Application Note

DC MOTOR CONTROL USING MULTI PULSE GENERATOR (MPG)

THE POSSIBILITIES ARE INFINITE FUJITSU

Introduction

Recent advancement in microcontroller (MCU) technology allows motors to be controlled more efficiently and at a lower cost than ever before. This has accelerated the transition from electromechanical to electronic motor control. The MCU-controlled blushless dc motors eliminate the brush wearout mechanism and arcing. The advantages include higher efficiency, high torque-to-inertia ratios, greater speed capability, lower audible noise, higher thermal efficiency and lower EMI characteristics.

Fujitsu's multi pulse generator (MPG) offers flexible, cost-efficient, microcontroller solution for DC motor control. This application note describeS how the MPG can be used for controlling the blushless DC motor with hall sensors.

Overview of Multi-Pulse Generator

The multi pulse generator consists of:

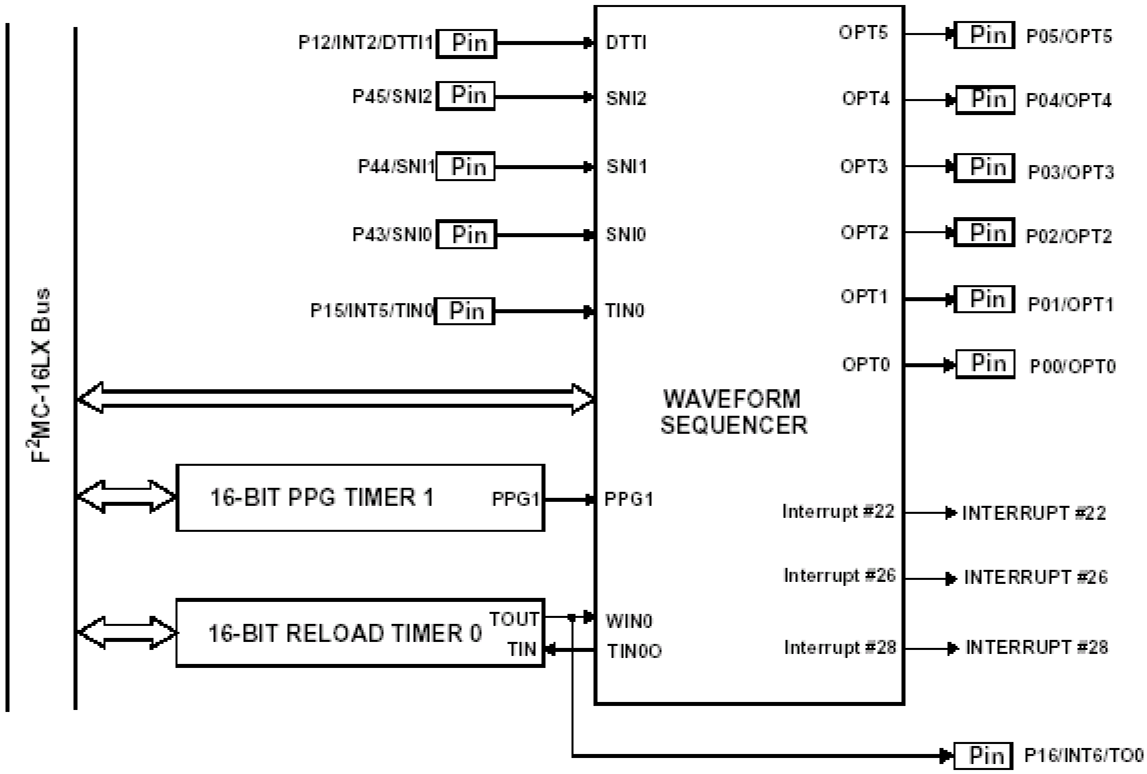
1) 16-bit PPG timer: Provides PPG signal for waveform sequencer.

2) 16-bit reload timer: Acts as an interval timer for Waveform Sequencer and used for motor speed checking. It records time in each state (to calculate speed) and detects any abnormality in the motor operation. On detection of missing position detect it disables the OPT output of Multi-pulse Generator.

3) Waveform sequencer. The Waveform Sequencer is the heart of Multi-pulse Generator. It is capable of generating the various waveforms, such as PPG waveform, non-overlap waveform. The waveform sequencer directs the 16-bit PPG timer output signal to Multi-pulse Generator output pins (OPT5~0) according to the input signal of Multi-pulse Generator (SNI2~0). The OPT5~0 output signals are synchronized with the PPG signal in order to eliminate the unwanted glitch.

   The OPT5~0 output signal can be hardware terminated by DTTI1 input in case of emergency.

The below is the block diagram of MPG.



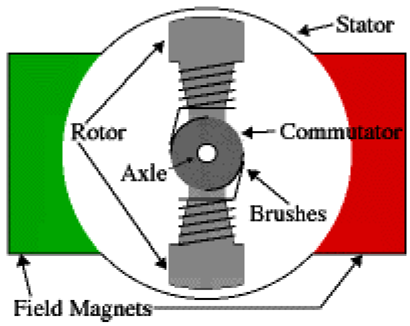
Concept of DC Motors

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. In most common DC motors the external magnetic field is produced by high-strength permanent magnets.

Every DC motor has six basic parts -- axle, rotor (armature), stator, commutator, field magnet(s), and brushes. The stator is the stationary part of the motor. It includes the motor casing, and two or more permanent magnet pole pieces. The rotor consists of windings. The windings are electrically connected to the commutator. The rotor (together with the axle and attached commutator) rotate with respect to the stator.

The geometry of the brushes, commutator contacts, and rotor windings are such that when power is applied, the polarities of the energized winding and the stator magnet(s) are misaligned. The rotor will rotate until it is almost aligned with the stator's field magnets. As the rotor reaches alignment, the brushes move to the next commutator contacts, and energize the next winding.

The below diagram shows a common motor layout -- with the rotor inside the stator field magnets.



Advantages of DC Motors

- Easy to understand design
- Easy to control speed
- Easy to control torque
- Simple, cheap drive design
- Smaller than induction motors of same power
- Variable speed requires fewer components than induction motors

Disadvantages of DC Motors

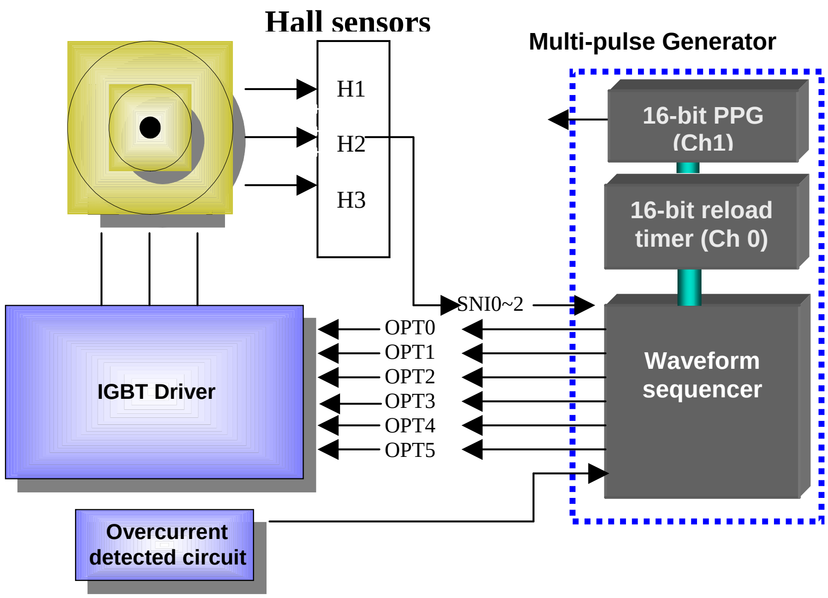
- Expensive to produce
- Can't reliably control at lowest speeds
- Physically larger
- High maintenance
- Dust
- Cannot be used in some hazardous environments
- Louder than induction motors

DC MOTOR control using MPG

DC motor is controlled by the sequences generated by the waveform sequencer. The sequence waveforms are composed of PPG, and change state according to the current rotor position. The Output Data Register (OPDR) determines which OPT output (OPT5~0) pins should output the 16-bit PPG timer output. By loading different Output Data Buffer Registers (OPDBRB~0) into the Output Data Register (OPDR), various combination of OPT outputs (OPT5~0) is generated. This way 16-bit PPG timer output can be presented/absented at Multi-pulse Generator output (OPT5~0). the PPG timer output signal also switch from one OPT output to another OPT output according to the sequence set in the Output Data Register (OPDR) and the Output Data Buffer Registers (OPDBRB~0).

Since DC motors are closed loop control, it always has feedback from the motor. Some motor has rotor position sensors (hall sensors), and some are sensorless. For the hall sensors, Position Detect Circuit in Multi-pulse Generator is used to detect the edge/level of the position input (SNI2~0) to detect the rotor position of the DC motor. However, in case of sensorless, an external circuit is required to sense the back EMF from the motor coils and translate them into position signal. The position signal from motor sensors/back emf circuit will connect to input capture for speed

calculation. If the actual speed is higher/lower than expected, the PPG duty is adjusted to correct the speed.
The diagram below shows how the DC motor interfaced with the multi-pulse generator. The hall sensors are used as a feedback system.



Emergency stop of DC motor

The DTTI1 Control is used to stop the Multi-pulse Generator output in case of emergency. It is triggered by level “0” of DTTI1 input.

Speed Calculation

DC motor control usually contains 6 states. The timer in MCU records the time used in each state, and then sum up the duration of the 6 states. The resultant sum is the time for one electric cycle.

One electric cycle = T1 + T2 + T3 + T4 + T5 + T6 = Ts
One physical cycle (rotor rotates one revolution) = Ts x (no. of pole pairs)
Therefore, RPM = 60 / (Ts x (no. of pole pairs))

The speed can be adjusted by adjusting the duty cycle of the PPG.

Multi pulse generator Waveform for DC motor

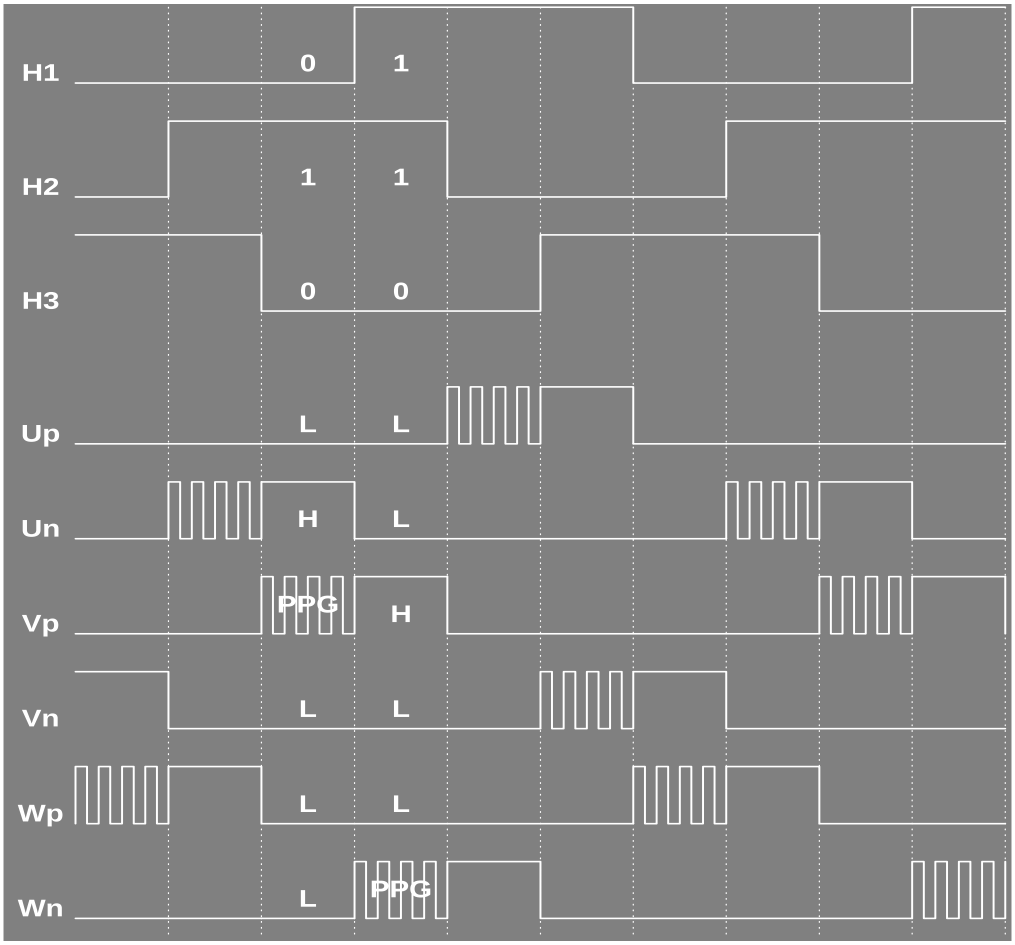
The Output Data Buffer Register (OPDBR) is composed of twelve registers. By loading different OPDBR register into the Output Data Regsiter (OPDR), various kind of waveform is output at the Multi-pulse Generator Output (OPT5~0).

The data in the Output Data Buffer Register (OPDBR) whose address specified by the BNKF, RDA2~0 bits is transferred to the Output Data Register (OPDR) at the write timing generated by the Data Write Control Unit.

The BNKF, RDA2~0 bits of the Output Data Buffer Register (OPDBR) decide the order of data transfer to the Output Data Register (OPDR), and the OPx1/OPx0 bits decide the shape of the output waveform. The output waveform is updated automatically as long as the write timing (WTO) is generated.

An example below shows one of the settings of the Output Data Buffer Register (OPDBR) and corresponding waveform generated by the waveform sequencer.

No.	0	1	2	3	4	5	6
BNKF	0	0	0	0	0	0	0
RDA2	1	1	0	0	1	1	0
RDA1	1	0	1	0	1	0	1
RDA0	0	1	1	1	0	0	0
OP51	0	1	0	0	0	0	0
OP50	0	1	0	1	0	0	0
OP41	0	0	0	0	0	0	1
OP40	1	0	0	0	1	0	1
OP31	1	0	0	0	1	0	0
OP30	1	0	0	0	1	1	0
OP21	0	0	0	1	0	0	0
OP20	0	0	1	1	0	0	0
OP11	0	0	1	0	0	0	0
OP10	0	0	1	0	0	0	1
OP01	0	0	0	0	0	1	0
OP00	0	1	0	0	0	1	0
No.seq	6	5	3	1	6	4	2
OPT5	L	H	L	PPG	L	L	L
OPT4	PPG	L	L	L	PPG	L	H
OPT3	H	L	L	L	H	PPG	L
OPT2	L	L	PPG	H	L	L	L
OPT1	L	L	H	L	L	L	PPG
OPT0	L	PPG	L	L	L	H	L


H1
0
1
H2
1
1
H3
0
0
Up
L
L
Un
H
L
Vp
PPG
H
Vn
L
L
Wp
L
L
Wn
L
PPG