High Performance DC Servomotors
for Industrial Markets

CALLAN TECHNOLOGY NEWS

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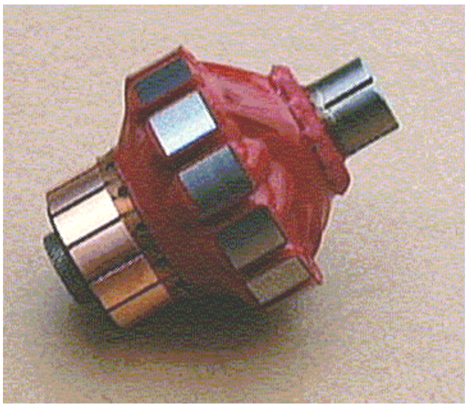
Callan Technology Ltd is a design and manufacturing company for a wide range of industrial DC servomotors, tachogenerators and components. Callan Technology's industrial motor platform (M4 range) is a family of rare earth permanent magnet DC servomotors:

M4-200X (0.4 – 1.6 Nm),
M4-295X (2.0 – 8.1 Nm)
M4-420X (10.4 – 30 Nm)

C4-16X (0.2 - 0.4 Nm) is a family of compact, rare earth servomotors specifically designed for applications where low cost is important while maintaining ruggedness and performance.

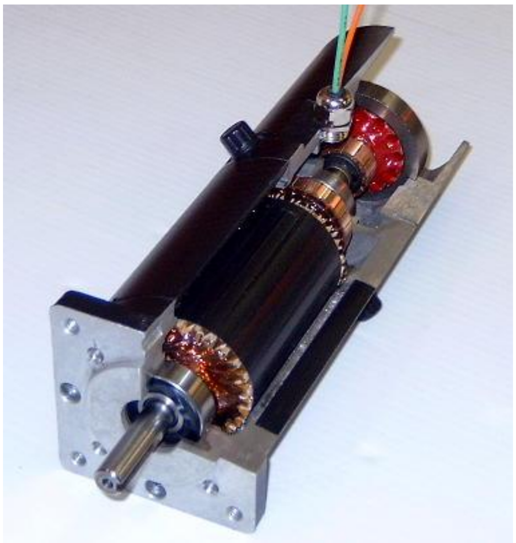


All motors are available in a variety of shafts & mounts, connection types, tachogenerator or incremental encoder feedback, parking brake and a variety of other special features.

The use of rare earth magnets results in compact motors with superior thermal stability and power/weight ratio compared to conventional ferrite motors.

The M4-200X motor family is offered with optional tachogenerator type TGF 1568. This tachogenerator family was recently extended to provide windings with voltage constant (KG) of 3.0, 4.0, 7.0 or 14 V/krpm. The TGF 1568 is a 2-pole DC tachogenerator with exceptionally rugged construction and superb thermal stability. Speed range is up to 6,000 rpm

For further details see :
www.callantechnology.com/callan_technology_products/Tachnogenerators/TGF-1568.html



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Engineered to Order - Case Study

A new customer in the automation industry required a DC tachogenerator with the following specification -

- High value voltage constant (KG > 50 V/krpm)
- Low value tach ripple (<1.5% pk-pk/avg)
- Low temperature sensitivity (<0.05%/°C)
- Frameless (kit) construction
- Short overall length

After detailed review, a modified version of model TGF 2030 was found to meet the specification requirements.

The TGF 2030 is a family of 4 pole, frameless DC tachogenerator. The field is realised with rare earth (Samarium Cobalt) magnets which provides excellent thermal stability and is virtually impossible to demagnetise.

A range of windings are provided with different value of voltage constant and maximum speeds up to 5,000 rpm. Operation is permitted up to maximum temperature of 130°C.

For further details of TGF 2030 tachogenerators see www.callantechnology.com/callan_technology_products/Tachnogenerators/TGF-2030.html

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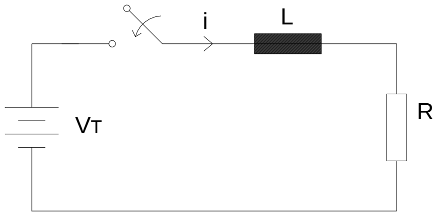
DC Servomotor Tutorial –
Time Constants - Electrical (τ_e) , Mechanical (τ_m) and Thermal (τ_{th})

Data sheets for DC servomotor products frequently refer to a number of different time constants – electrical time constant (τ_e), mechanical time constant (τ_m) and thermal time constant (τ_{th}). Most users tend to largely ignore these parameters yet it can be most beneficial to understand what they mean and how they might be used in practice.

Electrical Time Constant (τ_e)

Most users are familiar with the electric time constant of an inductive – restive (L-R) circuit.



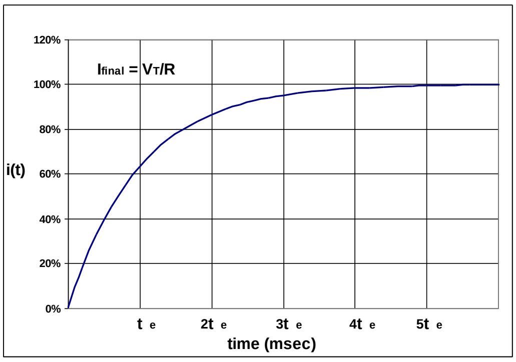
When the switch is closed, the current rises in the circuit according to

$$i(t) = (V_T/R) \quad [1-\exp(-t/\tau_e)] \quad ....(1)$$

where the electrical time constant is

$$\tau_e = L/R \quad ..... (2)$$

[L in mH and R in Ω gives τ_e in msec]



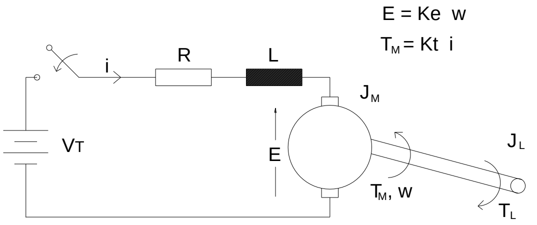
From eqn. 1, it can be deduced that at time t= τ_e, the current has reached 63% of its ultimate value. After 5 electrical time constants the current has reached more than 99% of its final value.

If the rotor of a permanent magnet DC motor is locked (hand held in the case of a small motor) and a voltage supply (V_T) applied to its terminals, then the current will rise exponentially to V_T/R according to eqn. 1. It is very important that this is not done at full rated terminal voltage of the motor as the full locked rotor current can damage the motor if maintained for even a short time duration.

In a servo system we frequently require rapid changes in torque (current). This is more easily performed when the electrical time constant is as short as possible. However, when the motor is supplied with rectified or chopped voltage, higher value armature inductance is beneficial in smoothing the armature current and this is more difficult when the electrical time constant is very short. (In such cases an external inductance will help to smooth the current waveform)

Mechanical Time Constant (τ_m)

Considering the DC servomotor equivalent circuit below



The mechanical time constant is defined as

$$\tau_m = RJ / Kt^2 \quad ..... (3)$$

[J in kgm^2 and R in Ω gives τ_m in sec]

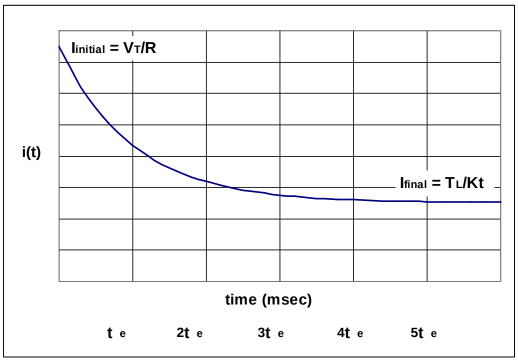
When the switch is closed, the current, I, and the speed, **w**, rise and eventually settle out at their ultimate value. The equations for the transients of speed and current are quite complex. However if motor inductance, L, is ignored, then the equations reduce to

$$i(t) = (T_L/K_t) + [(V_T/R) - (T_L/K_t)] \ \exp(-t/\tau_m) \quad ...... (4)$$

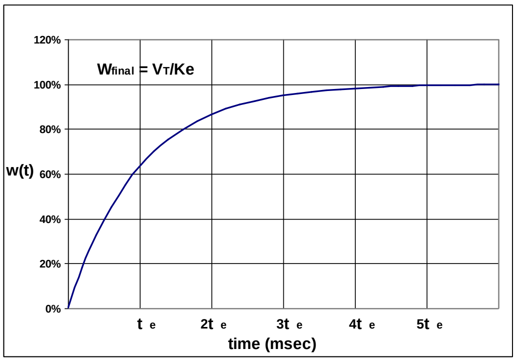
$$w(t) = [(V_T/K_e) - (RT_L/K_eK_t)] \ [1-\exp(-t/\tau_m)] \quad ...... (5)$$

In eqn. 3,4 and 5, J is sum of motor inertia ,J_M and reflected load inertia, J_L. T_L is total load torque and includes any friction or rotational losses in the motor. **w** is the angular velocity of the motor shaft.

Eqn. 4 describes a situation where the current i(t) rises instantaneously to V_T/R and then falls exponentially to T_L/K_t . After time t= τ_m , the current has fallen by 63% of its ultimate drop. This is obtained from equations, derived by ignoring motor inductance, L. It tends to be accurate when L is not negligible provided τ_e is much less than **τ_m.**



Eqn. 5 describes a situation where the speed **w**(t) rises exponentially from zero to a final settled value of VT/Ke with time constant **τm.** Again this is obtained from equations derived by ignoring motor inductance, L, but it tends to be accurate even when L is not negligible provided τe is much less than **τm.**



Thermal Time Constant (τth)

The motor current heats up the armature winding (and thereby the complete motor) under the effects of the dissipated power loss, P. We assume that the heat is generated entirely by I^2R power in the winding.

A portion of the power loss leads to an increase in the temperature of the materials in the heat flow path between winding and ambient, by transfer of Joule energy.

The remainder of the power dissipation maintains the temperature difference between the motor winding and ambient, predominantly by natural convection to the surrounding air.

This situation is described by the eqn.

$$P = C\,(d\Delta T/dt) + \Delta T/\Re_{th}$$

where
P= power due to copper losses, I^2R (W)
ΔT = temp rise of winding above ambient (°C)
t = time (sec)
C = heat capacity of material between winding and ambient (Ws/°C)
ℜth = thermal resistance of material between winding and ambient (°C/W)

which can be solved for temp rise **ΔT** as follows

$$\Delta T(t) = (P\,\Re_{th})\;[1-\exp(-t/\tau_{th})] \quad \ldots\ldots (6)$$

Therefore, provided the power dissipation is kept constant, the temp rise of the winding (above ambient) follows a similar behavious as the motor speed in the previous discussion of mechanical time constant , τm (see graph)

Eqn. 6 describes a situation where the winding temperature rise ΔT, rises exponentially from zero to a final settled value of **P ℜth** with time constant **τth.**

Values of **ℜth** and C and hence **τth** could in principle be calculated from the detailed geometry of the motor and a knowledge of the thermal properties of the motor materials. However it is easier and more common to perform a test with constant dissipated power P. The value of **ℜth** is the ultimate temperature rise divided by the power dissipation (by eqn. 6). The thermal time constant **τth** , can be evaluated as the time when the temperature rise is 63% of the ultimate temperature rise.

AfterMarket Focus

Motor: **M4-2950-1B-3537**
Originally used on: Bofors (Defence Industry)
Body Diameter: 108mm
Length: 246 mm
Shaft:- Ø0.625” (15.875 mm)
Rear Shaft Ext. Ø0.375” x 0.88”
Shaft Seal, motor sealed IP45
Tachogenerator:- 12.5 V/krpm