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PIC16F639 Microcontroller Overview

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INTRODUCTION

The PIC16F639 is a suitable microcontroller for bidirectional communications, remote passive keyless entry and low-frequency sensing applications. The device includes a PIC16F636 microcontroller and a three channel Low-Frequency (LF) front-end device in a single 20-pin SSOP package. These two devices are internally connected via a modified SPI interface.

The CS, SCLK/ALERT and LFDATA/RSSI/CCLK/SDIO pads of the analog front-end device are internally wire bonded to RC1, RC2 and RC3 pads of the PIC16F639 microcontroller, respectively.

The PIC16F639 has twelve digital I/O pins and four LF I/O pins. The digital I/O pins are used in the same way as on the PIC16F636 device. Figure 1 shows the pin diagram of the PIC16F639.

The four LF I/O pins (LCX, LCY, LCZ, LCCOM) are used to detect low-frequency input signals and to transmit data by modulating the input voltage. External LC resonant circuits need to be connected to the LF I/O pins. The device's LF analog channels are optimized for 125 kHz input signal with an input sensitivity of about 1 mVPP, which allows a bidirectional communication distance of up to a few meters. See Table 1 for more feature details.

The device also has 2K words of Flash program memory, two comparators, a KEELOQ® encryption/decryption peripheral, user-selectable internal oscillator frequency and three-channel analog front-end for low-frequency detection and LF talk-back. The three-channel analog front-end allows orthogonally positioned antenna connections to detect input signals from x, y and z directions.

For a low-power battery operation, the device has various low-power modes (Sleep, Standby, Active) and is optimized to consume very low currents. The device can also be operated in battery backup and batteryless modes using only a few external components. An example of the circuit is shown in the "*PIC12F635/PIC16F636/639 Data Sheet*" (DS41232).

FIGURE 1: PIC16F639 PIN DIAGRAM

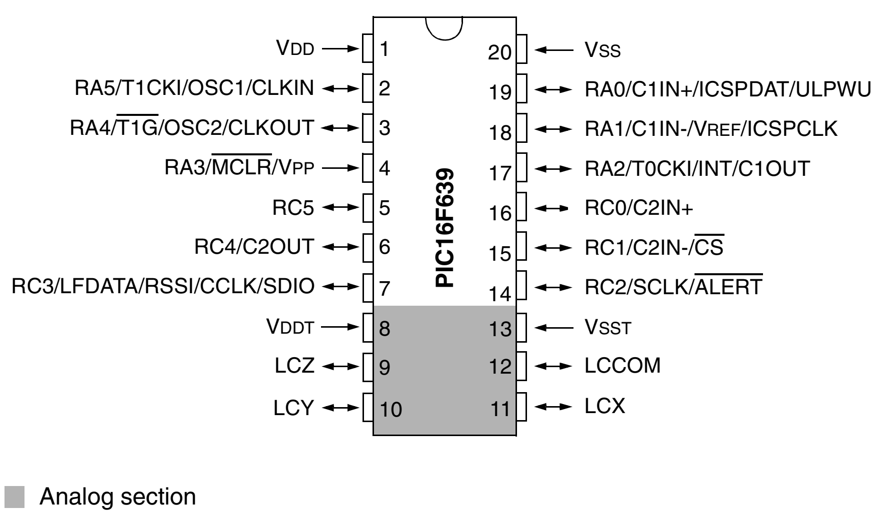

TABLE 1: DEVICE FEATURES

Parameters/Features	Description
Supply Voltage	2.0-3.6V
LF Input Sensitivity	1-6 mV_{PP}
LF Input Wake-up Pattern	Programmable: High and low pulse durations (8 different timing choices)
Eight Configuration AFE Registers	Programmable via a modified SPI, except STATUS register (read-only)
Selectable AFE Output	Demodulated Data, RSSI Current, Carrier Clock
LF Input Channel Selection	Each channel can be individually enabled or disabled
LF Input Modulation Depth Selection	8%, 14%, 33%, 60%
Antenna Tuning Capacitance	Programmable up to 63 pF (1 pF/step) for each channel
Input Sensitivity Reductions	Programmable up to 30 dB (2 dB/step) for each channel
Sleep Current	200 nA typical for both MCU and analog front-end
Standby Current	1 channel enabled: 2 µA, V_{DD} = 3.0V and MCU = Sleep condition 2 channels enabled: 3 µA, V_{DD} = 3.0V and MCU = Sleep condition 3 channels enabled: 4 µA, V_{DD} = 3.0V and MCU = Sleep condition
Active Current	MCU: 500 µA @ V_{DD} = 3.0V and F_{OSC} = 4 MHz AFE: 13 µA (3 channels enabled)
Base Station Data Rate to Transponder	10 Kbps (max) with NRZ Format
MCU Memory	Program Flash Memory: 2048 Words EEPROM: 256 Bytes SRAM: 128 Bytes
MCU I/O Pins	12 I/O, 3 I/O are shared with AFE
Selectable MCU Internal Clock	31 kHz, 125 kHz, 250 kHz, 500 kHz, 1 MHz, 2 MHz, 4 MHz, 8 MHz
Encryption/Decryption	KEELOQ® hardware peripheral in microcontroller
Interrupt-on-Change of PORTA (IOCA)	Each of the PORTA pins is individually configured as an interrupt-on-change pin
Programmable Low-Voltage Detector (PLVD)	This feature can be used to detect V_{DD} (battery voltage) level
Two Analog Comparators	These comparators are general purpose. One can be used when implementing firmware-based ADC for RSSI output.
Two Internal Timers (Timer0, Timer1)	These timers are useful for measuring pulse timing. The Timer1 can also be used for firmware-based ADC implementation.
Operating Temperature	-40°C to +85°C

Note: Refer to the “*PIC12F635/PIC16F636/639 Data Sheet*” (DS41232) for more detail.

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LF Signal Detection and Detector Output

To detect the LF signal, or to send a response with LF, the device needs external LC parallel resonant circuits at the LF input pins. The LC resonant antenna becomes most sensitive when the antenna is tuned precisely to the frequency of interest (carrier frequency of the base station). Each LF input channel has dynamical programmable tuning capacitance up to 63 pF (1 pF per step) to compensate for the discrepancy in frequency tuning due to the variation of external component tolerance of the LC resonant circuits.

The analog front-end functions are controlled by its eight Configuration registers, which can be dynamically reprogrammed by the microcontroller firmware based on real-time signal conditions and applications. The analog front-end outputs demodulated data, a carrier clock or a received signal strength indicator (RSSI current) by controlling the output selection bit of the internal Configuration register.

When the RSSI output is selected, the device outputs analog current proportional to the input signal strength. The RSSI feature can be effectively used for tuning the LC resonant antenna and distance measurement from the signal source. The digitized value of the RSSI can be obtained by implementing a firmware-based ADC. The digitized value of the RSSI output can be transmitted to the base station for further information. For example, on the LC resonant antenna tuning, the device selects its internal resonant capacitor while monitoring the RSSI value until the highest RSSI value is found. This antenna tuning can be accomplished by firmware, which saves the system manufacturer's labor intense time for the manual LC tuning during the assembly process.

The device can be configured to detect amplitude-modulated input signals with various modulation depths (8%, 14%, 33% and 60%). For example, if the device is configured to 8% minimum modulation depth, it can demodulate the input signal in a noisy environment more efficiently than with a higher modulation depth setting. In addition, it can also detect the signal when it is very close to the base station antenna, where the modulation depth of the amplitude-modulated signal becomes weaker due to a long decay time of strong RF signals.

A significant advantage that the PIC16F639 device has, when compared to similar devices in the marketplace, is that it can demodulate weakly modulated input signals.

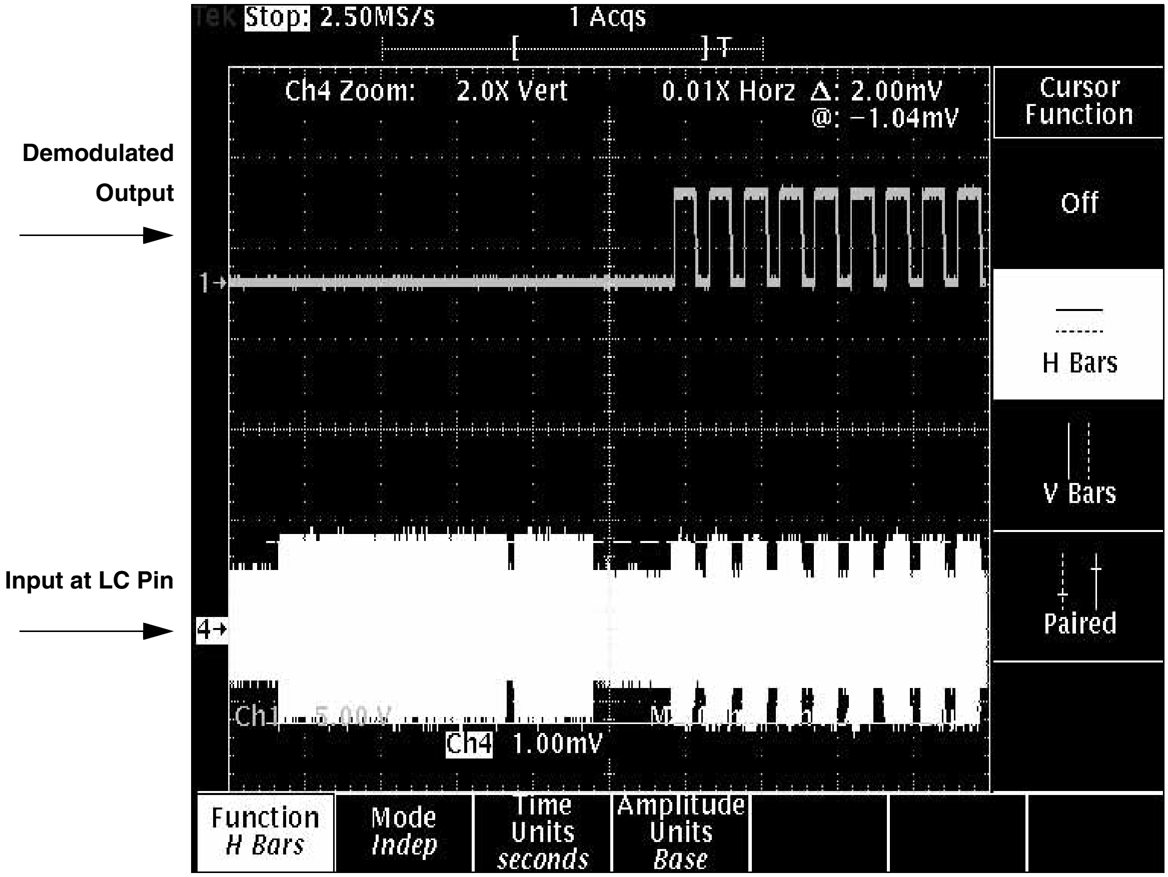
Figure 2 shows an example of the device's demodulated output for an input signal with 2 mV$_{PP}$ amplitude and about 14% modulation depth. In this example, the device's minimum modulation depth setting is 8% and the output enable filter (wake-up filter) is enabled.

The output appears right after the output enable filter's waveform. For more information on the output enable filter and minimum modulation depth settings, see the "*PIC12F635/PIC16F636/639 Data Sheet*" (DS41232).

When the device detects valid input signals, it sends a message to the base station via an external UHF transmitter or the internal LF talk-back modulator of each channel. The KEELOQ® cryptographic hardware peripheral of the microcontroller allows it to transmit and receive encrypted data for secure data communications.

The dynamically reconfigurable output enable (wake-up) filter allows the microcontroller to wake-up only after a predefined signal has been received, thus keeping current consumption to a minimum, but ignoring all other unwanted signals. The output enable (wake-up) filter consists of high and low durations of the pulse in the header of the input data stream. The user has the choice of up to 8 different output enable (wake-up) filter settings.

FIGURE 2: EXAMPLE OF DEVICE'S DEMODULATED OUTPUT VS. INPUT



CONCLUSION

The PIC16F639 is an microcontroller-based, low-frequency transponder. The device is easy to use and has a high degree of flexibility for LF applications. With its high input sensitivity (3 mVPP), ability to detect input signal with weak modulation depth (down to 8%), built-in KEELOQ® encryption/decryption peripheral and firmware-based feature control, the device can be used in various applications, including a low-cost Passive Keyless Entry (PKE) transponder, a magnetic field sensor in tire pressure monitoring systems, long range access control applications and many more.

MCU Firmware Development Tools

Compatible with the following PIC16F639 development tools:

- MPLAB® Integrated Development Environment Software (IDE)
- MPLAB® ICE 2000 High-Performance Universal In-Circuit Emulator
- MPLAB® PM3 Device Programmer
- PICSTART® Plus Development Programmer
- MPLAB® ICD 2 In-Circuit Debugger
- PICkit™ 1 Flash Starter Kit

REFERENCES

1. "*PIC12F635/PIC16F636/639 Data Sheet*" (DS41232); Microchip Technology Inc.
2. *AN959, "Using the PIC16F639 MCU for Smart Wireless Applications*" (DS00959); Microchip Technology Inc.

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