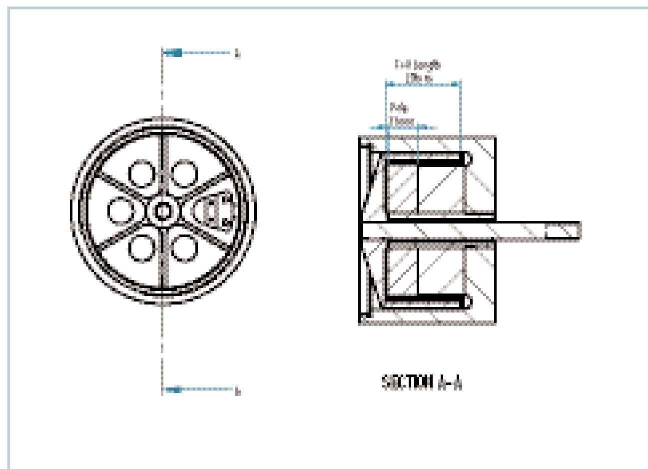
Voice Coil Motors of VM series incorporate shafts and bearings to ensure accurate guidance of the coil assembly within the magnet assembly, and to facilitate easy installation in your application. For wear resistance and good surface finish the shaft material is a hardened stainless steel which is magnetic and will have a slight influence on the force characteristic (shafts of non-magnetic stainless steel can be supplied to special order but are much more susceptible to mechanical damage).



The magnet assembly of VM series is designed for good volumetric efficiency at the expense of some loss of linearity. High Energy Density magnets drive the material of the voice coil pot (housing) close to magnetic saturation to develop the strongest possible magnetic field. Custom designs can demonstrate better linearity at the expense of increased size / weight & cost.

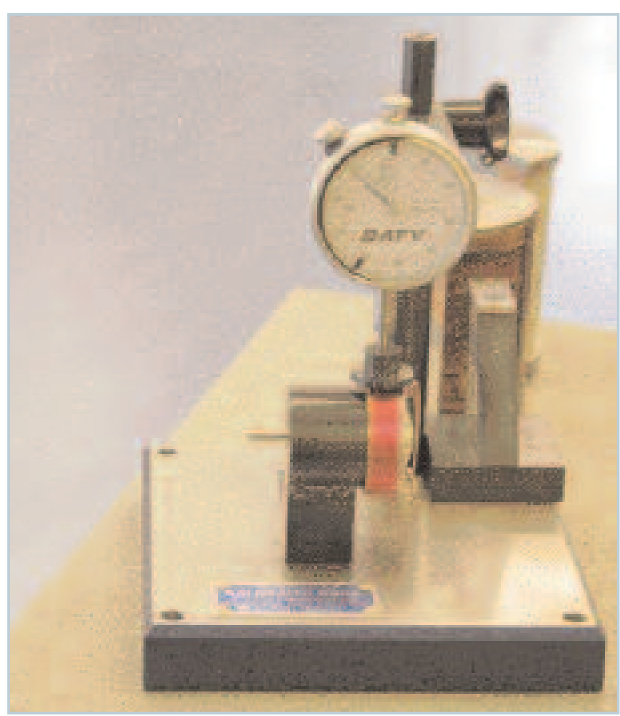
- Coils of standard VM series are normally designed to use the full depth of the pot assembly. This results in maximum mechanical work output capability, but may result in a force characteristic which is not ideally suited to a given application. The portion of the coil which lies outside the airgap field dissipates power (as heat) but develops no useful force.
- The linear range of a voice coil (the range within which developed force is >90% of peak force) will normally be roughly equal to the difference between the coil length, and the length of the pole.
- For maximum force, the coil length and pole length should be approximately equal in length, but the linear range with this configuration will be small.
- For best linearity, one of the coil and polepiece should be longer than the other by the linear range required. It is usually more cost effective to make the coil longer than the magnet assembly – making the coil shorter than the polepiece results in lower moving mass and faster dynamic response, but this may require a more massive and expensive magnet assembly to produce a required force characteristic.





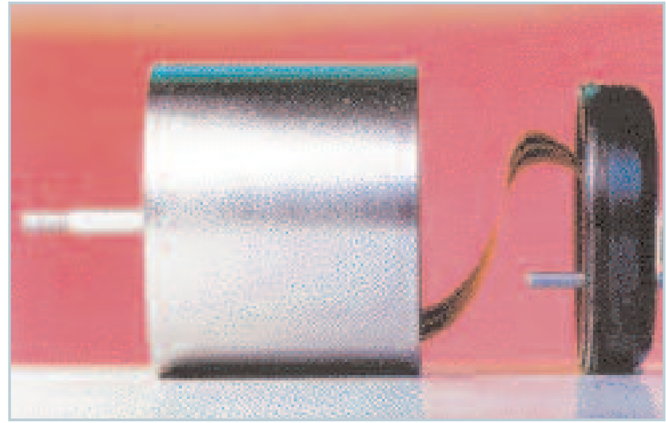
Mechanical Integrity

The design of VM series devices ensures good concentricity and mechanical integrity of the complete device. Accurate fixtures are used in assembly to control assembly dimensions, and coil assemblies are individually measured to ensure concentricity and clearance with the magnet assembly. All devices are designed to ensure that finite clearances are maintained throughout an operating range from 0ºC to 130ºC.



Electrical Termination

Connection to the moving coil of a voice coil motor must be implemented with care to ensure reliable operation. Flexible cable with many fine strands and Silicone Rubber insulation can provide reliable termination, care should be taken that the leads are mechanically secured to the moving assembly preferably at some distance from the soldered joints (solder fuses the strands together, and leads to large stresses being applied to the termination pins, or to fatigue adjacent to the fused portion of the wire). The leads should be carefully routed to minimise stress. A more consistent means of termination is to use a flexible circuit, this is offered as a standard option in the VM5050 device (see picture).



Motor Parameters

Force Constant K_{NI} N / Ampere-turn

The force developed per Ampere-turn of coil excitation. The force developed by the voice coil is the product of the Force constant, multiplied by the excitation in Ampere-turns.

Linear Range mm

The range of movement for which the developed force is >90% of the peak force developed by the motor.

Thermal Resistance R_{th} ºC / W

The temperature rise of the coil per watt excitation power with the pot assembly mounted on a massive aluminium block.

Max Temperature T_{max} ºC

Maximum permissible coil temperature for the motor

Continuous Force F_{100} N

The peak force developed by the motor when continuously energised at a power level such that the coil attains the maximum temperature, when the pot assembly is attached to a massive aluminium block at 20ºC. This may vary slightly for different coil winding options.

Continuous Power Rating P_{100} W

The continuous power input which results in the coil reaching maximum rated temperature when fully inserted in the pot, which is attached to a massive aluminium block at 20ºC

Motor Parameters

Motor Type	K_{NI} ($^{N}/_{At}$)	Linear Range (mm)	Rth (ºC/w)	T_{max} (ºC)	F_{100} (N)	P_{100} (W)
VM8054	0.072	15	2	130	45	50
VM6548	0.054	13	2.9	130	24	28
VM5042	0.052	7	4.2	130	21	24
VM4632	0.051	5	5.6	130	12.5	18
VM4032	0.029	9	8.4	130	10	12
VM2618	0.019	4	10	130	3.6	10
VM1614	0.005	4	20	130	0.8	5

Coil Parameters

Coil Parameters are tabulated with drawing data for each motor type

Turns	N		
Resistance	R	Ω	Measured at a temperature of

20ºC

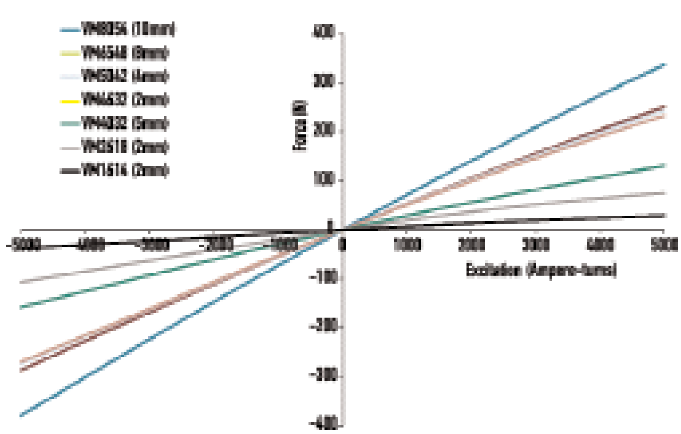
Velocity Constant	K_V	Vs/m

The voltage developed per m/s velocity of the coil. This varies for different coil winding options.

Inductance	L	mH

Inductance is measured with the coil fully inserted in the pot assembly (0mm)

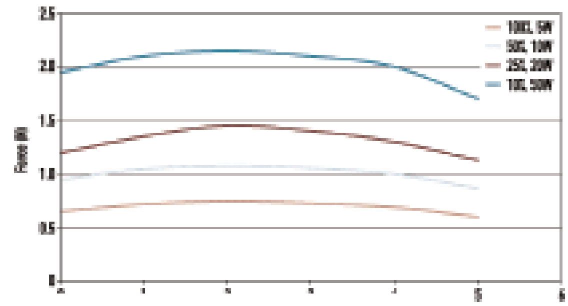
Performance Curves

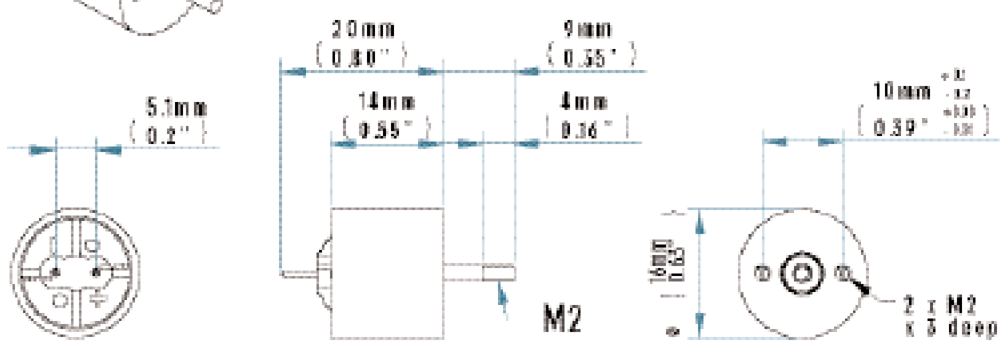


VM1614

Model No.	Turns	Resistance (Ω)	Inductance (mH)	Velocity Constant (Vs/m)
VM1614-100	480	40		2.4
VM1614-180	148	4.5		0.75
VM1614-200	134	2.8		0.65

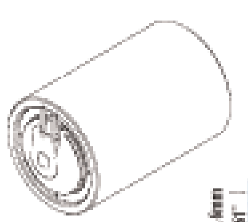
Weight 15g Coil weight 3g

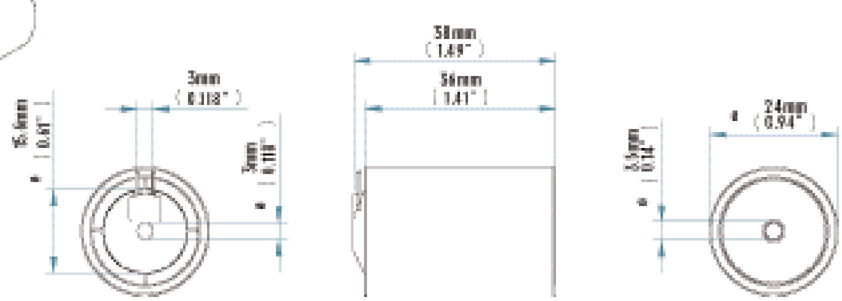




VM2436

Model No.	Turns	Resistance (Ω)	Inductance (mH)	Velocity Constant (Vs/m)
VM2436-112				
VM2436-180				

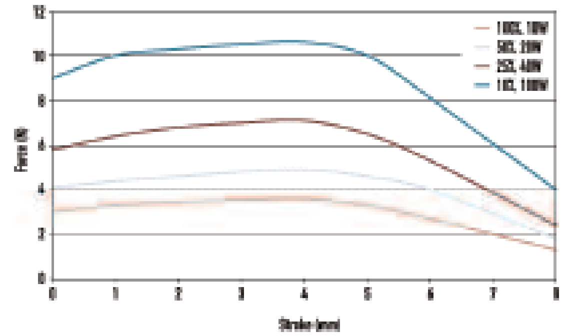


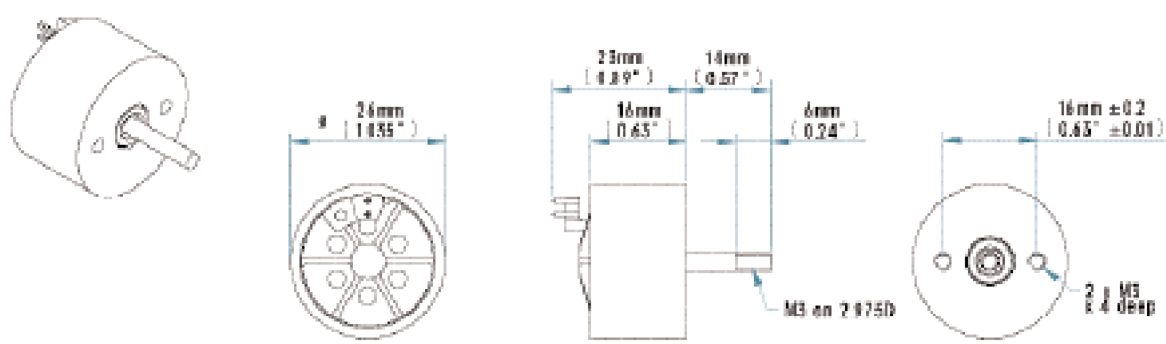


VM2618

Model No.	Turns	Resistance (Ω)	Inductance (mH)	Velocity Constant (Vs/m)
VM2618-40g5	1165	315	45	24
VM2618-080	1090	286	40	22
VM2618-112		55		
VM2618-180	198	9.6	13	3.2

Weight 60g Coil weight 6g

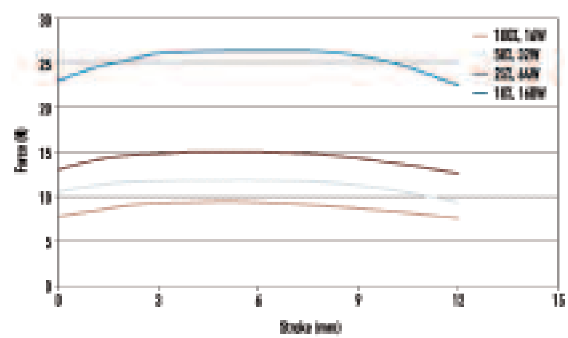


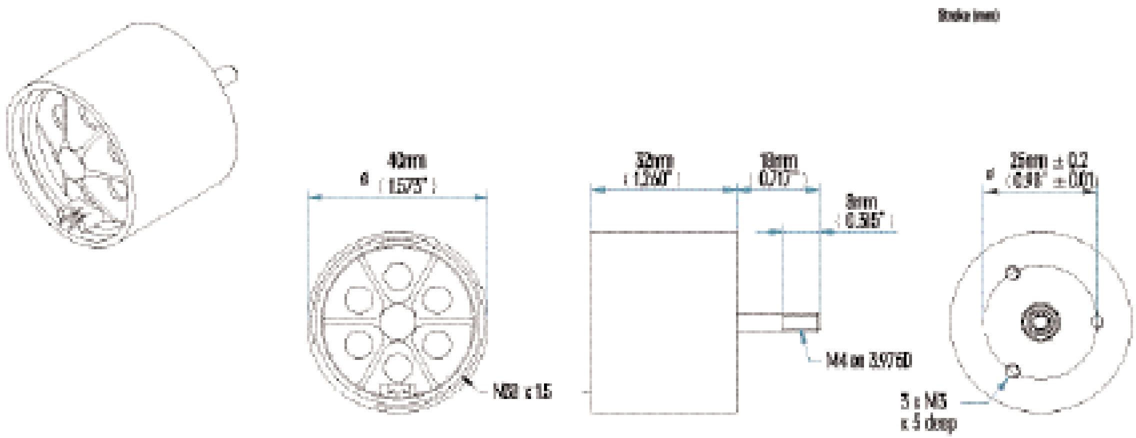


VM4032

Model No.	Turns	Resistance (Ω)	Inductance (mH)	Velocity Constant (Vs/m)
VM4032-200	456	26		14.4
VM4032-250	362	12.8		11.2
VM4032-315	200	4.3		6.4

Weight 230g Coil weight 25g



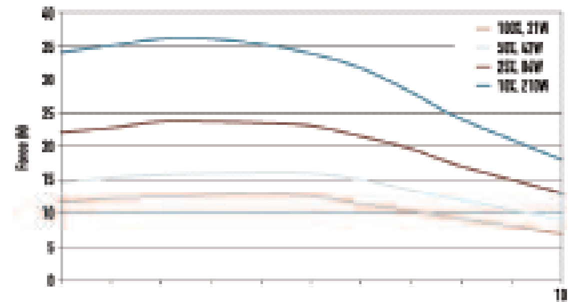


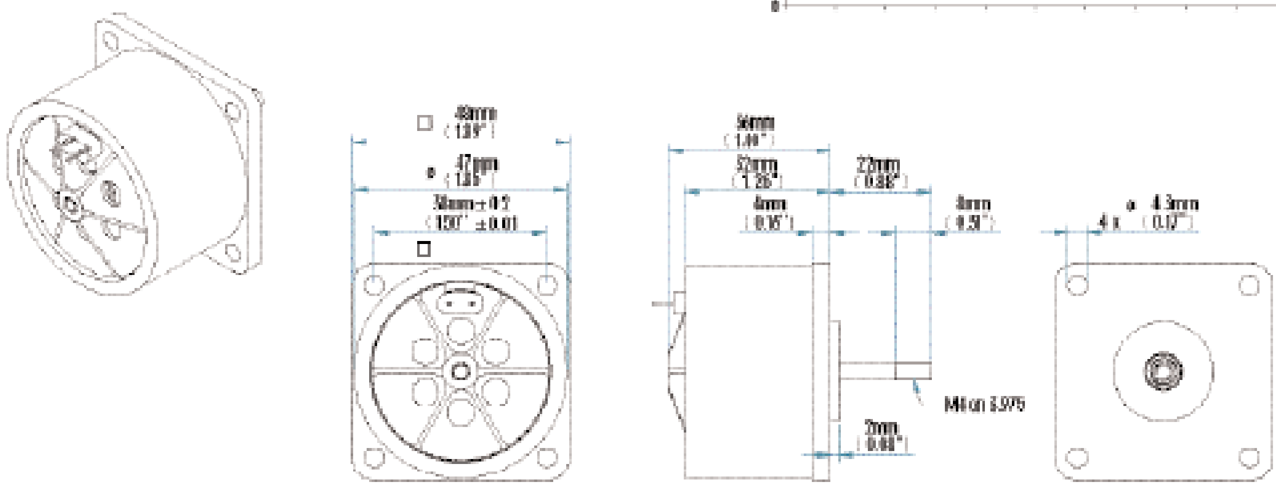
[Voice coil motors] (All dimensions are in mm, unless otherwise stated)

VM4632

Model No.	Turns	Resistance (Ω)	Inductance (mH)	Velocity Constant (Vs/m)
VM4632-180	445	35	12.1	21
VM4632-200	398	24.5	9.7	18.7
VM4632-250	246	10.1	3.7	12.4
VM4632-335	112	2.45	0.78	5.3

Weight 360g Coil weight 22g

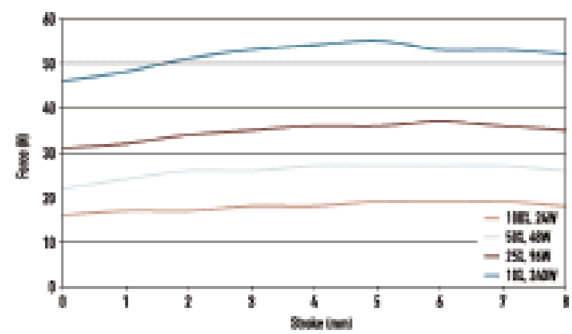


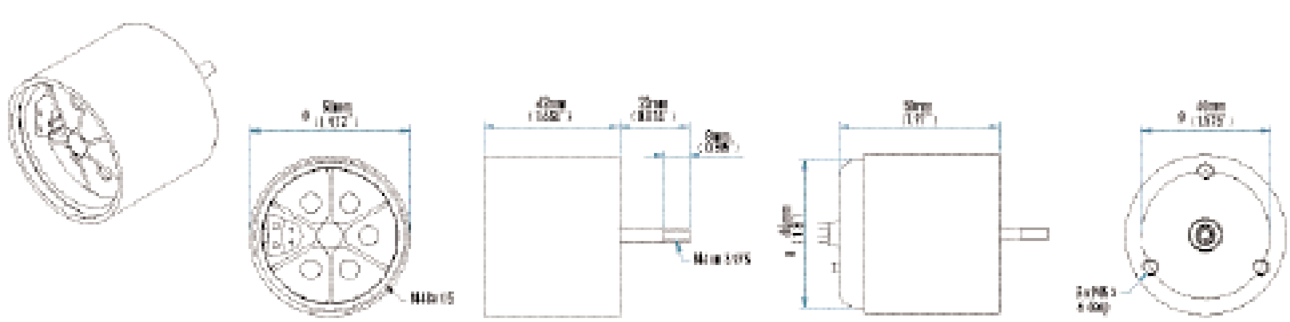


VM5042

Model No.	Turns	Resistance (Ω)	Inductance (mH)	Velocity Constant (Vs/m)
VM5042/ VM5050-190	586	45	20	35
VM5042/ VM5050-250	331	15.3	6.4	19.5
VM5042/ VM5050-400	137	2.5	2.1	8

Weight 480g Coil weight 35g



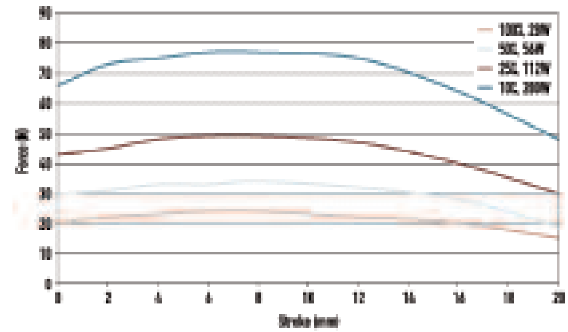


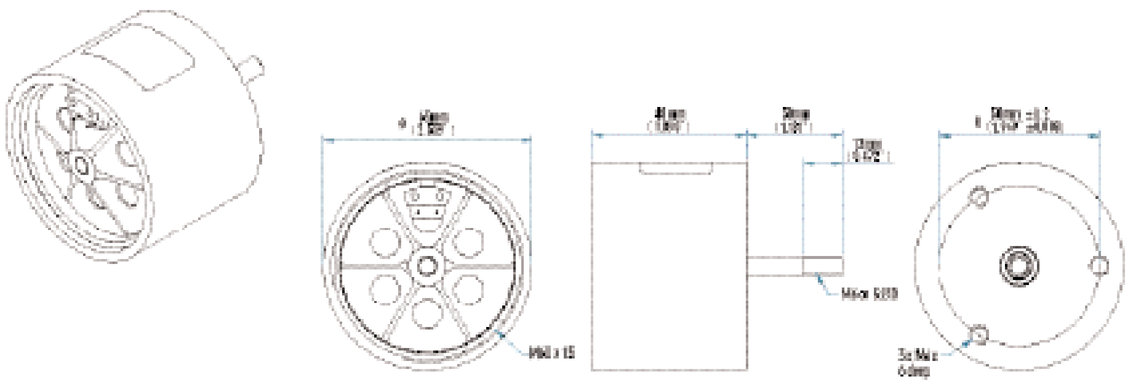
VM5050 incorporates end cover and flex circuit termination to coil. User termination is by 300mm leadwires.

VM6548

Model No.	Turns	Resistance (Ω)	Inductance (mH)	Velocity Constant (Vs/m)
VM6548-200	1335	121		80
VM6548-315	596	23.3		36
VM6548-400	350	7.8		22

Weight 950g Coil weight 90g

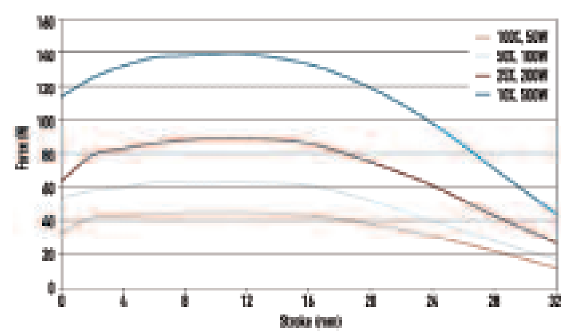


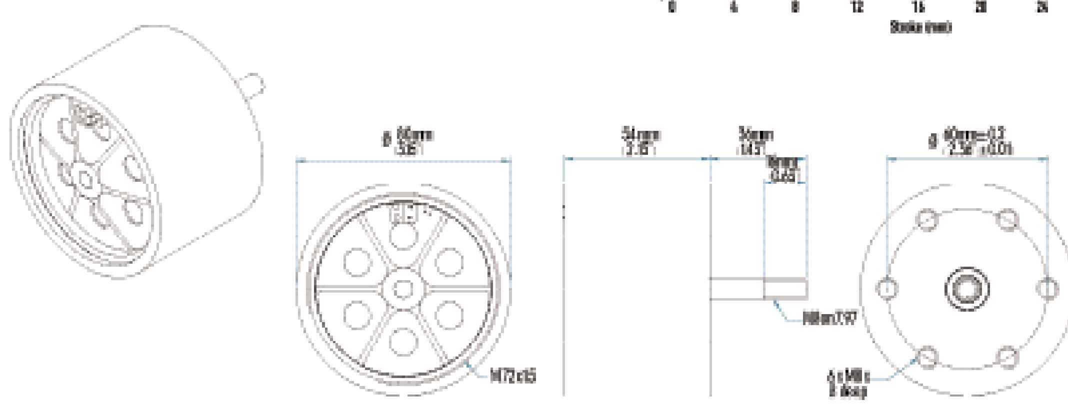


VM8054

Model No.	Turns	Resistance (Ω)	Inductance (mH)	Velocity Constant (Vs/m)
VM8054-250	1150	85		86
VM8054-400	450	11.5		34

Weight 1700g Coil weight 150g



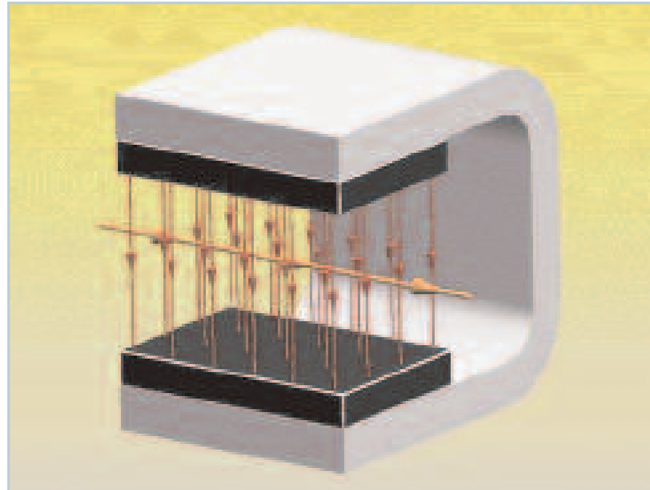


[Voice coil motors]

The behaviour of a voice coil motor can be explained by reference to the classical physics problem of a current carrying wire supported in a magnetic field. Where the magnetic field strength is B, the current carried by the wire is I, and the length of the portion of wire cut by the field is l, a force F is developed according to the equation

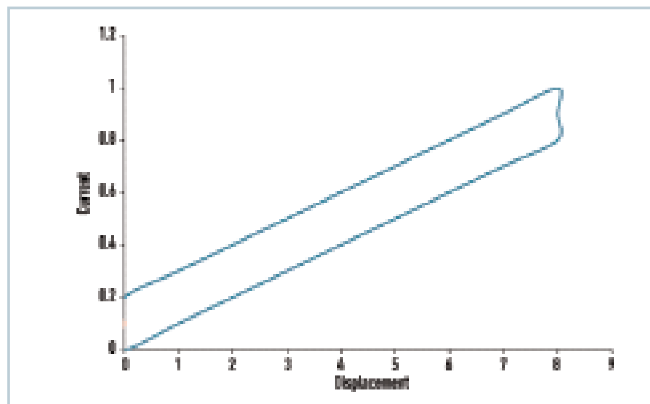
$$F = B \times I \times l$$

The force developed is perpendicular to both the magnetic field, and to the current flowing in the wire.



Hysteresis

Hysteresis is analogous to backlash in mechanical systems which can give rise to position or force errors. The graph shows how hysteresis is manifested in a positioning system - as current is varied to change the direction of a move it needs to change back significantly to achieve any movement. Hysteresis in solenoid devices can be as great as 10% or more of the developed force, where as in voice coil motors it is typically <<1% of the developed force. Low hysteresis enables precise and repeatable position control to be realised.



Basic Equations

A voice coil motor will develop a back emf E according to the equation

$$E = K_v \times V$$

(v is velocity in m/s)

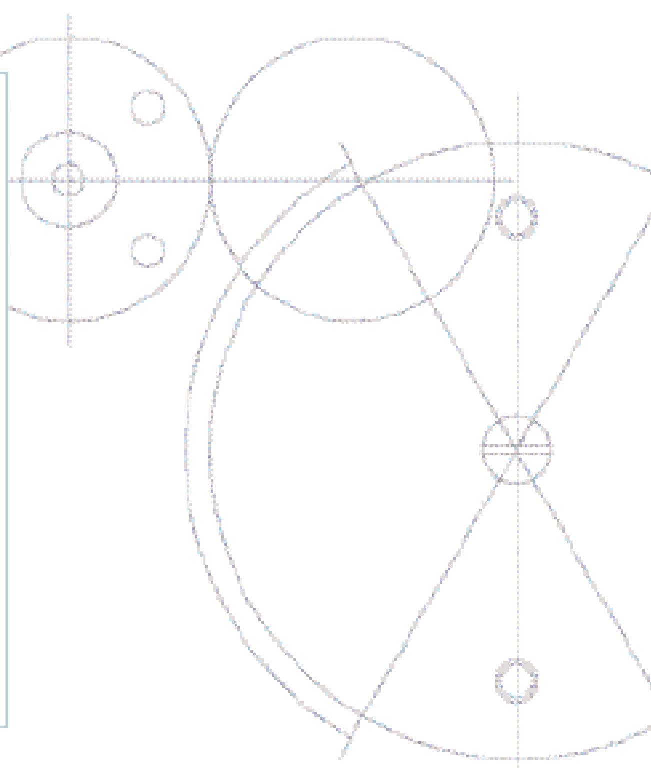
When driven with a constant current I, the force developed by the motor is given by the equation

$$F = K_{NI} \times N \times I$$

When driven with a constant voltage V, the relationship between force F and velocity v is governed by the equations

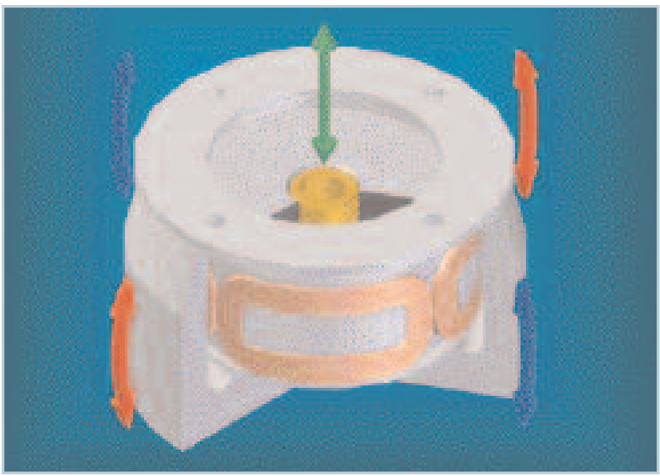
$$F = K_{NI} \times N \times (V - [K_V \times V]) / R$$

$$V = ([F \times R] / [K_{NI} \times N] - V) / K_V$$



X-Y Tilting Motor

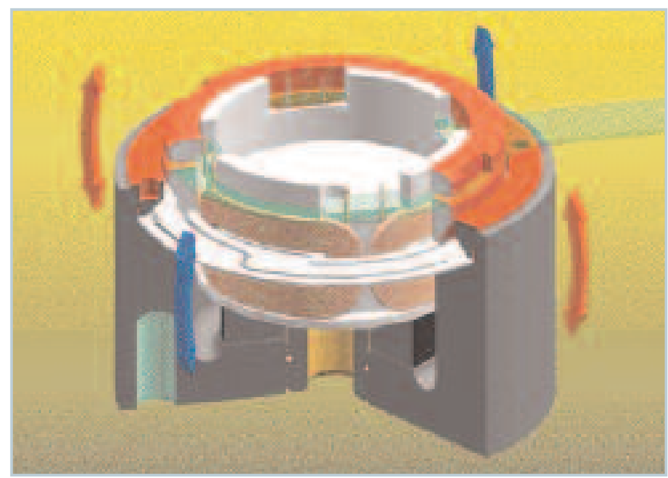
Tilting motors are used for beam-steering applications in optical or other systems. A complex coil assembly is used with (typically) 4 coils wound on the former. When a coil is energised, it develops thrust just as a normal voice coil does, but generates this thrust at a point displaced from the axis of the assembly. If two opposing coils are energised in opposing directions, a turning moment is developed.



In a typical application, the tilting motor coil assembly would be attached to the mirror of a steering mechanism, the mirror would be supported in flexure bearings. When all 4 coils can be independently energised, it is possible to control inclination of the assembly in either the X or the Y plane, or by applying a current in the same sense to opposing coils to generate a linear displacement along the axis.

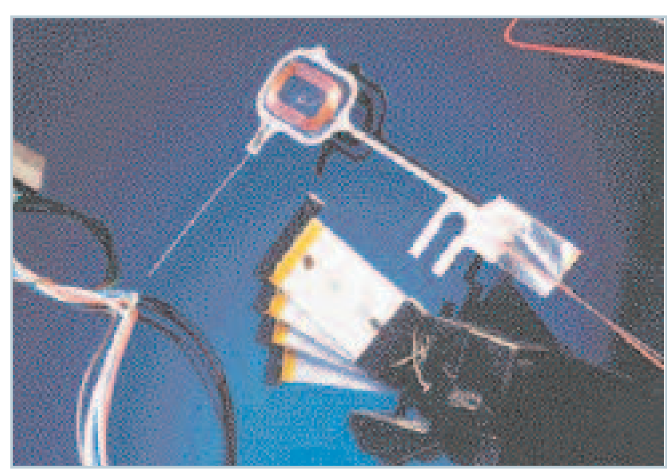
The multiple coil configuration offers a much more elegant solution to steering mechanisms than systems based on multiple actuators, The resultant designs typically exhibit lower moving mass, and faster dynamic response. The use of a single large magnet assembly makes it easier to achieve large airgaps to allow for the tilting of the coil assembly.

The VMXY36 actuator integrates a steel flexure ring support, and flex termination to the coils, within a compact unit only 36mm in diameter. The opposing coils are connected in reverse polarity, so only X or Y inclination is possible with this unit (Z displacement is not possible with this device). This unit offers hysteresis free operation in a very small package for small beam deflection systems.



Custom Solutions

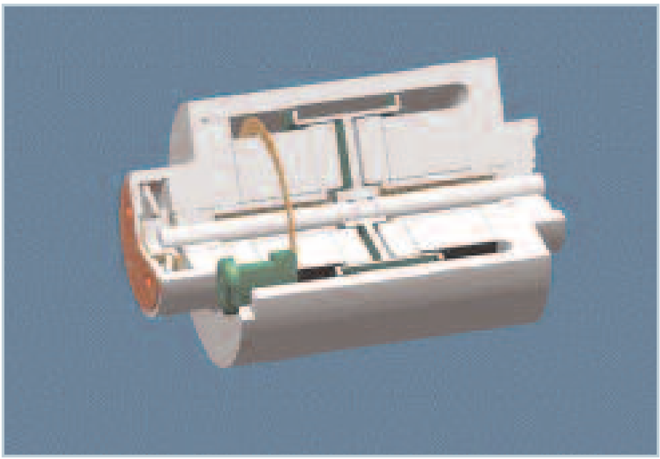
In addition to the devices described in detail in this catalogue, many other variants are possible as custom solutions. Modification or custom solutions are possible for quantities from 10's of pieces where this is commercially viable. In many cases it may be possible to utilise key components from standard designs in a custom solution to keep costs reasonable – custom solutions can offer the following benefits:

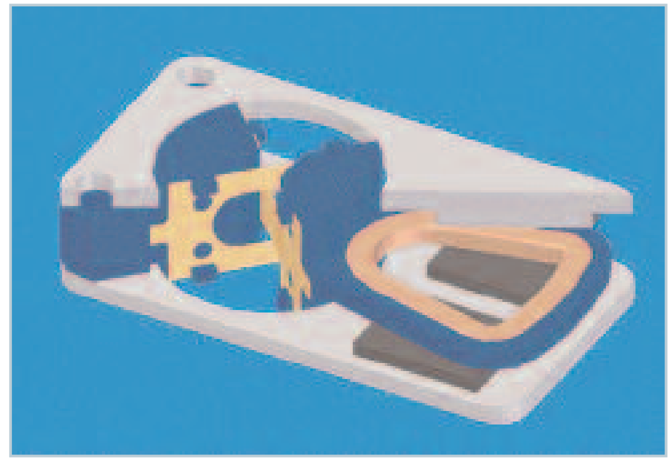


[Voice coil motors]

Double-ended designs develop more than twice the force of a conventional design of the same diameter. Opposed pot construction also results in greater linearity of force / stroke characteristic.

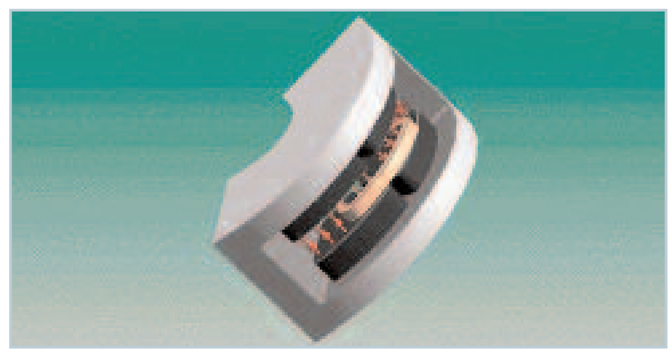
Position sensing can be incorporated in some designs for closed-loop operation.





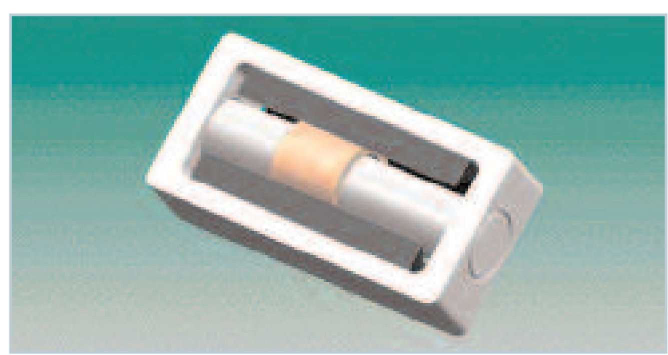
VMR Rotary Voice Coil Motors

Voice coil motors can be built with a flat 'sector' coil construction, in which the two radial sides are located in areas of opposing field, as the current in each is flowing in opposite directions, both sides will develop a torque about the axis of the device. These devices can give good control for small angles up to about 70-80º.



VMB Beam Type Motors

Long stroke requirements are best satisfied by using a 'beam' type construction. This develops a more uniform field over a large distance than a 'pot' construction, and is well suited to building devices with displacement of 100mm or greater.



VMF Flat Voice Coil Motors

For close packing in applications where many actuators need to be stacked close together, the voice coil can be built with a flat construction. Where only a few devices are required, it is possible to run several coil assemblies in a single field assembly to achieve stacking as close as 1-2mm between devices; for large arrays, intermediate field plates are required with spacing in the region of 5-15mm arrays of almost unlimited size are feasible.