Application Note

I C s f o r M o t o r C o n t r o l

Application of TDA5140AT with position indicator PG-IN and Speed Control

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Summary:

The Motor Control IC TDA5140AT has been especially designed for driving brushless VCR scanning motors.
Besides the back-EMF sensing, the commutation timing and the drive of the motor coils the IC features also a position indication method of the scanner drum with respect to the motor coils and some speed control circuitry.
For position indication the PG-IN input and the PG/FG output are used.
For the speed control the IC has an operational amplifier that drives an external series voltage regulator.
In this paper the functioning of both the position indication and the speed control have been described.

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1. Circuit description.

In figure 1 the circuit diagram has been depicted of the evaluation board of the TDA5140AT and in figure 2 a drawing of the pc-board with the components placing.

The pc-board has two STOCKO connectors. One connector (4-pole) has been used to make the connections to the motor and the second (7-pole) is used for the connections of the supply, the input control voltage, PG-IN and the PG/FG signals.

The supply voltage V_P is only used for the TDA5140AT the generate the timing signals for the commutation, the start oscillator and timing signals for internal use. According to the specification this voltage may vary between 4 and 18 volts.
The supply voltage V_S is used to supply the power for the motor. The motor voltage V_{mot} is derived from V_S. The voltage V_{mot} can be controlled via the series regulator T1 by means of V_{in}. The voltage V_{mot} may vary between 1.7 and 16 volts.

The back-EMF sensing is based upon the measurement the voltage across one motor coil. Therefore the star point of the motor must be connected to the TDA5140AT. However, if a motor is used without an external starpoint connection an artificial starpoint must be created. This can be done with three 1 kΩ resistors which are connected in a star configuration to the motor coil terminals. The starpoint has to be connected to the MOT0 terminal of the TDA5140AT. The evaluation board has already been provided with 3 resistors of 1 kΩ, which have been mounted on solder pins.

Although the all output drivers in the TDA5140AT have been provided with a fly-back diode external fly-back diodes from output terminals to ground might be necessary, because some oscillations may occur during the fly-back pulses. These oscillations could cause malfunction of other circuit components.

The timing capacitors have been determined in such a way that most motor applications will operate properly.

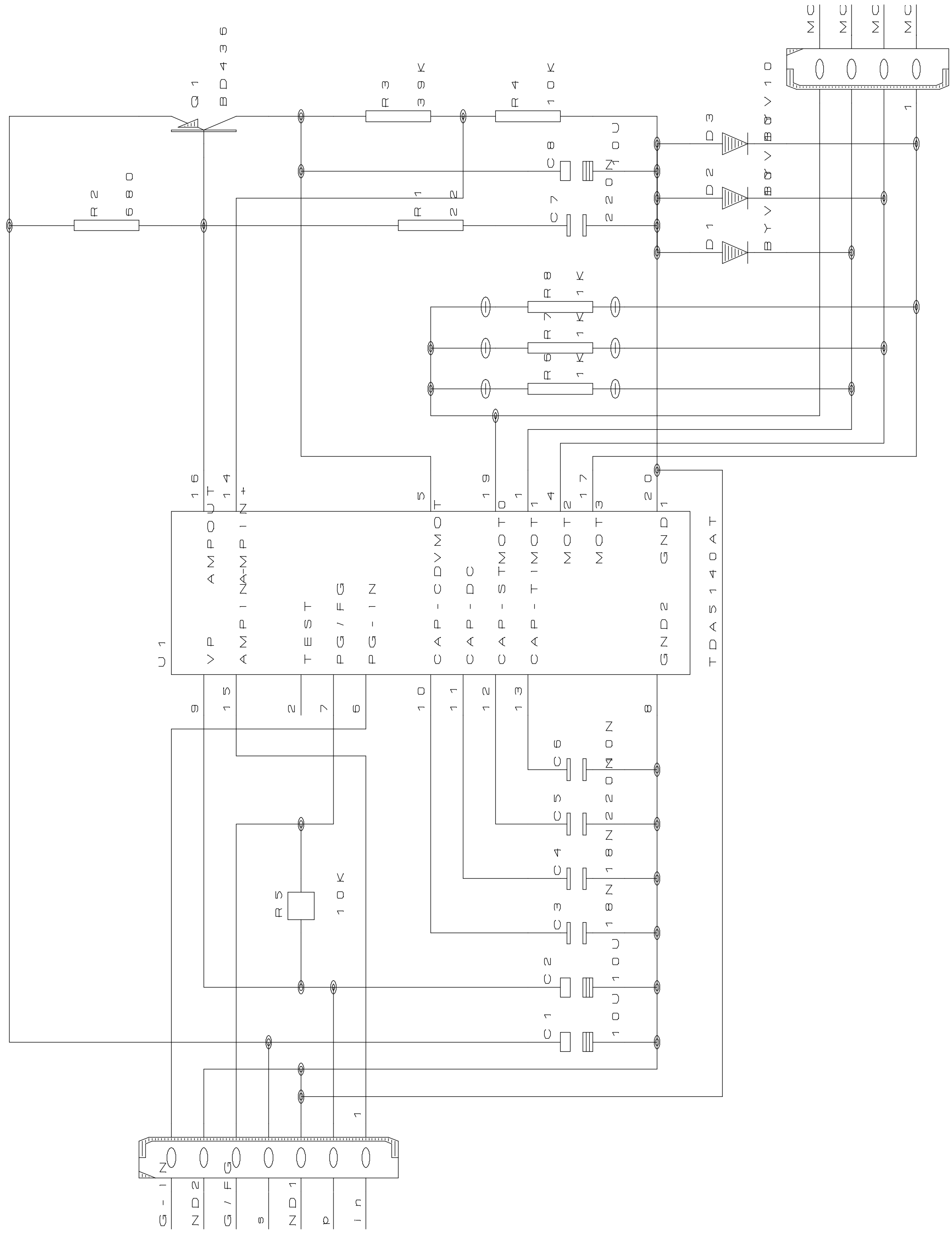

Figure 1

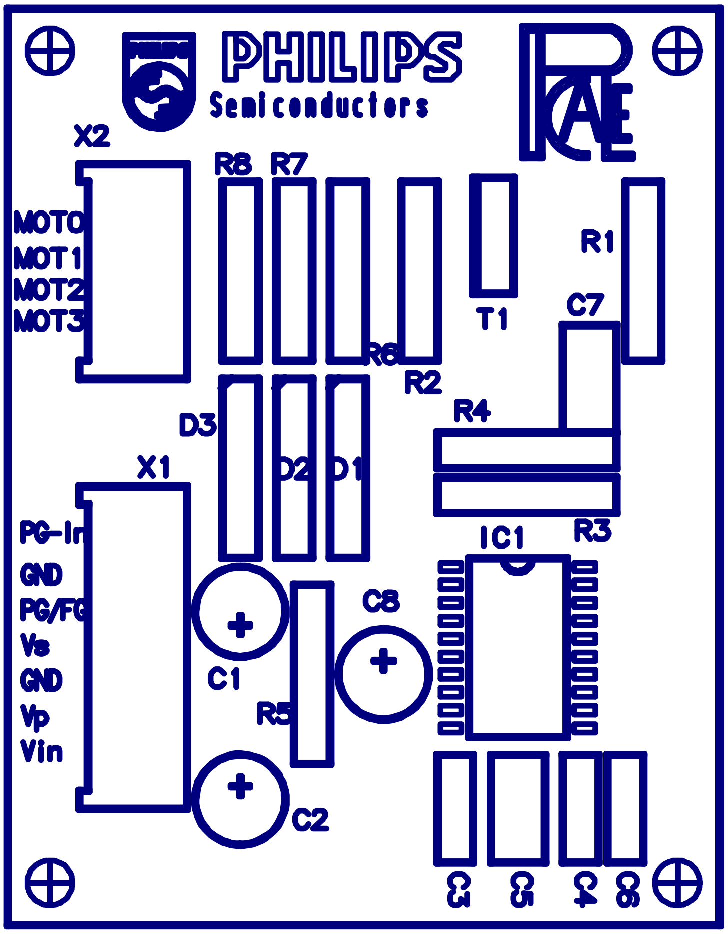
PHILIPS
Semiconductors
X2
R8
R7
MOT0
MOT1
MOT2
MOT3
R1
T1
C7
R6
R2
R4
D3
X1
D2
D1
PG-In
GND
PG/FG
Vs
GND
Vp
Vin
IC1
R3
C8
C1
R5
C2

Figure 2

2. Timing PG-IN and PG\FG signals.

The scanner drum of a VCR motor contains several heads to read the even and the odd lines from the video tape. To determine the start and the switch-over between the different read-heads it is very important to know the position of the scanner drum. For this reason the motor has been provided with a position indicator.
The position indicator consists of a small magnet mounted on the rotor of the motor and a simple low cost pick-up coil or an AC-coupled Hall-effect sensor. The pick-up element has to be mounted on the stator. The magnet is used to induce a voltage in the pick-up coil or to activate the Hall sensor. In this way the sensor can produce one pulse per revolution. This pulse is connected to the PG-IN input of the TDA5140AT. The TDA5140AT contains circuitry to determine the relation between this pulse and the voltages on the motor coil.
The motor has to be assembled in such a way that there is fixed relation between the position of the small rotor magnet with respect to the read-heads and the pick-up element with respect to the motor coils. In this way the position of the read heads can be determined.
The position (or phase) information is made available externally via the open collector output PG/FG. This output also gives information about the speed of the motor. Both signals are time multiplexed to the PG/FG output.

In the timing diagram of figure 3 the relation has been given between the motor coil voltages, the PG-IN input and PG/FG output.

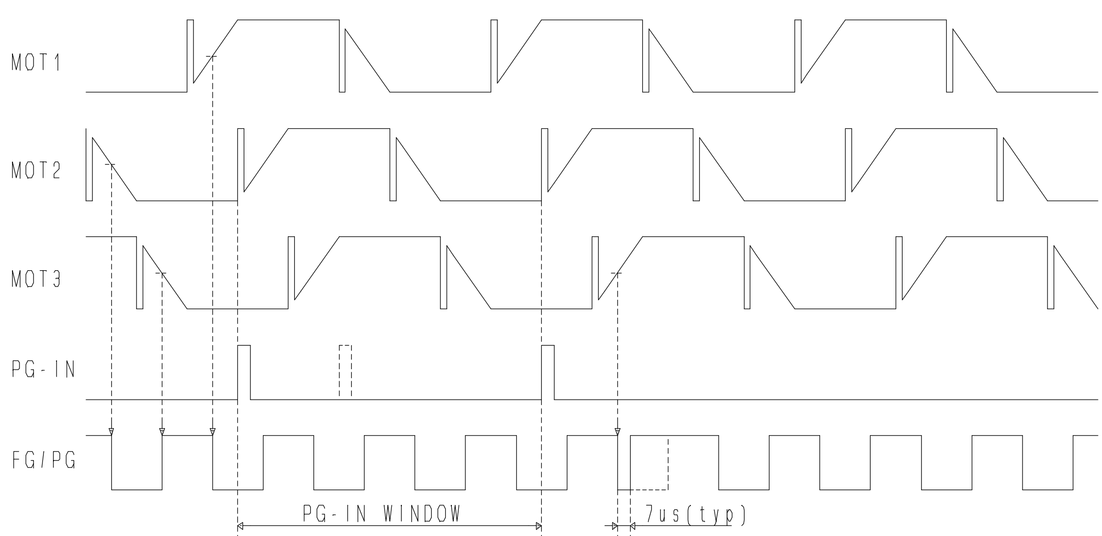

Figure 3

The voltage of the pick-up element is connected to the PG-IN input of the TDA5140AT. In the

TDA5140AT this input has been connected to a comparator circuit with hysteresis. According to the TDA5140AT specification the switching level of the comparator circuit has been specified between 86 and 107 mV with a hysteresis of typ. 8mV. The logic circuitry after the comparator is triggered on the positive edge of the PG-IN input signal.
As soon as a PG-IN signal has been detected this signal will be latched and the internal timing of the TDA5140AT will take-over the control. This will result in a change of the PG/FG output signal.
The PG/FG signal is the tacho signal that indicates all zero crossings of the motor coil back-EMF voltages. This has been indicated in figure 3 with the dotted lines. The tacho signal normally has a 50% duty factor.
If, however, a PG-IN signal has been detected the PG/FG output signal is multiplexed with a PG-pulse of maximum 18 µs (typ. 7 µs). This implies that the low level, initiated by the zero volt crossing of the MOT3 coil voltage, is set high after maximum 18 µs. This event always occurs at a zero crossing of the negative going MOT3 motor voltage.

In figure 3 the window has been depicted, in which the PG-IN signal must be detected by the logic in the TDA5140AT. The dotted PG-IN signal that has been drawn in this window indicates this. The PG-IN signal must be present between two states that the MOT2 voltage switches from a conducting low state to a floating state. Under these conditions a PG pulse, multiplexed with the tacho signal, can be expected at the next negative going MOT3 zero crossing.

The window, as has been depicted in figure 3, has a duration of 360 electrical degrees. If, for example, a motor is used with 6 pole-pairs on the rotor then the pick-up element must be mounted in mechanical window of 60 degrees.

In figure 4 a circuit has been depicted to generate the PG-IN signal. The pick-up coil has to be mounted on the stator in such a way that the magnet on the rotor can pass very nearby.
The magnet pick-up coil combination must be such that the induced voltage (> 107 mV) is large enough to switch the comparator in the TDA5140AT. Because the logic inside the TDA5140AT is triggered on a positive going edge of the PG-IN signal the duration of the PG-IN pulse is not critical.

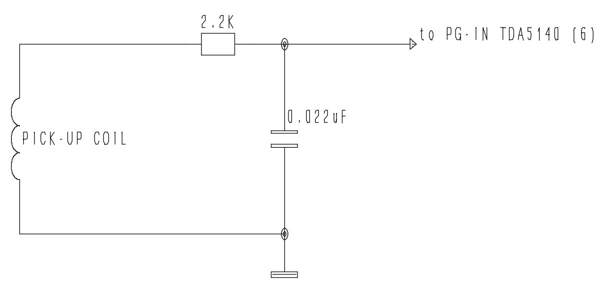

Figure 4

3. Speed control.

The motor speed can be regulated by controlling the voltage on the IC-pin V_{mot}. This voltage is the supply voltage for the on-chip power stages.
On the evaluation board the voltage V_{mot} is regulated in an analogue way by a series regulator transistor Q1 (BD436). The IC has been provided with an uncommitted Operational Transconductance Amplifier (OTA) that is able to drive directly the series regulator. The voltage V_{mot} is coupled back, via a voltage divider R3 and R4 (see figure 1), to the input AMPIN+ of the OTA. The input voltage V_{in}, to control V_{mot}, is connected to the AMPIN- input of the OTA.
The voltage divider R3 and R4 determines the control range for V_{in} in relation to V_{mot}.

Assume a supply voltage V_s of 12 V ±10% and a minimum allowed voltage drop Q1 of 1 V to guarantee a linear control.

With these requirements the worst case maximum value of V_{mot} can be 0.9 x 12 - 1 V = 9.8 V.

As a general rule for the OTA applies that: AMPIN+ = AMPIN-

The value of V_{in} at which, with the given resistors R3 and R4, a V_{mot} of 9.8 V is obtained can be calculated as follows:

$$V_{in} = V_{mot} \frac{R4}{R3 + R4} = 9.8 \frac{10}{39+10} = 2\ V \tag{1}$$

With a voltage V_{in}, ranging to 2 V, the voltage V_{mot} can be controlled up to 9.8 V.
However, keep in mind that the voltage V_{mot} may not become lower than 1.7 V, because at lower voltages the back-EMF comparators does not operate correctly at this low voltage.

The values for R3 and R4 have to be adapted when a different relation between V_{mot} and V_{in} is required.

In the example above the maximum voltage on the OTA inputs for the active control range is 2 V. Because the supply for the OTA is retrieved from V_P the maximum voltage on the OTA inputs is related to V_p and the inputs voltages may, according to the specification, not exceed V_p - 1.7 V. So, keep in mind that, when other values for R3 and R4 have to be determined the maximum input voltages on the OTA inputs are not exceeded.

The series connection of R1 and C7 is necessary to obtain a good stability of the control loop.