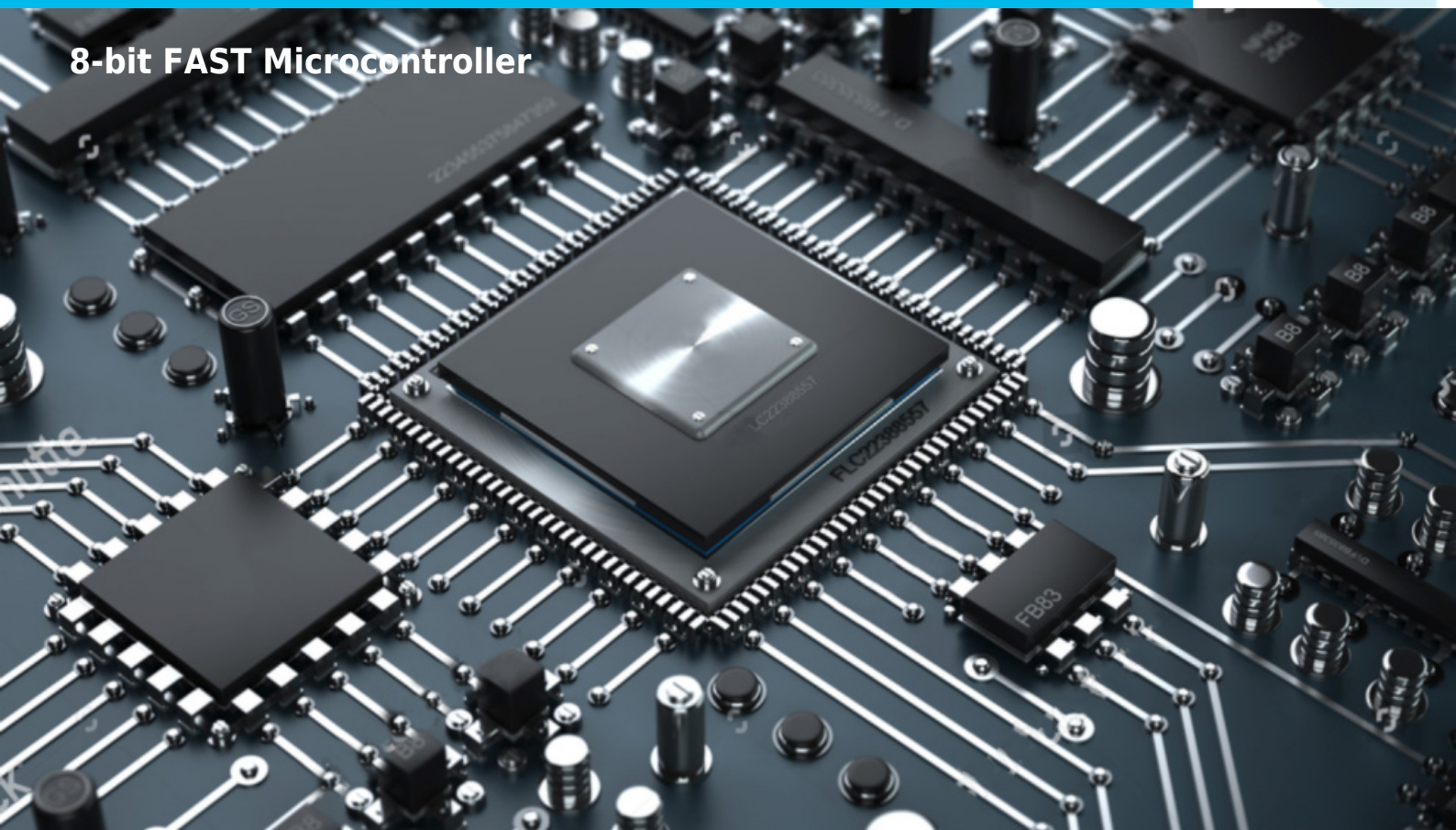
DIGITAL CORE DESIGN

DF6811K

8-bit FAST Microcontroller



COMPANY OVERVIEW

Digital Core Design is a leading IP Core provider and a System-on-Chip design house. The company was founded in 1999 and since the very beginning has been focused on IP Core architecture improvements. Our innovative, silicon proven solutions have been employed by over 300 customers and with more than 500 hundred licenses sold to companies like Intel, Siemens, Philips, General Electric, Sony and Toyota. Based on more than 70 different architectures, starting from serial interfaces to advanced microcontrollers and SoCs, we are designing solutions tailored to your needs.

IP CORE OVERVIEW

DF6811K 8-bit MCU IP Core – High-Performance, Fully Configurable 68HC11K Compatible

The **DF6811K** is an advanced **8-bit microcontroller IP Core** with highly integrated on-chip peripherals, fully **binary-compatible** with the industry-standard Motorola **68HC11K** microcontroller. Leveraging DCD's **FAST architecture**, the DF6811K delivers up to **4× higher performance** compared to the original 68HC11K, making it ideal for **automotive, battery-powered, and industrial SoC applications**.

This core is **fully customizable**, allowing developers to configure it to match the following 68HC11K family variants: **MC68HC11K0, MC68HC11K1, MC68HC11K4, MC68HC711K4, MC68HC11KS2, MC68HC711KS2**. Flexible configuration ensures that only the required features are included, **reducing silicon usage** and optimizing cost.

Key Features & Capabilities:

- **Dual Serial Interfaces:** Asynchronous **SCI** and synchronous **SPI** for versatile communication.
- **16-bit Free-Running Timer:** Includes 3 input capture lines, 5 output compare lines, and real-time interrupt system.
- **Pulse Accumulator:** 8-bit subsystem for counting external events or measuring periods.
- **Reliability & Safety:** On-chip self-monitoring, **COP watchdog**, and illegal opcode detection with **non-maskable interrupt**.
- **Power Efficiency: WAIT** and **STOP** software-controlled low-power modes for energy-sensitive applications.
- **Optional ADC Support:** External ADC controllers can be integrated as internal ADCs while maintaining full **68HC11K compatibility**.
- **Fully Automated Validation:** Delivered with a complete **test bench** and verification suite for seamless SoC integration.
- **DoCD™ Debug Support:** Built-in real-time hardware debugger providing **non-intrusive SoC debugging**, including CPU registers, program/data memory, SFRs, and user-defined peripherals.

The **DF6811K**'s combination of **high performance, low power, and fully integrated peripherals** makes it a versatile solution for **automotive electronics, battery-driven embedded systems, industrial controls**, and **general-purpose SoCs**.

Applications:
Automotive, industrial controls, battery-powered embedded systems, SoCs requiring highly reliable and configurable MCU cores.

ALL DCD'S IP CORES ARE TECHNOLOGY AGNOSTIC, ENSURING 100% COMPATIBILITY WITH ALL FPGA AND ASIC VENDORS.

For further details, email info@dcd-semi.com

CPU FEATURES

- FAST architecture – **4 times faster** than the original implementation
- Software compatible with 68HC11 industry standard
- 10 times faster multiplication
- 16 times faster division
- 256 bytes of remapped System Function Registers space (SFRs)
- De-multiplexed Address/Data Bus, to allow easy memory connection
- **Core can also be used without I/O wrapper, so each peripheral functions pins will be separated from I/O ports lines.**
- Two power saving modes: STOP, WAI
- Ready pin allows Core to operate with slow program and data memories.
- Fully synthesizable
- Static synchronous design
- No internal reset generator or gated clock
- Positive edge clocking and no internal tri-states
- Scan test ready
- **1 GHz** of virtual clock frequency, compared to original implementation
- USB, Ethernet, I2C, SPI, UART, CAN, LIN, HDLC, Smart Card interfaces available

DESIGN FEATURES

- One global system clock
- Synchronous reset
- All asynchronous input signals are synchronized before internal use

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PERIPHERALS

The peripherals listed below are implemented in the standard configuration of DF6811K.

- **DoCD™ On-Chip Debugger**
  - Processor execution control
  - Read, write all processor contents
  - Hardware execution breakpoints
  - Three wire communication interface
- **I/O Ports**
- **Interrupt Controller**
  - Dedicated vector and interrupt priority for each interrupt source
- **Main16-bit timer/counter system**
  - 16 bit free running counter
  - Four stage programmable prescaler
  - Real Time Interrupt
- **16-bit Compare/Capture Unit**
  - Three independent input-capture
  - Five output-compare channels
  - Events capturing
  - Pulses and digital signals generation
  - Gated timers
  - Sophisticated comparator
- **8-bit Pulse accumulator**
  - Two major modes of operation
  - Simple event counter
  - Gated time accumulation
  - Clocked by internal source or external pin
- **SPI – Master and Slave Serial Peripheral Interface**
  - Software selectable polarity and phase of serial clock SCK
  - System errors detection
  - Allows operation from a wide range of system clock frequencies (build-in 5-bit timer)
  - Interrupt generation
- **Full-duplex UART – SCI**
  - Standard Non-return to Zero format
  - 8 or 9 bit data transfer
  - Integrated baud rate generator
  - Noise, Overrun and Framing error detection
  - IDLE and BREAK characters generation
  - Wake-up block to recognize UART wake-up from IDLE condition
  - Three SCI related interrupts
  - PWM – Modulation Timer/Counter
  - Memory extension unit and Chip select

OPTIONAL PERIPHERALS

Optional peripherals (not included in the presented DF6811K Microcontroller Core) can be implemented upon customer's request.

- **I2C Master & Slave bus controllers**
  - Master operation
  - Multi-master systems supported
  - Performs arbitration and clock synchronization
  - Interrupt generation
  - Supports speed up to 3,4Mb/s (standard, fast & HS modes)
  - Allows operation from a wide range of clock frequencies (build-in 8-bit timer)
  - User-defined timing
- **Floating-Point Arithmetic Coprocessor (DFPAU) IEEE-754 standard single precision**
  - FADD, FSUB – addition, subtraction
  - FMUL, FDIV- multiplication, division
  - FSQRT- square root
  - FUCOM – compare
  - FCHS – change sign
  - FABS – absolute value
- **Floating-Point Math Coprocessor (DFPMU) – IEEE-754 standard single precision real, word and short integers**
  - FADD, FSUB- addition, subtraction
  - FMUL, FDIV- multiplication, division
  - FSQRT- square root
  - FUCOM- compare
  - FCHS – change sign
  - FABS – absolute value
  - FSIN, FCOS- sine, cosine
  - FPTAN, FPATAN- tangent, arcs tangent

UNITS SUMMARY

Control Unit – Performs the core synchronization and data flow control. This module manages execution of all instructions. The Control Unit also manages execution of STOP instruction and wakes the processor up from the STOP mode.
Opcode Decoder – Performs an instruction opcode decoding and the control functions for all other blocks.
ALU – Arithmetic Logic Unit performs the arithmetic and logic operations, during execution of an instruction. It contains accumulator (A), Condition Code Register (CCREG), Index registers (X) and related logic like arithmetic unit, logic unit and multiplier.
Bus Controller – Program Memory, Data Memory & SFR's (Special Function Register) interface – controls access into the program and data memories and special registers. It contains Program Counter (PC), Stack Pointer (SP) register and related logic.
Interrupt Controller – extended IC has implemented 7-level interrupt priority control. The interrupt requests may come from external pin (IRQ), as well as from particular peripherals. The DF6805 peripheral systems generate maskable interrupts, which are recognized only if the global interrupt mask bit (I) in the CCR is cleared. Maskable interrupts are prioritized, according to default arrangement established during reset. When interrupt condition occurs, an interrupt status flag is set, to indicate the condition.
Timer, Compare Capture & COP Watchdog – This timer system is based on a free-running, 16-bit counter, with a 4-stage programmable prescaler. A timer overflow function allows software to extend the timing capability of the system, beyond the 16-bit range of the counter. Three independent input-capture functions are used, to automatically record the time, when a selected transition is detected at a respective timer input pin. Five output-compare functions are included,

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for generating output signals or for timing software delays. Since the input-capture and output-compare functions may not be familiar to all users, these concepts are explained in greater detail. A programmable periodic interrupt circuit called RTI is tapped off of the main 16-bit timer counter. Software can select one of four rates for the RTI, which is most commonly used to pace the execution of software routines. The COP watchdog function, is loosely related to the main timer in that the clock input to the COP system (clk*2^{17}) is tapped off the free-running counter chain. The timer subsystem involves more registers and control bits, than any other subsystem on the MCU. Each of the three input-capture functions has its own 16-bit time capture latch (input-capture register); and each of the five output-compare functions has its own 16-bit compare register. All timer functions, including the timer overflow and RTI, have their own interrupt controls and separate interrupt vectors. Additional control bits permit software, to control the edge(s), that trigger each input-capture function and the automatic actions that result from output-compare functions. Although hardwired logic is included to automate many timer activities, this timer architecture is mainly a software-oriented system. This structure is easily adaptable to a very wide range of applications, although for some specific timing applications it is not as efficient, as dedicated hardware.

SCI – The SCI is a full-duplex UART type, asynchronous system, using standard non return to zero (NRZ) format : 1 start bit, 8 or 9 data bits and a 1 stop bit. The D68HC11E resynchronizes the receiver bit clock on all one to zero transitions in the bit stream. Therefore, differences in baud rate, between the sending device and the SCI, are not as likely to cause reception errors. Three logic samples are taken near the middle of data bit time and majority logic decides the sense for the bit. For the start and stop bits, seven logic samples are taken. Even if noise causes one of these samples to be incorrect, the bit will still be received correctly. The receiver also has the ability, to enter a temporary standby mode (called receiver wakeup), to ignore messages intended for a different receiver. Logic automatically wakes the receiver up, in time to see the first character of the next message. This wake up feature greatly reduces CPU overhead in multi-drop SCI networks. The SCI transmitter can produce queued characters of idle (whole characters of all logic 1) and break (whole characters of all logic 0). In addition to the usual transmit data register empty (TDRE) status flag, this SCI also provides transmit complete (TC) indication that can be used in applications with a modem.

SPI Unit – it's a fully configurable master/slave Serial Peripheral Interface, which allows user to configure polarity and phase of serial clock signal SCK. It allows the microcontroller, to communicate with serial peripheral devices. It is also capable of interprocessor communications, in a multi-master system. A serial clock line (SCK) synchronizes shifting and sampling of the information, on the two independent serial data lines. SPI data are simultaneously transmitted and received. SPI system is flexible enough, to interface directly with numerous standard product peripherals, from several manufacturers. Data rates are as high as CLK/4. Clock control logic allows a selection of clock polarity and a choice of two fundamentally different clocking protocols, to accommodate most available synchronous serial peripheral devices. When the SPI is configured as a master, software selects one of four different bit rates for the serial clock. SPI automatically drives slave select outputs SSO[7:0] and address SPI slave device, to exchange serially shifted data. Error-detection logic is included, to support interprocessor communications. A write-collision detector indicates, when an attempt is made to write data to the serial shift register, while a transfer is in progress. A multiple-master mode-fault detector automatically disables SPI output drivers, if more than one SPI devices, simultaneously attempt to become a bus master.

Pulse Accumulator – This system is based on an 8-bit counter and can be configured, to operate as a simple event counter or for gated time accumulation. Unlike the main timer, the 8-bit pulse accumulator counter can be read or written at any time (the 16-bit counter in the main timer cannot be written). Control bits allow the user, to configure and control the pulse accumulator subsystem. Two maskable interrupts are associated with the system, each having its own controls and interrupt vector. The PAI pin associated with the pulse accumulator can be configured to act as a clock (event counting mode) or as a gate signal, to enable a free-running E divided by 64 clock to the 8-bit counter (gated time accumulation mode). The alternate functions of the pulse accumulator input (PAI) pin, present some interesting application possibilities.

I/O Ports – All ports are 8-bit general-purpose bi-directional I/O system. The PORTA, PORTB, PORTC, PORTD data registers have their corresponding data direction registers DDRA, DDRC, DDRD to control ports data flow. It assures that all DF6811's ports have full I/O selectable registers. Writes to any ports pins cause data to be stored in the data registers. If any port pins are configured as output, then data registers are driven out of those pins. Reads from port pins configured as input, causes that input pin is read. If port pins is configured as output, during read data register is read. Writes to any ports pins, not configured as outputs, do not cause data to be driven out of those pins, but the data is stored in the output registers. Thus, if the pins later become outputs, the last data written to port will be driven out the port pins.

ADCCTRL – External ADC Controller, used as an interface between DF6811 internal registers and external serial/parallel ADC converter. This module has several different options, so its details are described in a separate document.

EEPROMCTRL – External Serial EEPROM controller. Manage data exchange between D68HC11E and external EEPROM. During initialization copy contents of whole external EEPROM to internal EEPRAM (EEPROM Mirror implemented in standard parallel RAM). This module has several different options, so its details are described in separate document.

DoCD™ – Debug Unit – it's a real-time hardware debugger, which provides debugging capability of a whole SoC system. Unlike other on-chip debuggers, **DoCD™** provides non-intrusive debugging of running application. It can halt, run, step into or skip an instruction, read/write any contents of microcontroller, including all registers, internal, external, program memories, all SFRs, including user defined peripherals. Hardware breakpoints can be set and controlled on program memory, internal and external data memories, as

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well as on SFRs. Hardware breakpoint is executed, if any write/read occurs at particular address, with certain data pattern or without pattern. The **DoCD™** system includes three-wire interface and complete set of tools, to communicate and work with core in real time debugging. It is built as scalable unit and some features can be turned off by the user, to save silicon and reduce power consumption. When debugger is not used, it is automatically switched to power save mode. Finally, when debug option is no longer used, whole debugger is turned off. The separate CLKDOCD clock line allows the debugger to operate, while the CPU is in STOP mode and the major clock line CLK is stopped.

Memory expansion – unit able to extend the memory space beyond the physical 64kB.

TIMER 2 – Timer 2 is available in DF6811KW1 only, it comprises a 4-stage prescaler and a 16-bit counter. It has three associated 16-bit output compare registers, along with a software-programmable input Capture or output compare register. The functions of Timer 2 share I/O with the pins of port J.

TIMER 3 – Timer 3 is available in DF6811KW1 only, it comprises a 4-stage prescaler and a 16-bit counter. It has three associated 16-bit output compare registers, along with a software-programmable input Capture or output compare register. The functions of Timer 3 share I/O with the pins of Port K

PERFORMANCE

The following table gives a survey about the Core area and performance in **ASIC** devices (all key features included):

Technology	Optimization	Gates
0.25 typical	area	21 000

DELIVERABLES

- HDL Source Code
- Testbench environment
  - Automatic Simulation macros
  - Tests with reference responses
- Synthesis scripts
- Technical documentation
- 12 months of technical support

LICENSING

Comprehensible and clearly defined licensing methods without royalty-per-chip fees make use of our IP Cores easy and simple.

– *Single-Site license option* – dedicated to small and middle sized companies which run their business at one place.

– *Remote Access license option* – allows authorized users to access and use the licensed product from a remote location.

In all cases the number of IP Core instantiations within a project and the number of manufactured chips are unlimited. There are no restrictions regarding the time of use.

The IP is delivered in HDL Source code suitable for ASIC and FPGA projects.

CONTACT

DCD-SEMI Sp. z o.o. Headquarters:
Wroclawska 94, 41-902 Bytom, POLAND
E-mail: info@dcd.pl
tel.: +48 32 282 82 66
fax: +48 32 282 74 37
Distributors:
Please check: dcd.pl/contact-us/

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