RL78 Motor Control

YRMCKITRL78G14 Starter Kit

Renesas Electronics Europe

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Industrial Business Group

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Renesas MCU for 3-phase Motor Control

Available Now

Control Method

Brushless AC

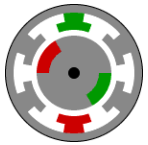
Vector Control — 180°

RENESAS RX RX600

RENESAS RL78

- Sensorless ✓
  - ⇨1 or 3 shunts
- Sensored ✓
  - ⇨ Hall, encoder…

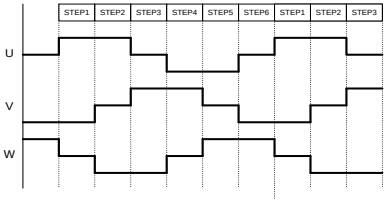
Brushless DC



Trapezoidal Control — 120°

RENESAS RL78

- Sensorless ✓
  - ⇨ Back EMF
- Sensored ✓
  - ⇨ Hall, encoder…



Induction AC

Vector Control — 180°

RENESAS RX RX600

- Sensorless ✓
  - ⇨ 1 or 3 shunts
- Sensored ✓
  - ⇨ Hall, encoder…

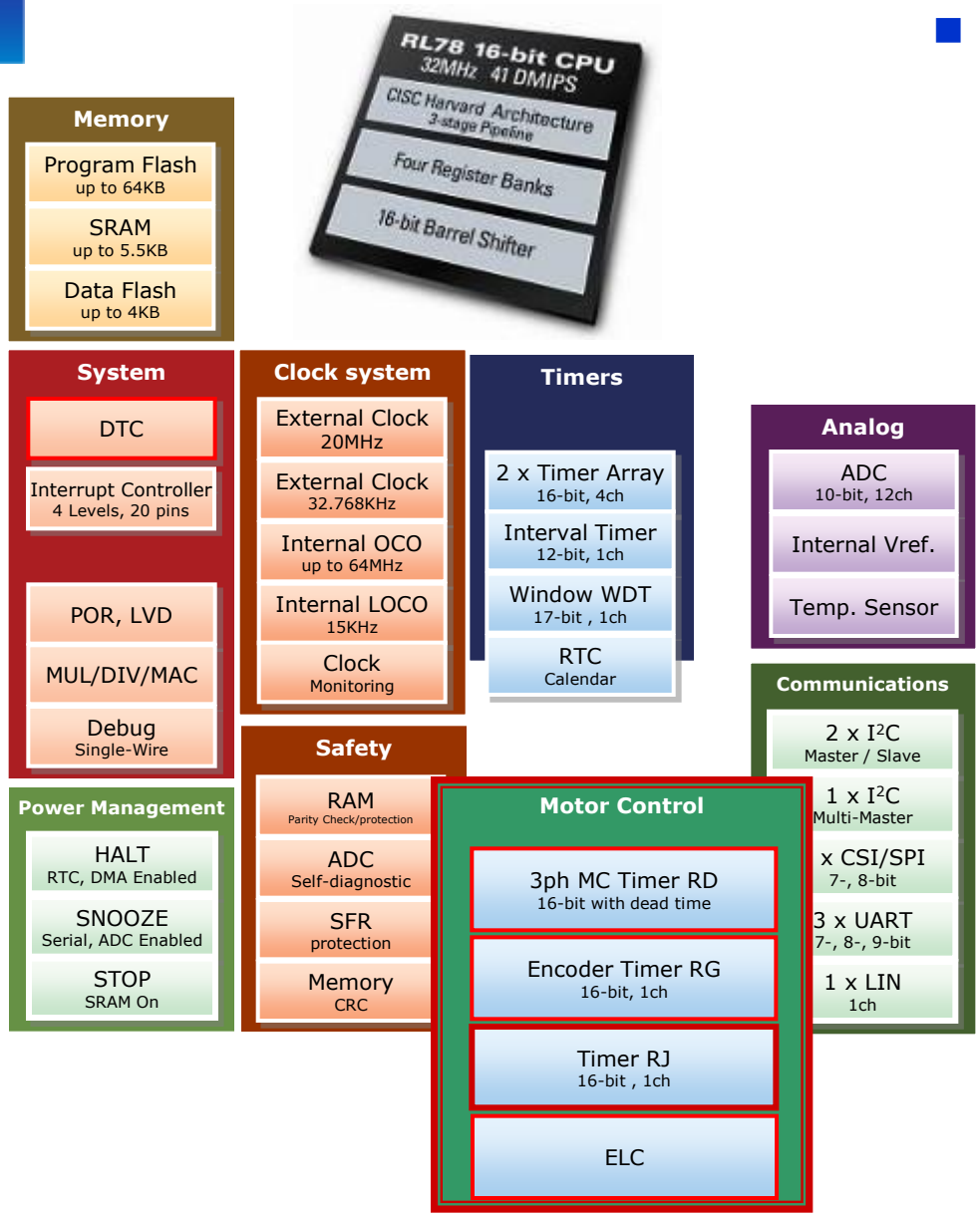
V/f Control — 180°

RENESAS RL78

- Sensored ✓
  - ⇨ Tacho, Hall, encoder…

Renesas MCU portfolio covers all 3-phase MC requirements

RL78/G14: 16-bit MCU for Motor Control



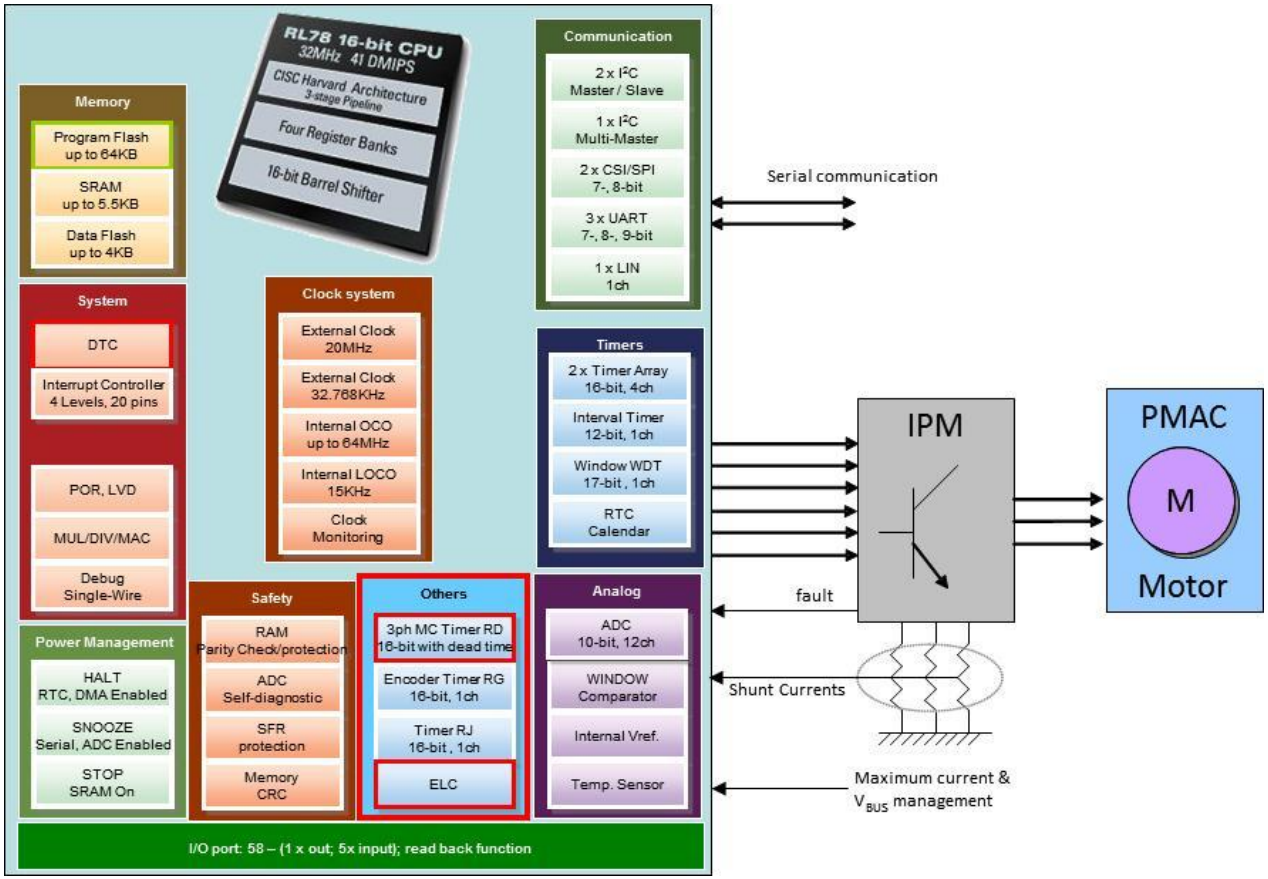
- On Chip Features
  - 1% Internal Clock (64MHz)
  - 32MHz CPU
    - Including MUL/DIV/MAC instructions
    - Barrel Shifter
  - Motor Control
    - 16bit Motor Control Timer
      - 64MHz Motor Control 3-Phase timer (RD)
      - Timer for H/W encoder (RJ)
      - ADC trigger
    - H/W support
      - Event Link Controller (ELC)
      - Data Transfer Controller (DTC)
  - 10-bit A/D
    - Analogue comparator (Larger Devices)
    - Internal temperature sensor
    - Internal Voltage reference
  - H/W safety and self test:
    - Flash ECC, RAM Parity, HW CRC, Clock Monitor
    - Windowed WDT, A/D self test, RAM/SFR write protect,
    - Window Watchdog with separate clock
    - Hardware Shutdown (INTP))

Used in the motor control kit

RL78/G14: Typical Applications

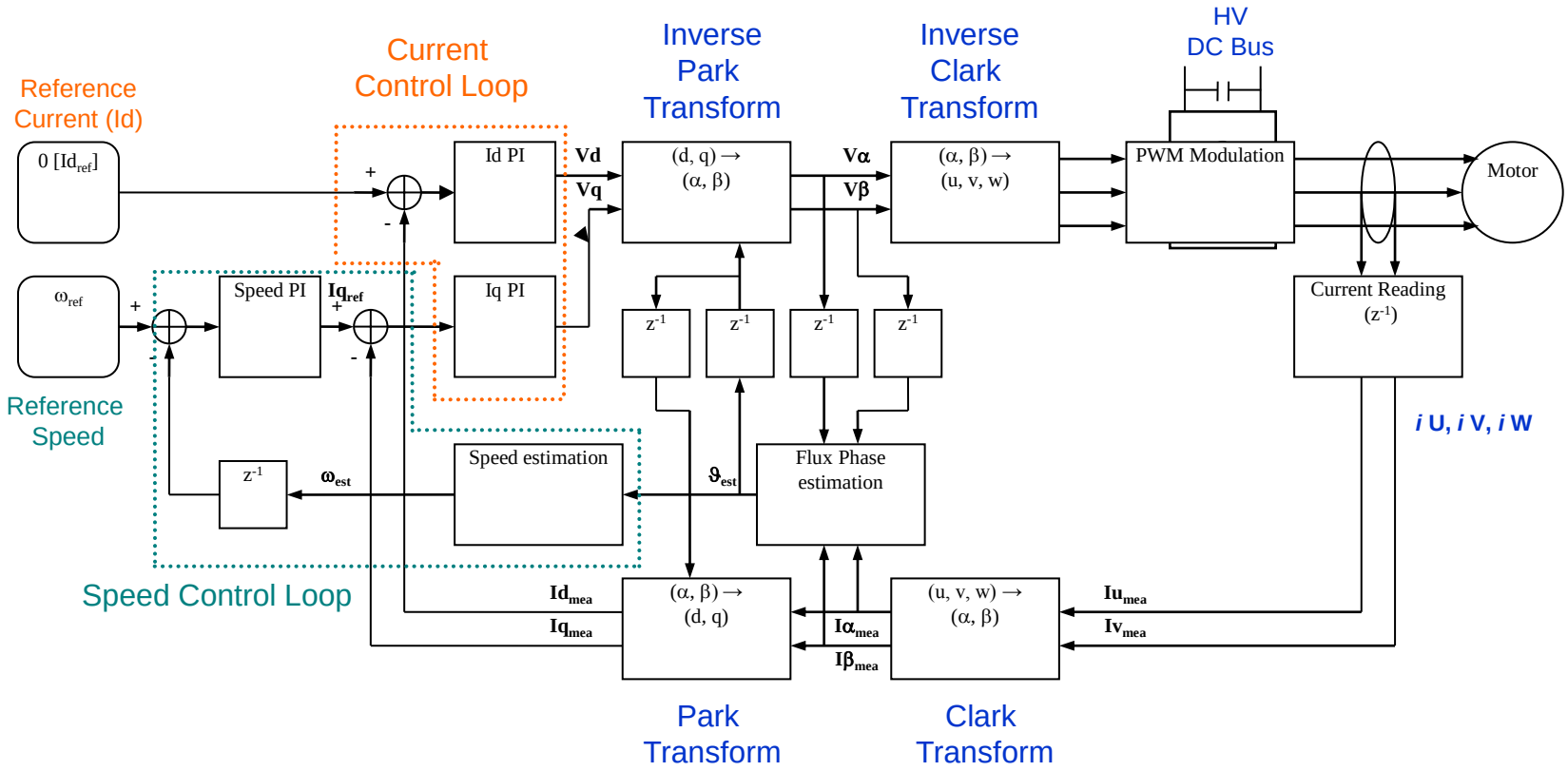
- Typical application fields include:
  - Small Appliances
  - Fans and Blowers
  - Pumps
  - Power Tools

Typical application Block Diagram



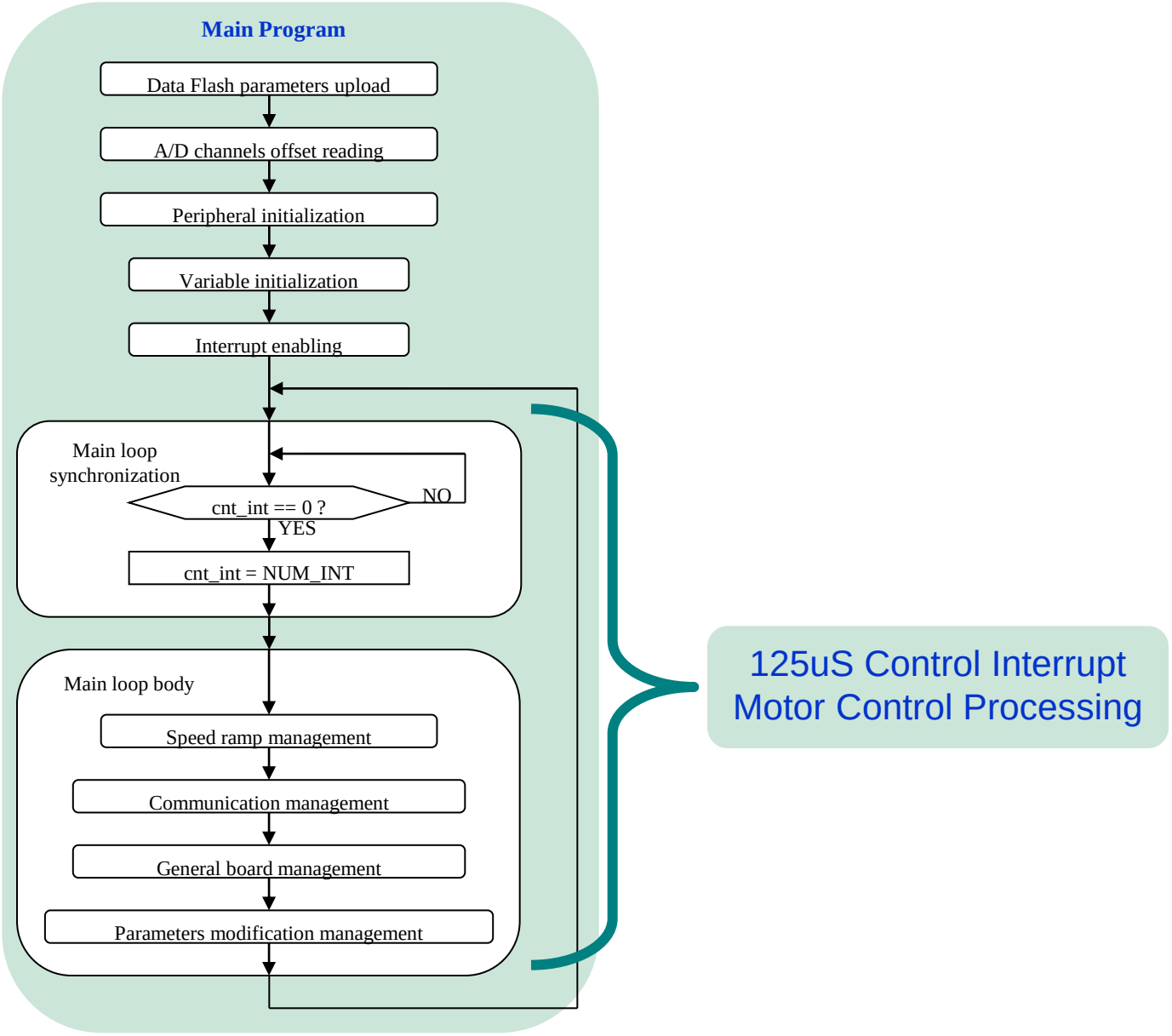
RL78/G14 F.O.C Overview

RL78 F.O.C Sensorless Algorithm

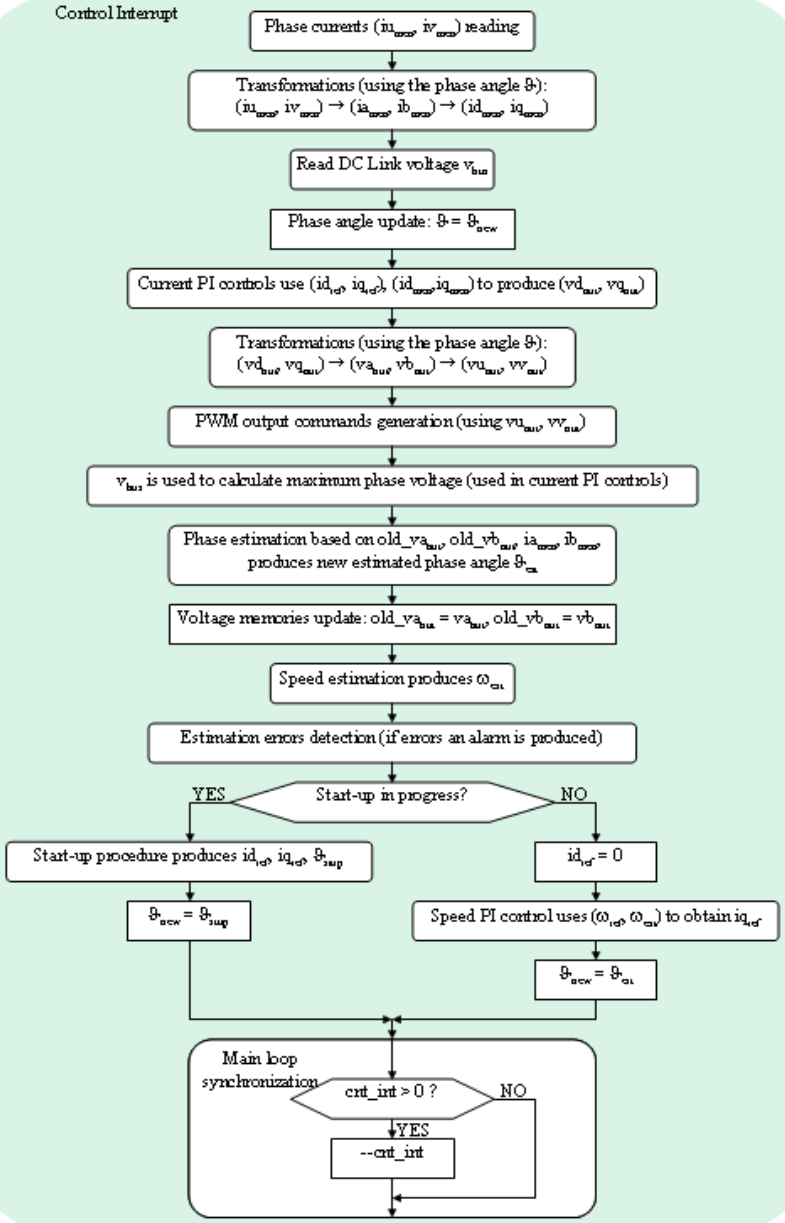


- Variables are Signed Integer

RL78/G14 F.O.C Software Overview



RL78/G14 F.O.C Software Overview



- Sensorless FOC algorithm
  - Signed integer 16 and 32bit variables
  - Low level assembler maths functions
    - Shift and Add
    - Multiply and Shift
    - Divide
    - Multiply and Divide

RL78/G14 – F.O.C Software Organisation

Modules	Function Descriptions
C Modules	
hwsetup.c	The basic hardware initialisation
stl_support.c	Support routines for the self test functions
main.c:	The main program loop
userif.c	Communication routines (i.e. GUI)
par_tab.c	The Parameter management routines definitions and tables
globalvar.c	Global variable definitions
Assembler Modules	
self-test	IEC assembler Self test routines (RAM, FLASH, Registers and Clock)
multiply.s87	Combined assembler maths functions
cstartup.s87	Customised start up file for March C RAM test
Library Module	
MCRP08_RL78_Lib.r87	Motor Control Library Module

RL78/G14 – F.O.C Software Organisation-Cont

Modules	Function Descriptions
Header Files	
customise.h	Basic parameters, not modifiable through the GUI
const_def.h	Definition of the basic numerical constants
mcrplib.h	Motor control library definitions, references and function prototypes
par_tab.h	Parameter definitions, function prototypes and references
hwsetup.h	Hardware definitions, references and function prototype (low_level_init)
globalvars.h	Global variable definitions and references
multiply.h	Assembler Maths function references
mask.h	General support definitions and references
userif.h	General support definitions, references and function prototypes

RL78/G14 F.O.C - Software/GUI Parameter List

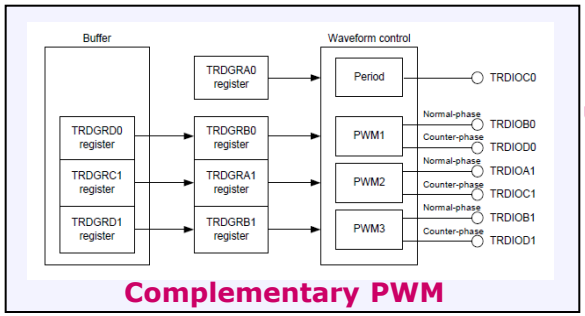
Index	Parameter Description	Unit
1	00 Default Parameter Setting	--
2	01 Minimum Speed	RPM
3	02 Maximum Speed	RPM
4	03 Acceleration	RPM/s
5	04 Deceleration	RPM/s
6	05 Polar Couples	--
7	06 Start Up Current	Apeak / 10
8	07 Maximum “q” current	Apeak / 10
9	08 Stator Resistance	Ohm/10
10	09 Synchronous Inductance	Henry/10000
11	10 Start Up Time	mS
12	11 Current Loop Kp	--
13	12 Current Loop Ki	--
14	13 Speed Loop Kp	--
15	14 Speed Loop Kp	--
16	15 Free	--
17	16 Free	--
18	17 Pi Tuning Trigger	--
19	18 Free	--
20	19 Free	--

RL78/G14 Peripheral Hardware Support

- Timer RD
- Interrupt Culling (ELC and Timer RJ)
- Hardware Shutdown (INTP0 pin and HW control)

RL78/G14 Example - Automatic Interrupt Culling

Timer RD: complementary PWM

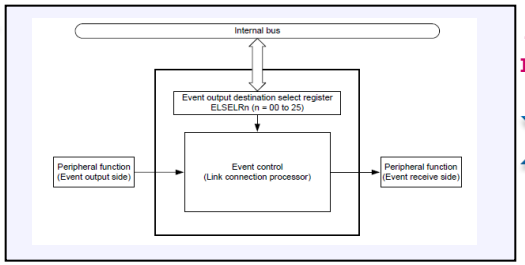


Timer RD is set to operate in Complementary 3-phase mode:

PWM can be set up to 24KHz

TRD1 Underflow

Event Link Controller

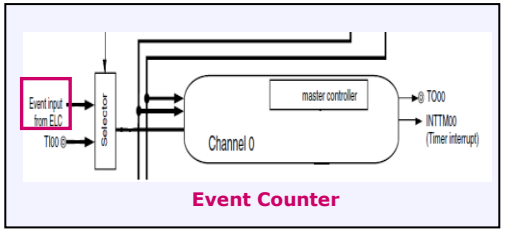


ELC is set to trigger external count in Timer RJ or TAU, when timer RD underflows

Interrupt is not generated, so ISR is not accessed

Timer Event Input Trigger

Timer RJ – event counter

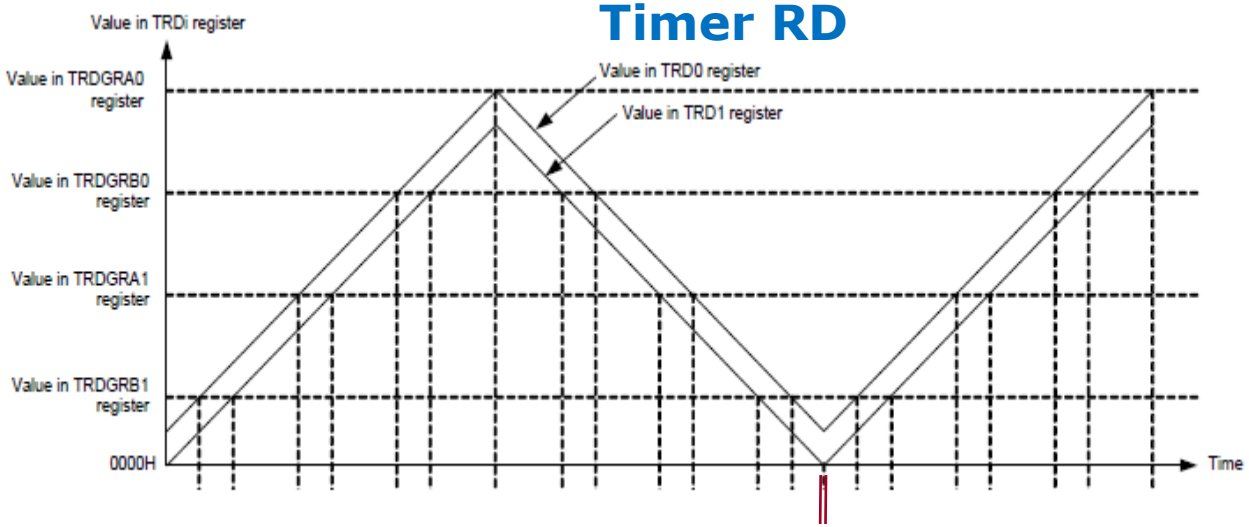


Timer is set to external event count mode. Timer counts down on each ELC trigger. When the count reaches zero the interrupt is generated. (The event count value is reloaded automatically)

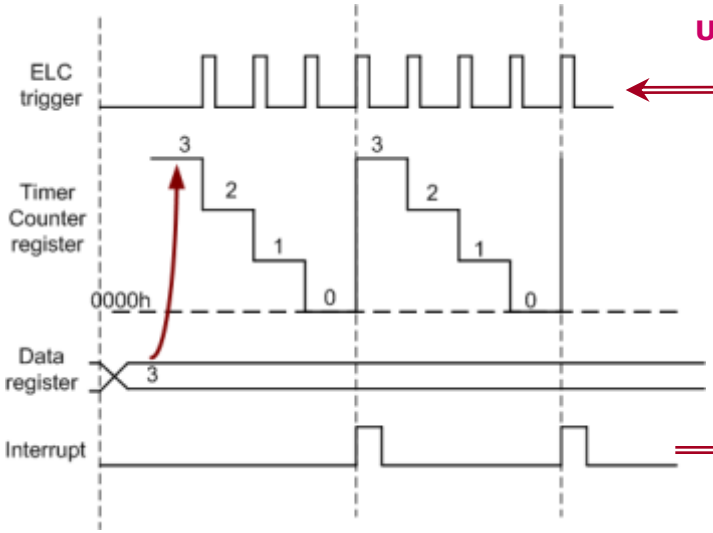
This is the Control Loop Interrupt

RL78/G14 Example - Automatic Interrupt Culling

Timer RD



TRD1 Underflow



Timer RJ/TAU Interrupt i.e. Control Loop Interrupt

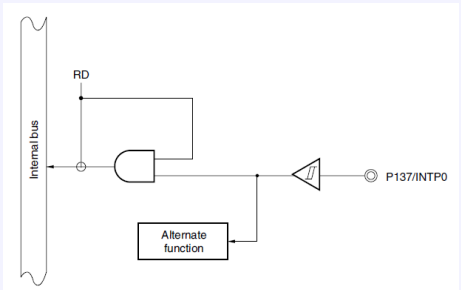
Example Shown

- *Timer RD set to 24KHz PWM frequency*
- *Timer RJ/ TAU set to Event counter*
  - 24KHz / 3 = 8KHz
- *ELC set to trigger Timer RJ (event count) every TRD1 underflow*

Timer RJ or TAU (CH0 or CH1)

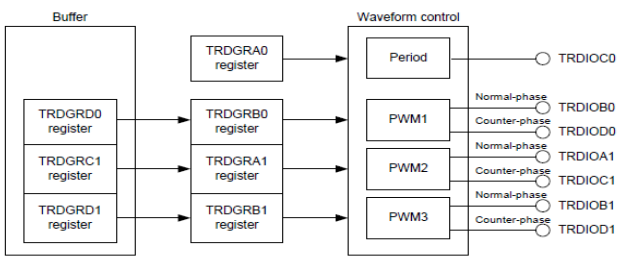
RL78/G14 – Hardware Shutdown

I/O Port Pin P137 – INTP0

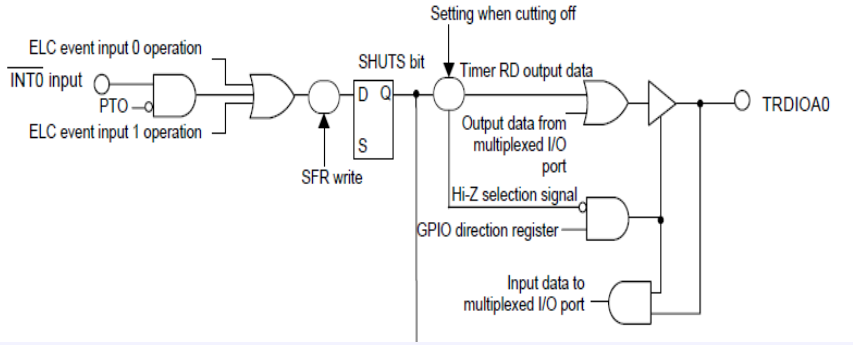


External Over Current Interrupt

INTP0 Interrupt: RD Software Shutdown



Complementary PWM



Hardware Output PWM Shutdown

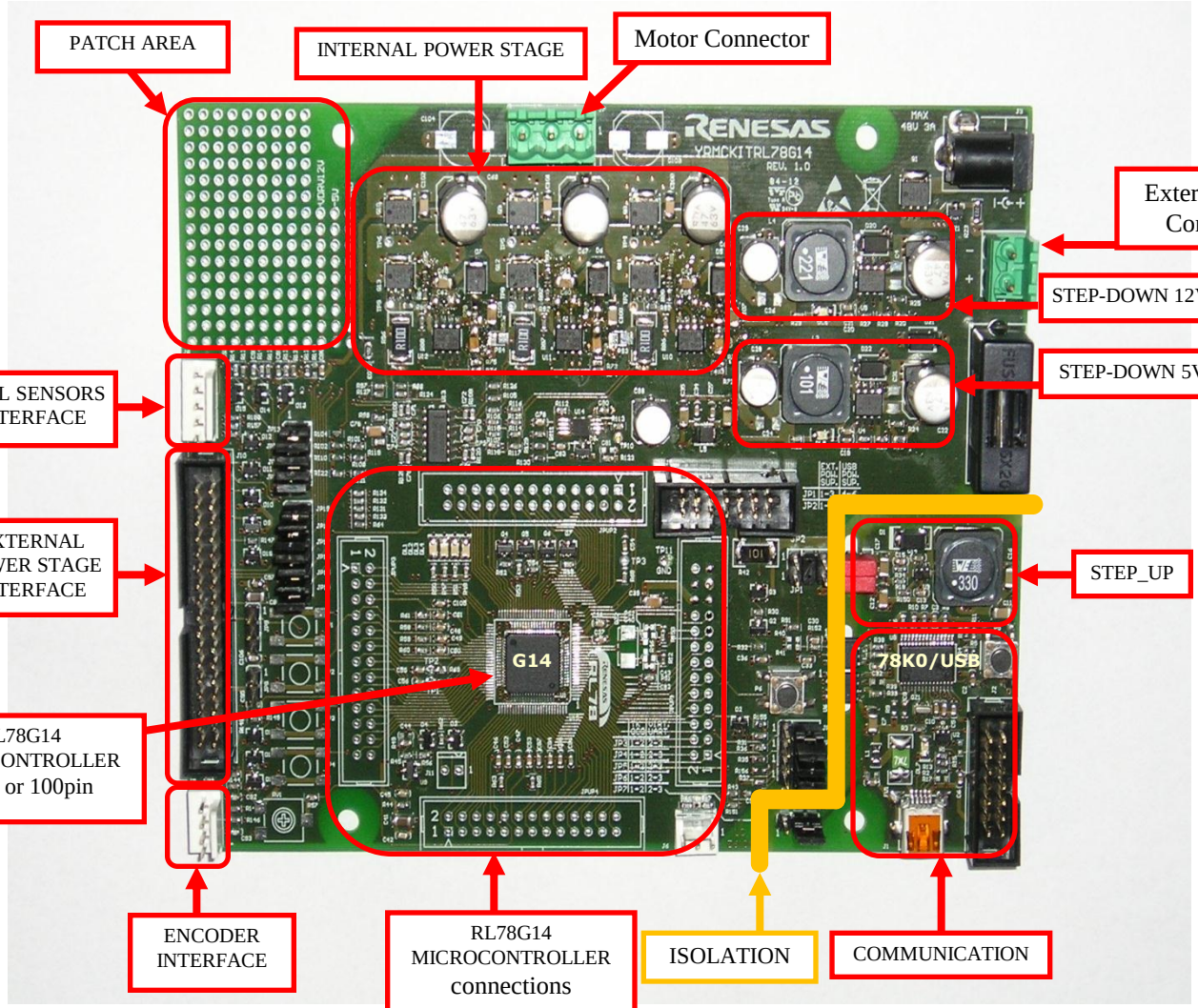
RL78/G14 Self Test / Safety Functions

Self Test / Safety Functions – RL78/G14

Run @ Start Up	User Protection Options (Optional)
Register Tests (Software) USED	Watchdog (Option - clock cannot be stopped Set in Option Byte)
RAM Test (Software) USED	Flash and Data Flash ECC Always On USED
CRC (Hardware) USED	RAM Parity (Hardware Parity generator/checker) USED
System Clock Test (Software or Hardware) USED	Illegal Access Protection (Hardware Detection) USED
	SFR Protection (SFR write protect)
	RAM area Protection (RAM area write protect)

RL78/G14 Motor Control Reference Kit

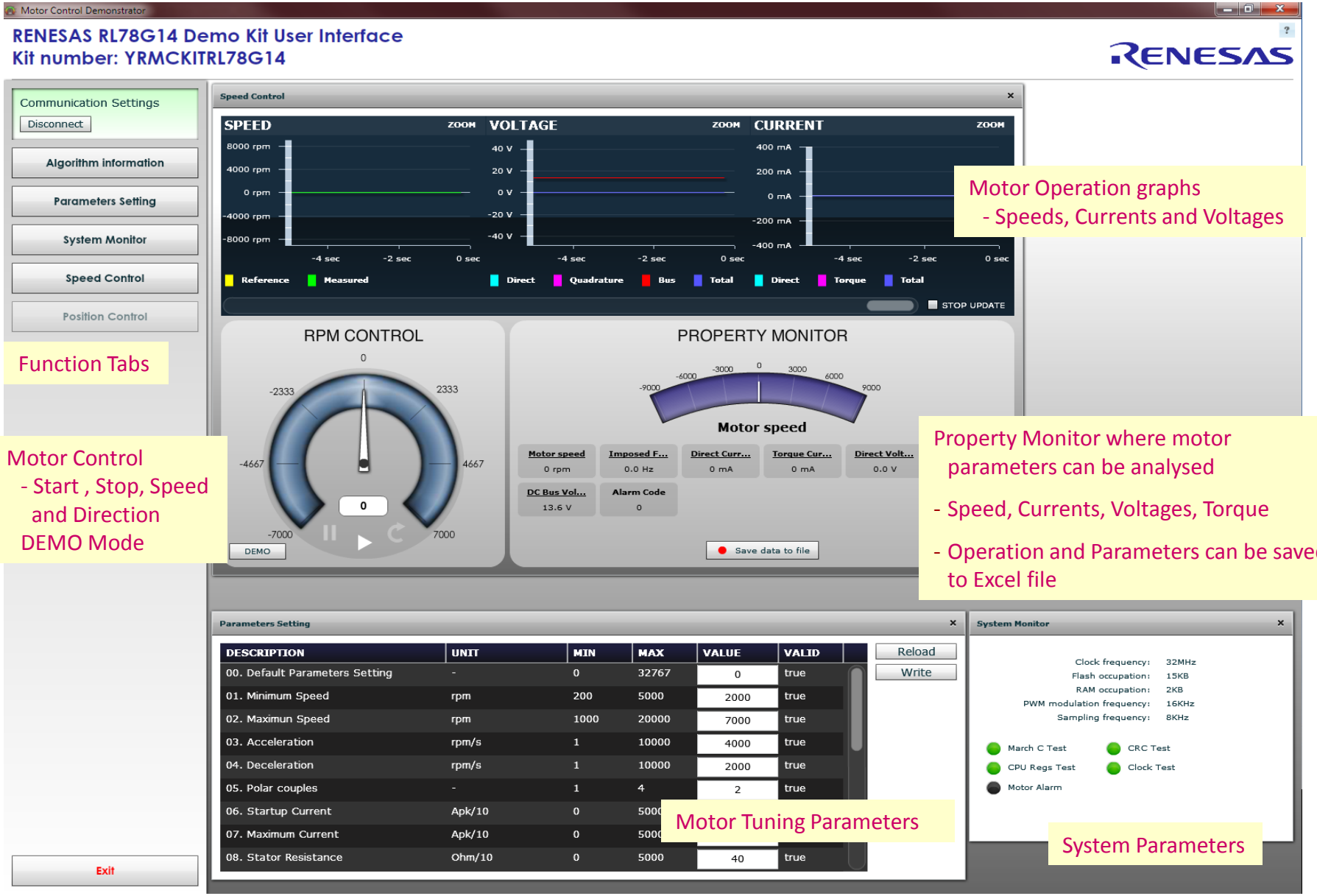
RL78/G14 Motor control Kit – Board details



Renesas Parts used

- RL78G14 (R5F104LE or 104PJ)
- 78K0/USB (uPD78F0730)
- Power MosFets - RJK0654
- Analogue Comparator - HAT1631
- EEPROM - R1EX240

RL78/G14 MC Kit - PC Control GUI



Function Tabs

Motor Control
- Start , Stop, Speed and Direction
DEMO Mode

Motor Operation graphs
- Speeds, Currents and Voltages

Property Monitor where motor parameters can be analysed
- Speed, Currents, Voltages, Torque
- Operation and Parameters can be saved to Excel file

Motor Tuning Parameters

System Parameters

RL78/G14 Motor control Kit Resources

Resource	Usage	Value	Notes
Device	R5F104LE (64KB (F), 5.5KB (R) 4KB (DF) R5F104PJ (256KB (F), 24KB (R), 8KB (DF)	64pin 100pin	Dual footprint supported
Flash Memory	Source Code	13KB	Includes ■ Motor control algorithm ■ GUI serial interface ■ Data Flash interface ■ IEC Self test code
	Constants	2KB	Includes ■ Motor Control Algorithm ■ Reference CRC table ■ Data Flash Library
RAM Memory	All variables	2KB	Includes ■ Motor control algorithm ■ Data Flash Library ■ Self Test variables
Timing	Control Loop Interrupt	8KHz (125uS)	Includes ■ Motor Control Algorithm ■ Data Flash interface ■ GUI interface
	Control loop execution time	86uS	70% CPU used

Renesas Electronics Europe