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C8051F96x

Ultra Low Power 128K, LCD MCU Family

Ultra Low Power Consumption at 3.6V
- 130 µA/MHz Low-Power Active mode with dc-dc enabled
- 110 nA sleep current w/ data retention; POR monitor enabled
- 400 nA sleep mode with SmaRTClock (internal LFO)
- 700 nA sleep mode with SmaRTClock (ext. crystal)
- 2 µs wakeup time; 1.5 µA analog settling time

12-Bit; 16 Ch. Analog-to-Digital Converter
- Up to 75 ksps (12-bit mode) or 300 ksps (10-bit mode)
- External pin or internal VREF (no ext cap required)
- On-chip voltage reference; 0.5x gain allows measuring voltages up to twice the reference voltage
- Autonomous burst mode with 16-bit auto-averaging accumulator
- Integrated temperature sensor

Two Low Current Comparators
- Programmable hysteresis and response time
- Configurable as wake-up or reset source

Internal 6-Bit Current Reference
- Up to ±500 µA; source and sink capability
- Enhanced resolution via PWM interpolation

Integrated LCD Controller
- Supports up to 128 segments (32x4)
- LCD controller consumes only 400 nA for 32-segment static display
- Integrated charge pump for contrast control

Metering-Specific Peripherals
- DC-DC buck converter allows dynamic voltage scaling for maximum efficiency (250 mW output)
- Sleep-mode pulse accumulator with programmable switch, de-bounce and pull-up control; interfaces directly to metering sensor
- Data Packet Processing Engine (DPPE) includes hardware AES, DMA, CRC and encoding blocks for acceleration of wireless protocols

High-Speed 8051 µC Core
- Pipelined instruction architecture; executes 70% of instructions in 1 or 2 system clocks

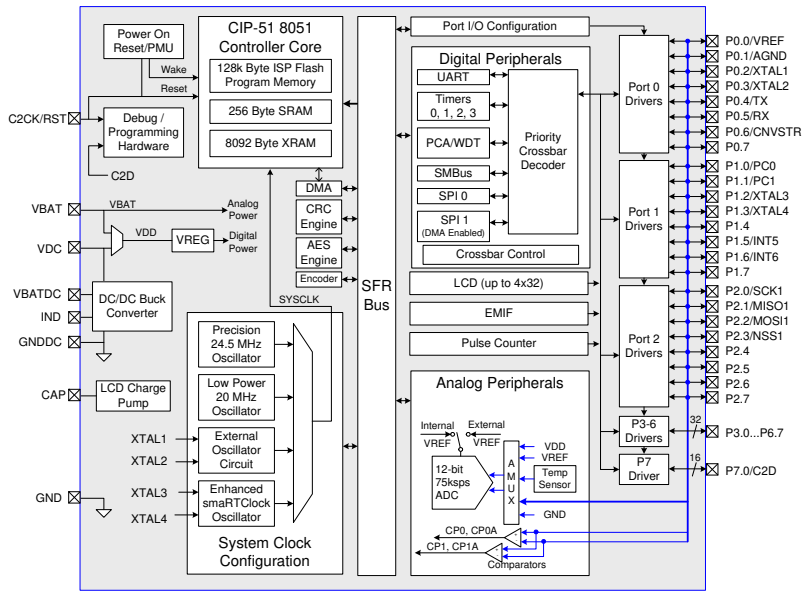
Memory
- Up to 128 kB Flash; In-system programmable; Full read/write/erase functionality over supply range
- Up to 8 kB internal data RAM

Digital Peripherals
- 57 or 34 port I/O; All 5 V tolerant with high sink current and programmable drive strength
- Hardware SMBus™ (I^2C™ Compatible), 2 x SPI™, and UART serial ports available concurrently
- Four general purpose 16-bit counter/timers
- Programmable 16-bit counter/timer array with six capture/compare modules and watchdog timer

Clock Sources
- Precision Internal oscillator: 24.5 MHz, 2% accuracy supports UART operation; spread-spectrum mode for reduced EMI
- Low power internal oscillator: 20 MHz
- External oscillator: Crystal, RC, C, or CMOS Clock
- SmaRTClock oscillator: 32 kHz Crystal or 16.4 kHz internal LFO

On-Chip Debug
- On-chip debug circuitry facilitates full-speed, non-intrusive in-system debug (no emulator required)
- Provides 4 breakpoints, single stepping

Packages
- 76-pin DQFN (6 x 6 mm)
- 40-pin QFN (6 x 6 mm)
- 80-pin TQFP (12 x 12 mm)
- **Temperature Range: –40 to +85 °C**



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This information applies to a product under development. Its characteristics and specifications are subject to change without notice.

Table of Contents

1. System Overview 23
1.1. CIP-51™ Microcontroller Core 29
1.1.1. Fully 8051 Compatible 29
1.1.2. Improved Throughput 29
1.1.3. Additional Features 29
1.2. Port Input/Output 30
1.3. Serial Ports 31
1.4. Programmable Counter Array 31
1.5. SAR ADC with 16-bit Auto-Averaging Accumulator and Autonomous Low Power Burst Mode 32
1.6. Programmable Current Reference (IREF0) 33
1.7. Comparators 33
2. Ordering Information 35
3. Pinout and Package Definitions 36
3.1. DQFN-76 Package Specifications 46
3.1.1. Package Drawing 46
3.1.2. Land Pattern 47
3.1.3. Soldering Guidelines 48
3.2. QFN-40 Package Specifications 50
3.3. TQFP-80 Package Specifications 52
3.3.1. Soldering Guidelines 55
4. Electrical Characteristics 56
4.1. Absolute Maximum Specifications 56
4.2. Electrical Characteristics 57
5. SAR ADC with 16-bit Auto-Averaging Accumulator and Autonomous Low Power Burst Mode 78
5.1. Output Code Formatting 78
5.2. Modes of Operation 80
5.2.1. Starting a Conversion 80
5.2.2. Tracking Modes 80
5.2.3. Burst Mode 82
5.2.4. Settling Time Requirements 83
5.2.5. Gain Setting 83
5.3. 8-Bit Mode 84
5.4. 12-Bit Mode 84
5.5. Low Power Mode 85
5.6. Programmable Window Detector 91
5.6.1. Window Detector In Single-Ended Mode 93
5.6.2. ADC0 Specifications 94
5.7. ADC0 Analog Multiplexer 95
5.8. Temperature Sensor 97
5.8.1. Calibration 97
5.9. Voltage and Ground Reference Options 100

5.10. External Voltage Reference 101
5.11. Internal Voltage Reference 101
5.12. Analog Ground Reference 101
5.13. Temperature Sensor Enable 101
5.14. Voltage Reference Electrical Specifications 102
6. Programmable Current Reference (IREF0) 103
6.1. PWM Enhanced Mode 103
6.2. IREF0 Specifications 104
7. Comparators 105
7.1. Comparator Inputs 105
7.2. Comparator Outputs 106
7.3. Comparator Response Time 107
7.4. Comparator Hysterisis 107
7.5. Comparator Register Descriptions 108
7.6. Comparator0 and Comparator1 Analog Multiplexers 112
8. CIP-51 Microcontroller 115
8.1. Instruction Set 116
8.1.1. Instruction and CPU Timing 116
8.2. CIP-51 Register Descriptions 121
9. Memory Organization 124
9.1. Program Memory 124
9.1.1. MOVX Instruction and Program Memory 127
9.2. Data Memory 127
9.2.1. Internal RAM 128
9.2.2. External RAM 128
10. External Data Memory Interface and On-Chip XRAM 129
10.1. Accessing XRAM 129
10.1.1. 16-Bit MOVX Example 129
10.1.2. 8-Bit MOVX Example 129
10.2. Configuring the External Memory Interface 130
10.3. Port Configuration 130
10.4. Multiplexed and Non-multiplexed Selection 134
10.4.1. Multiplexed Configuration 134
10.4.2. Non-multiplexed Configuration 134
10.5. Memory Mode Selection 135
10.5.1. Internal XRAM Only 136
10.5.2. Split Mode without Bank Select 136
10.5.3. Split Mode with Bank Select 136
10.5.4. External Only 136
10.6. Timing 137
10.6.1. Non-Multiplexed Mode 139
10.6.2. Multiplexed Mode 142
11. Direct Memory Access (DMA0) 146
11.1. DMA0 Architecture 147
11.2. DMA0 Arbitration 148

11.2.1. DMA0 Memory Access Arbitration 148
11.2.2. DMA0 Channel Arbitration 148
11.3. DMA0 Operation in Low Power Modes 148
11.4. Transfer Configuration 149
12. Cyclic Redundancy Check Unit (CRC0) 160
12.1. 16-bit CRC Algorithm 160
12.3. Preparing for a CRC Calculation 163
12.4. Performing a CRC Calculation 163
12.5. Accessing the CRC0 Result 163
12.6. CRC0 Bit Reverse Feature 167
13. DMA-Enabled Cyclic Redundancy Check Module (CRC1) 168
13.1. Polynomial Specification 168
13.2. Endianness 169
13.3. CRC Seed Value 170
13.4. Inverting the Final Value 170
13.5. Flipping the Final Value 170
13.6. Using CRC1 with SFR Access 171
13.7. Using the CRC1 module with the DMA 171
14. Advanced Encryption Standard (AES) Peripheral 175
14.1. Hardware Description 176
14.1.1. AES Encryption/Decryption Core 177
14.1.2. Data SFRs 177
14.1.3. Configuration sfrs 178
14.1.4. Input Multiplexer 178
14.1.5. Output Multiplexer 178
14.1.6. Internal State Machine 178
14.2. Key Inversion 179
14.2.1. Key Inversion using DMA 180
14.2.2. Key Inversion using SFRs 181
14.2.3. Extended Key Output Byte Order 182
14.2.4. Using the DMA to unwrap the extended Key 183
14.3. AES Block Cipher 184
14.4. AES Block Cipher Data Flow 185
14.4.1. AES Block Cipher Encryption using DMA 186
14.4.2. AES Block Cipher Encryption using SFRs 187
14.5. AES Block Cipher Decryption 188
14.5.1. AES Block Cipher Decryption using DMA 188
14.5.2. AES Block Cipher Decryption using SFRs 189
14.6. Block Cipher Modes 190
14.6.1. Cipher Block Chaining Mode 190
14.6.2. CBC Encryption Initialization Vector Location 192
14.6.3. CBC Encryption using DMA 192
14.6.4. CBC Decryption 195
14.6.5. Counter Mode 198
14.6.6. CTR Encryption using DMA 200

15. Encoder/Decoder 207
15.1. Manchester Encoding 208
15.2. Manchester Decoding 209
15.3. Three-out-of-Six Encoding 210
15.4. Three-out-of-Six Decoding 211
15.5. Encoding/Decoding with SFR Access 212
15.6. Decoder Error Interrupt 212
15.7. Using the ENC0 module with the DMA 213
16. Special Function Registers 216
16.1. SFR Paging 216
16.2. Interrupts and SFR Paging 216
16.3. SFR Page Stack Example 218
17. Interrupt Handler 237
17.1. Enabling Interrupt Sources 237
17.2. MCU Interrupt Sources and Vectors 237
17.3. Interrupt Priorities 238
17.4. Interrupt Latency 238
17.5. Interrupt Register Descriptions 240
17.6. External Interrupts INT0 and INT1 247
18. Flash Memory 249
18.1. Programming the Flash Memory 249
18.1.1. Flash Lock and Key Functions 249
18.1.2. Flash Erase Procedure 249
18.1.3. Flash Write Procedure 250
18.1.4. Flash Write Optimization 251
18.2. Non-volatile Data Storage 252
18.3. Security Options 252
18.4. Determining the Device Part Number at Run Time 254
18.5. Flash Write and Erase Guidelines 255
18.5.1. VDD Maintenance and the VDD Monitor 255
18.5.2. PSWE Maintenance 256
18.5.3. System Clock 256
18.6. Minimizing Flash Read Current 257
19. Power Management 262
19.1. Normal Mode 263
19.2. Idle Mode 263
19.3. Stop Mode 264
19.4. Low Power Idle Mode 264
19.5. Suspend Mode 268
19.6. Sleep Mode 268
19.7. Configuring Wakeup Sources 269
19.8. Determining the Event that Caused the Last Wakeup 269
19.9. Power Management Specifications 273
20. On-Chip DC-DC Buck Converter (DC0) 274
20.1. Startup Behavior 275

20.4. Optimizing Board Layout 276
20.5. Selecting the Optimum Switch Size 276
20.6. **DC-DC Converter Clocking Options 276**
20.7. Bypass Mode 277
20.8. DC-DC Converter Register Descriptions 277
20.9. DC-DC Converter Specifications 281
21. Voltage Regulator (VREG0) 282
21.1. Voltage Regulator Electrical Specifications 282
22. Reset Sources 283
22.1. Power-On Reset 284
22.2. Power-Fail Reset 285
22.3. External Reset 288
22.4. Missing Clock Detector Reset 288
22.5. Comparator0 Reset 288
22.6. PCA Watchdog Timer Reset 288
22.7. Flash Error Reset 289
22.8. SmaRTClock (Real Time Clock) Reset 289
22.9. Software Reset 289
23. Clocking Sources 291
23.1. Programmable Precision Internal Oscillator 292
23.2. Low Power Internal Oscillator 292
23.3. External Oscillator Drive Circuit 292
23.3.1. External Crystal Mode 292
23.3.2. External RC Mode 294
23.3.3. External Capacitor Mode 295
23.3.4. External CMOS Clock Mode 295
23.4. Special Function Registers for Selecting and Configuring the System Clock 296
24. SmaRTClock (Real Time Clock) 300
24.1. SmaRTClock Interface 301
24.1.1. SmaRTClock Lock and Key Functions 302
24.1.2. Using RTC0ADR and RTC0DAT to Access SmaRTClock Internal Registers 302
24.1.3. SmaRTClock Interface Autoread Feature 302
24.1.4. RTC0ADR Autoincrement Feature 302
24.2. SmaRTClock Clocking Sources 305
24.2.1. Using the SmaRTClock Oscillator with a Crystal or External CMOS Clock 305
24.2.2. Using the SmaRTClock Oscillator in Self-Oscillate Mode 306
24.2.3. Using the Low Frequency Oscillator (LFO) 306
24.2.4. Programmable Load Capacitance 306
24.2.5. Automatic Gain Control (Crystal Mode Only) and SmaRTClock Bias Doubling 307
24.2.6. Missing SmaRTClock Detector 309
24.2.7. SmaRTClock Oscillator Crystal Valid Detector 309

24.3. SmaRTClock Timer and Alarm Function 309
24.3.1. Setting and Reading the SmaRTClock Timer Value 309
24.3.2. Setting a SmaRTClock Alarm 310
24.3.3. Software Considerations for using the SmaRTClock Timer and Alarm 310
25. Low-Power Pulse Counter 317
25.1. Counting Modes 318
25.2. Reed Switch Types 319
25.3. Programmable Pull-Up Resistors 320
25.4. Automatic Pull-Up Resistor Calibration 322
25.5. Sample Rate 322
25.6. Debounce 322
25.7. Reset Behavior 323
25.8. Wake up and Interrupt Sources 323
25.9. Real-Time Register Access 324
25.10. Advanced Features 324
25.10.1. Quadrature Error 324
25.10.2. Flutter Detection 325
26. LCD Segment Driver 339
26.1. Configuring the LCD Segment Driver 339
26.2. Mapping Data Registers to LCD Pins 340
26.3. LCD Contrast Adjustment 343
26.3.1. Contrast Control Mode 1 (Bypass Mode) 343
26.3.2. Contrast Control Mode 2 (Minimum Contrast Mode) 344
26.3.3. Contrast Control Mode 3 (Constant Contrast Mode) 344
26.3.4. Contrast Control Mode 4 (Auto-Bypass Mode) 345
26.4. Adjusting the VBAT Monitor Threshold 349
26.5. Setting the LCD Refresh Rate 350
26.6. Blinking LCD Segments 351
26.7. Advanced LCD Optimizations 353
27. Port Input/Output 356
27.1. Port I/O Modes of Operation 357
27.1.1. Port Pins Configured for Analog I/O 357
27.1.2. Port Pins Configured For Digital I/O 357
27.1.3. Interfacing Port I/O to High Voltage Logic 358
27.1.4. Increasing Port I/O Drive Strength 358
27.2. Assigning Port I/O Pins to Analog and Digital Functions 358
27.2.1. Assigning Port I/O Pins to Analog Functions 358
27.2.2. Assigning Port I/O Pins to Digital Functions 359
27.2.3. Assigning Port I/O Pins to External Digital Event Capture Functions 359
27.3. Priority Crossbar Decoder 360
27.4. Port Match 366
27.5. Special Function Registers for Accessing and Configuring Port I/O 368
28. SMBus 386
28.1. Supporting Documents 387

28.2. SMBus Configuration 387
28.3. SMBus Operation 387
28.3.1. Transmitter Vs. Receiver 388
28.3.2. Arbitration 388
28.3.3. Clock Low Extension 388
28.3.4. SCL Low Timeout 388
28.3.5. SCL High (SMBus Free) Timeout 389
28.4. Using the SMBus 389
28.4.1. SMBus Configuration Register 389
28.4.2. SMB0CN Control Register 393
28.4.3. Hardware Slave Address Recognition 395
28.4.4. Data Register 398
28.5. SMBus Transfer Modes 398
28.5.1. Write Sequence (Master) 398
28.5.2. Read Sequence (Master) 399
28.5.3. Write Sequence (Slave) 400
28.5.4. Read Sequence (Slave) 401
28.6. SMBus Status Decoding 402
29. UART0 407
29.1. Enhanced Baud Rate Generation 408
29.2. Operational Modes 409
29.2.1. 8-Bit UART 409
29.2.2. 9-Bit UART 409
29.3. Multiprocessor Communications 410
30. Enhanced Serial Peripheral Interface (SPI0) 416
30.1. Signal Descriptions 417
30.1.1. Master Out, Slave In (MOSI) 417
30.1.2. Master In, Slave Out (MISO) 417
30.1.3. Serial Clock (SCK) 417
30.1.4. Slave Select (NSS) 417
30.2. SPI0 Master Mode Operation 417
30.3. SPI0 Slave Mode Operation 419
30.4. SPI0 Interrupt Sources 420
30.5. Serial Clock Phase and Polarity 420
30.6. SPI Special Function Registers 422
32. Timers 448
32.1. Timer 0 and Timer 1 450
32.1.1. Mode 0: 13-bit Counter/Timer 450
32.1.2. Mode 1: 16-bit Counter/Timer 451
32.1.3. Mode 2: 8-bit Counter/Timer with Auto-Reload 451
32.1.4. Mode 3: Two 8-bit Counter/Timers (Timer 0 Only) 452
32.2. Timer 2 458
32.2.1. 16-bit Timer with Auto-Reload 458
32.2.2. 8-bit Timers with Auto-Reload 459
32.2.3. Comparator 0/SmaRTClock Capture Mode 459

32.3. Timer 3 464
32.3.1. 16-bit Timer with Auto-Reload 464
32.3.2. 8-Bit Timers with Auto-Reload 465
32.3.3. SmaRTClock/External Oscillator Capture Mode 465
33. Programmable Counter Array 470
33.1. PCA Counter/Timer 471
33.2. PCA0 Interrupt Sources 472
33.3. Capture/Compare Modules 473
33.3.1. Edge-triggered Capture Mode 474
33.3.2. Software Timer (Compare) Mode 475
33.3.3. High-Speed Output Mode 476
33.3.4. Frequency Output Mode 477
33.3.5. 8-Bit, 9-Bit, 10-Bit and 11-Bit Pulse Width Modulator Modes 478
33.3.6. 16-Bit Pulse Width Modulator Mode 480
33.4. Watchdog Timer Mode 481
33.4.1. Watchdog Timer Operation 481
33.4.2. Watchdog Timer Usage 482
33.5. Register Descriptions for PCA0 484
34. C2 Interface 490
34.1. C2 Interface Registers 490
34.2. C2 Pin Sharing 493
Document Change List 494
Contact Information 496

List of Figures

Figure 1.1. C8051F960 Block Diagram 24
Figure 1.2. C8051F961 Block Diagram 24
Figure 1.3. C8051F962 Block Diagram 25
Figure 1.4. C8051F963 Block Diagram 25
Figure 1.5. C8051F964 Block Diagram 26
Figure 1.6. C8051F965 Block Diagram 26
Figure 1.7. C8051F966 Block Diagram 27
Figure 1.8. C8051F967 Block Diagram 27
Figure 1.9. C8051F968 Block Diagram 28
Figure 1.10. C8051F969 Block Diagram 28
Figure 1.11. Port I/O Functional Block Diagram 30
Figure 1.12. PCA Block Diagram 31
Figure 1.13. ADC0 Functional Block Diagram 32
Figure 1.14. ADC0 Multiplexer Block Diagram 33
Figure 1.15. Comparator 0 Functional Block Diagram 34
Figure 1.16. Comparator 1 Functional Block Diagram 34
Figure 3.1. DQFN-76 Pinout Diagram (Top View) 43
Figure 3.2. QFN-40 Pinout Diagram (Top View) 44
Figure 3.3. TQFP-80 Pinout Diagram (Top View) 45
Figure 3.4. DQFN-76 Package Drawing 46
Figure 3.5. DQFN-76 Land Pattern 47
Figure 3.6. Recomended Inner Via Placement 49
Figure 3.7. Typical QFN-40 Package Drawing 50
Figure 3.8. QFN-40 Landing Diagram 51
Figure 3.9. TQFP-80 Package Drawing 52
Figure 3.10. TQFP80 Landing Diagram 54
Figure 4.1. Frequency Sensitivity (External CMOS Clock, 25°C) 64
Figure 4.2. Typical VOH Curves, 1.8–3.6 V 66
Figure 4.3. Typical VOL Curves, 1.8–3.6 V 67
Figure 5.1. ADC0 Functional Block Diagram 78
Figure 5.2. 10-Bit ADC Track and Conversion Example Timing (BURSTEN = 0) 81
Figure 5.3. Burst Mode Tracking Example with Repeat Count Set to 4 82
Figure 5.4. ADC0 Equivalent Input Circuits 83
Figure 5.5. ADC Window Compare Example: Right-Justified Single-Ended Data 94
Figure 5.6. ADC Window Compare Example: Left-Justified Single-Ended Data 94
Figure 5.7. ADC0 Multiplexer Block Diagram 95
Figure 5.8. Temperature Sensor Transfer Function 97
Figure 5.9. Temperature Sensor Error with 1-Point Calibration (V_{REF} = 1.68 V) 98
Figure 5.10. Voltage Reference Functional Block Diagram 100

Figure 7.1. Comparator 0 Functional Block Diagram 105
Figure 7.2. Comparator 1 Functional Block Diagram 106
Figure 7.3. Comparator Hysteresis Plot 107
Figure 7.4. CPn Multiplexer Block Diagram 112
Figure 8.1. CIP-51 Block Diagram 115
Figure 9.1. C8051F96x Memory Map 124
Figure 9.2. Flash Program Memory Map 125
Figure 9.3. Address Memory Map for Instruction Fetches 126
Figure 10.1. Multiplexed Configuration Example 134
Figure 10.2. Non-multiplexed Configuration Example 135
Figure 10.3. EMIF Operating Modes 135
Figure 10.4. Non-multiplexed 16-bit MOVX Timing 139
Figure 10.5. Non-multiplexed 8-bit MOVX without Bank Select Timing 140
Figure 10.6. Non-multiplexed 8-bit MOVX with Bank Select Timing 141
Figure 10.7. Multiplexed 16-bit MOVX Timing 142
Figure 10.8. Multiplexed 8-bit MOVX without Bank Select Timing 143
Figure 10.9. Multiplexed 8-bit MOVX with Bank Select Timing 144
Figure 11.1. DMA0 Block Diagram 147
Figure 12.1. CRC0 Block Diagram 160
Figure 12.2. Bit Reverse Register 167
Figure 13.1. Polynomial Representation 168
Figure 14.1. AES Peripheral Block Diagram 176
Figure 14.2. Key Inversion Data Flow 179
Figure 14.3. AES Block Cipher Data Flow 185
Figure 14.4. Cipher Block Chaining Mode 190
Figure 14.5. CBC Encryption Data Flow 191
Figure 14.6. CBC Decryption Data Flow 195
Figure 14.7. Counter Mode 198
Figure 14.8. Counter Mode Data Flow 199
Figure 16.1. SFR Page Stack 217
Figure 16.2. SFR Page Stack While Using SFR Page 0x0 To Access SMB0ADR 218
Figure 16.3. SFR Page Stack After SPI0 Interrupt Occurs 219
Figure 16.4. SFR Page Stack Upon PCA Interrupt Occurring During a SPI0 ISR 220
Figure 16.5. SFR Page Stack Upon Return From PCA Interrupt 221
Figure 16.6. SFR Page Stack Upon Return From SPI0 Interrupt 222
Figure 18.1. Flash Security Example 252
Figure 19.1. C8051F96x Power Distribution 263
Figure 19.2. Clock Tree Distribution 264
Figure 20.1. Step Down DC-DC Buck Converter Block Diagram 274
Figure 22.1. Reset Sources 283
Figure 22.2. Power-On Reset Timing Diagram 284
Figure 23.1. Clocking Sources Block Diagram 291
Figure 23.2. 25 MHz External Crystal Example 293

Figure 24.1. SmaRTClock Block Diagram 300
Figure 24.2. Interpreting Oscillation Robustness (Duty Cycle) Test Results 308
Figure 25.1. Pulse Counter Block Diagram 317
Figure 25.2. Mode Examples 318
Figure 25.3. Reed Switch Configurations 319
Figure 25.4. Debounce Timing 323
Figure 25.5. Flutter Example 325
Figure 26.1. LCD Segment Driver Block Diagram 339
Figure 26.2. LCD Data Register to LCD Pin Mapping 341
Figure 26.3. Contrast Control Mode 1 343
Figure 26.4. Contrast Control Mode 2 344
Figure 26.5. Contrast Control Mode 3 344
Figure 26.6. Contrast Control Mode 4 345
Figure 27.1. Port I/O Functional Block Diagram 356
Figure 27.2. Port I/O Cell Block Diagram 357
Figure 27.3. Crossbar Priority Decoder with No Pins Skipped 361
Figure 27.4. Crossbar Priority Decoder with Crystal Pins Skipped 362
Figure 28.1. SMBus Block Diagram 386
Figure 28.2. Typical SMBus Configuration 387
Figure 28.3. SMBus Transaction 388
Figure 28.4. Typical SMBus SCL Generation 390
Figure 28.5. Typical Master Write Sequence 399
Figure 28.6. Typical Master Read Sequence 400
Figure 28.7. Typical Slave Write Sequence 401
Figure 28.8. Typical Slave Read Sequence 402
Figure 29.1. UART0 Block Diagram 407
Figure 29.2. UART0 Baud Rate Logic 408
Figure 29.3. UART Interconnect Diagram 409
Figure 29.4. 8-Bit UART Timing Diagram 409
Figure 29.5. 9-Bit UART Timing Diagram 410
Figure 29.6. UART Multi-Processor Mode Interconnect Diagram 411
Figure 30.1. SPI Block Diagram 416
Figure 30.2. Multiple-Master Mode Connection Diagram 419
Figure 30.3. 3-Wire Single Master and 3-Wire Single Slave Mode Connection Diagram 419
Figure 30.4. 4-Wire Single Master Mode and 4-Wire Slave Mode Connection Diagram 419
Figure 30.5. Master Mode Data/Clock Timing 421
Figure 30.6. Slave Mode Data/Clock Timing (CKPHA = 0) 421
Figure 30.7. Slave Mode Data/Clock Timing (CKPHA = 1) 422
Figure 30.8. SPI Master Timing (CKPHA = 0) 426
Figure 30.9. SPI Master Timing (CKPHA = 1) 426
Figure 30.10. SPI Slave Timing (CKPHA = 0) 427
Figure 30.11. SPI Slave Timing (CKPHA = 1) 427
Figure 32.1. T0 Mode 0 Block Diagram 451

Figure 32.2. T0 Mode 2 Block Diagram 452
Figure 32.3. T0 Mode 3 Block Diagram 453
Figure 32.4. Timer 2 16-Bit Mode Block Diagram 458
Figure 32.5. Timer 2 8-Bit Mode Block Diagram 459
Figure 32.6. Timer 2 Capture Mode Block Diagram 460
Figure 32.7. Timer 3 16-Bit Mode Block Diagram 464
Figure 32.8. Timer 3 8-Bit Mode Block Diagram 465
Figure 32.9. Timer 3 Capture Mode Block Diagram 466
Figure 33.1. PCA Block Diagram 470
Figure 33.2. PCA Counter/Timer Block Diagram 472
Figure 33.3. PCA Interrupt Block Diagram 473
Figure 33.4. PCA Capture Mode Diagram 475
Figure 33.5. PCA Software Timer Mode Diagram 476
Figure 33.6. PCA High-Speed Output Mode Diagram 477
Figure 33.7. PCA Frequency Output Mode 478
Figure 33.8. PCA 8-Bit PWM Mode Diagram 479
Figure 33.9. PCA 9, 10 and 11-Bit PWM Mode Diagram 480
Figure 33.10. PCA 16-Bit PWM Mode 481
Figure 33.11. PCA Module 5 with Watchdog Timer Enabled 482
Figure 34.1. Typical C2 Pin Sharing 493

List of Tables

Table 2.1. Product Selection Guide 35
Table 3.1. Pin Definitions for the C8051F96x 36
Table 3.2. DQFN-76 Package Dimensions 46
Table 3.3. DQFN-76 Land Pattern Dimensions 47
Table 3.4. Recomended Inner Via Placement Dimensions 49
Table 3.5. QFN-40 Package Dimensions 50
Table 3.6. QFN-40 Landing Diagram Dimensions 51
Table 3.7. TQFP-80 Package Dimensions 52
Table 3.8. TQFP80 Landing Diagram Dimensions 54
Table 4.1. Absolute Maximum Ratings 56
Table 4.2. Global Electrical Characteristics 57
Table 4.3. Digital Supply Current at VBAT pin with DC-DC Converter Enabled 57
Table 4.4. Digital Supply Current with DC-DC Converter Disabled 58
Table 4.5. Port I/O DC Electrical Characteristics 65
Table 4.6. Reset Electrical Characteristics 68
Table 4.7. Power Management Electrical Specifications 69
Table 4.8. Flash Electrical Characteristics 69
Table 4.9. Internal Precision Oscillator Electrical Characteristics 69
Table 4.10. Internal Low-Power Oscillator Electrical Characteristics 69
Table 4.11. SmaRTClock Characteristics 70
Table 4.12. ADC0 Electrical Characteristics 70
Table 4.13. Temperature Sensor Electrical Characteristics 71
Table 4.14. Voltage Reference Electrical Characteristics 72
Table 4.15. IREF0 Electrical Characteristics 73
Table 4.16. Comparator Electrical Characteristics 74
Table 4.17. VREG0 Electrical Characteristics 75
Table 4.18. LCD0 Electrical Characteristics 76
Table 4.19. PC0 Electrical Characteristics 76
Table 4.20. DC0 (Buck Converter) Electrical Characteristics 77
Table 5.1. Representative Conversion Times and Energy Consumption for the SAR ADC with 1.65 V High-Speed VREF 85
Table 8.1. CIP-51 Instruction Set Summary 117
Table 10.1. EMIF Pinout (C8051F960/3/6) 131
Table 10.2. AC Parameters for External Memory Interface 145
Table 12.1. Example 16-bit CRC Outputs 161
Table 12.2. Example 32-bit CRC Outputs 163
Table 14.1. Extended Key Output Byte Order 182
Table 14.2. 192-Bit Key DMA Usage 183
Table 14.3. 256-bit Key DMA Usage 183
Table 15.1. Encoder Input and Output Data Sizes 207
Table 15.2. Manchester Encoding 208
Table 15.3. Manchester Decoding 209
Table 15.4. Three-out-of-Six Encoding Nibble 210

Table 15.5. Three-out-of-Six Decoding 211
Table 16.1. SFR Map (0xC0–0xFF) 227
Table 16.2. SFR Map (0x80–0xBF) 228
Table 16.3. Special Function Registers 229
Table 17.1. Interrupt Summary 239
Table 18.1. Flash Security Summary 253
Table 19.1. Power Modes 262
Table 20.1. IPeak Inductor Current Limit Settings 275
Table 23.1. Recommended XFCN Settings for Crystal Mode 293
Table 23.2. Recommended XFCN Settings for RC and C modes 294
Table 24.1. SmaRTClock Internal Registers 301
Table 24.2. SmaRTClock Load Capacitance Settings 307
Table 24.3. SmaRTClock Bias Settings 308
Table 25.1. Pull-Up Resistor Current 320
Table 25.2. Sample Rate Duty-Cycle Multiplier 320
Table 25.3. Pull-Up Duty-Cycle Multiplier 320
Table 25.4. Average Pull-Up Current (Sample Rate = 250 µs) 321
Table 25.5. Average Pull-Up Current (Sample Rate = 500 µs) 321
Table 25.6. Average Pull-Up Current (Sample Rate = 1 ms) 321
Table 25.7. Average Pull-Up Current (Sample Rate = 2 ms) 321
Table 26.1. Bit Configurations to select Contrast Control Modes 343
Table 27.1. Port I/O Assignment for Analog Functions 358
Table 27.2. Port I/O Assignment for Digital Functions 359
Table 27.3. Port I/O Assignment for External Digital Event Capture Functions 359
Table 28.1. SMBus Clock Source Selection 390
Table 28.2. Minimum SDA Setup and Hold Times 391
Table 28.3. Sources for Hardware Changes to SMB0CN 395
Table 28.4. Hardware Address Recognition Examples (EHACK = 1) 396
Table 28.5. SMBus Status Decoding With Hardware ACK Generation Disabled (EHACK = 0) 403
Table 28.6. SMBus Status Decoding With Hardware ACK Generation Enabled (EHACK = 1) 405
Table 29.1. Timer Settings for Standard Baud Rates Using The Internal 24.5 MHz Oscillator 414
Table 29.2. Timer Settings for Standard Baud Rates Using an External 22.1184 MHz Oscillator 414
Table 30.1. SPI Slave Timing Parameters 428
Table 31.1. SPI Slave Timing Parameters 447
Table 32.1. Timer 0 Running Modes 450
Table 33.1. PCA Timebase Input Options 471
Table 33.2. PCA0CPM and PCA0PWM Bit Settings for PCA Capture/Compare Modules 473
Table 33.3. Watchdog Timer Timeout Intervals1 483

List of Registers

SFR Definition 5.1. ADC0CN: ADC0 Control 86
SFR Definition 5.2. ADC0CF: ADC0 Configuration 87
SFR Definition 5.3. ADC0AC: ADC0 Accumulator Configuration 88
SFR Definition 5.4. ADC0PWR: ADC0 Burst Mode Power-Up Time 89
SFR Definition 5.5. ADC0TK: ADC0 Burst Mode Track Time 90
SFR Definition 5.6. ADC0H: ADC0 Data Word High Byte 91
SFR Definition 5.7. ADC0L: ADC0 Data Word Low Byte 91
SFR Definition 5.8. ADC0GTH: ADC0 Greater-Than High Byte 92
SFR Definition 5.9. ADC0GTL: ADC0 Greater-Than Low Byte 92
SFR Definition 5.10. ADC0LTH: ADC0 Less-Than High Byte 93
SFR Definition 5.11. ADC0LTL: ADC0 Less-Than Low Byte 93
SFR Definition 5.12. ADC0MX: ADC0 Input Channel Select 96
SFR Definition 5.13. TOFFH: Temperature Sensor Offset High Byte 99
SFR Definition 5.14. TOFFL: Temperature Sensor Offset Low Byte 99
SFR Definition 5.15. REF0CN: Voltage Reference Control 102
SFR Definition 6.1. IREF0CN: Current Reference Control 103
SFR Definition 6.2. IREF0CF: Current Reference Configuration 104
SFR Definition 7.1. CPT0CN: Comparator 0 Control 108
SFR Definition 7.2. CPT0MD: Comparator 0 Mode Selection 109
SFR Definition 7.3. CPT1CN: Comparator 1 Control 110
SFR Definition 7.4. CPT1MD: Comparator 1 Mode Selection 111
SFR Definition 7.5. CPT0MX: Comparator0 Input Channel Select 113
SFR Definition 7.6. CPT1MX: Comparator1 Input Channel Select 114
SFR Definition 8.1. DPL: Data Pointer Low Byte 121
SFR Definition 8.2. DPH: Data Pointer High Byte 121
SFR Definition 8.3. SP: Stack Pointer 122
SFR Definition 8.4. ACC: Accumulator 122
SFR Definition 8.5. B: B Register 122
SFR Definition 8.6. PSW: Program Status Word 123
SFR Definition 9.1. PSBANK: Program Space Bank Select 127
SFR Definition 10.1. EMI0CN: External Memory Interface Control 132
SFR Definition 10.2. EMI0CF: External Memory Configuration 133
SFR Definition 10.3. EMI0TC: External Memory Timing Control 138
SFR Definition 11.1. DMA0EN: DMA0 Channel Enable 150
SFR Definition 11.2. DMA0INT: DMA0 Full-Length Interrupt 151
SFR Definition 11.3. DMA0MINT: DMA0 Mid-Point Interrupt 152
SFR Definition 11.4. DMA0BUSY: DMA0 Busy 153
SFR Definition 11.5. DMA0SEL: DMA0 Channel Select for Configuration 154
SFR Definition 11.6. DMA0NMD: DMA Channel Mode 155
SFR Definition 11.7. DMA0NCF: DMA Channel Configuration 156
SFR Definition 11.8. DMA0NBAH: Memory Base Address High Byte 157
SFR Definition 11.9. DMA0NBAL: Memory Base Address Low Byte 157
SFR Definition 11.10. DMA0NAOH: Memory Address Offset High Byte 158

SFR Definition 11.11. DMA0NAOL: Memory Address Offset Low Byte 158
SFR Definition 11.12. DMA0NSZH: Transfer Size High Byte 159
SFR Definition 11.13. DMA0NSZL: Memory Transfer Size Low Byte 159
SFR Definition 12.1. CRC0CN: CRC0 Control 164
SFR Definition 12.2. CRC0IN: CRC0 Data Input 165
SFR Definition 12.3. CRC0DAT: CRC0 Data Output 165
SFR Definition 12.4. CRC0AUTO: CRC0 Automatic Control 166
SFR Definition 12.5. CRC0CNT: CRC0 Automatic Flash Sector Count 166
SFR Definition 12.6. CRC0FLIP: CRC0 Bit Flip 167
SFR Definition 13.1. CRC1CN: CRC1 Control 172
SFR Definition 13.2. CRC1IN: CRC1 Data IN 173
SFR Definition 13.3. CRC1POLL: CRC1 Polynomial LSB 173
SFR Definition 13.4. CRC1POLH: CRC1 Polynomial MSB 173
SFR Definition 13.5. CRC1OUTL: CRC1 Output LSB 174
SFR Definition 13.6. CRC1OUTH: CRC1 Output MSB 174
SFR Definition 14.1. AES0BCFG: AES Block Configuration 202
SFR Definition 14.2. AES0DCFG: AES Data Configuration 203
SFR Definition 14.3. AES0BIN: AES Block Input 204
SFR Definition 14.4. AES0XIN: AES XOR Input 205
SFR Definition 14.5. AES0KIN: AES Key Input 205
SFR Definition 14.6. AES0YOUT: AES Y Output 206
SFR Definition 15.1. ENC0CN: Encoder Decoder 0 Control 214
SFR Definition 15.2. ENC0L: ENC0 Data Low Byte 215
SFR Definition 15.3. ENC0M: ENC0 Data Middle Byte 215
SFR Definition 15.4. ENC0H: ENC0 Data High Byte 215
SFR Definition 16.1. SFRPGCN: SFR Page Control 223
SFR Definition 16.2. SFRPAGE: SFR Page 224
SFR Definition 16.3. SFRNEXT: SFR Next 225
SFR Definition 16.4. SFRLAST: SFR Last 226
SFR Definition 17.1. IE: Interrupt Enable 241
SFR Definition 17.2. IP: Interrupt Priority 242
SFR Definition 17.3. EIE1: Extended Interrupt Enable 1 243
SFR Definition 17.4. EIP1: Extended Interrupt Priority 1 244
SFR Definition 17.5. EIE2: Extended Interrupt Enable 2 245
SFR Definition 17.6. EIP2: Extended Interrupt Priority 2 246
SFR Definition 17.7. IT01CF: INT0/INT1 Configuration 248
SFR Definition 18.1. DEVICEID: Device Identification 254
SFR Definition 18.2. REVID: Revision Identification 254
SFR Definition 18.3. PSCTL: Program Store R/W Control 258
SFR Definition 18.4. FLKEY: Flash Lock and Key 259
SFR Definition 18.5. FLSCL: Flash Scale 260
SFR Definition 18.6. FLWR: Flash Write Only 260
SFR Definition 18.7. FRBCN: Flash Read Buffer Control 261
SFR Definition 19.1. PCLKACT: Peripheral Active Clock Enable 265
SFR Definition 19.2. PCLKEN: Peripheral Clock Enable 266

SFR Definition 19.3. CLKMODE: Clock Mode 267
SFR Definition 19.4. PMU0CF: Power Management Unit Configuration 270
SFR Definition 19.5. PMU0FL: Power Management Unit Flag 271
SFR Definition 19.6. PMU0MD: Power Management Unit Mode 272
SFR Definition 19.7. PCON: Power Management Control Register 273
SFR Definition 20.1. DC0CN: DC-DC Converter Control 278
SFR Definition 20.2. DC0CF: DC-DC Converter Configuration 279
SFR Definition 20.3. DC0MD: DC-DC Converter Mode 280
SFR Definition 20.4. DC0RDY: DC-DC Converter Ready Indicator 281
SFR Definition 21.1. REG0CN: Voltage Regulator Control 282
SFR Definition 22.1. VDM0CN: VDD Supply Monitor Control 287
SFR Definition 22.2. RSTSRC: Reset Source 290
SFR Definition 23.1. CLKSEL: Clock Select 296
SFR Definition 23.2. OSCICN: Internal Oscillator Control 297
SFR Definition 23.3. OSCICL: Internal Oscillator Calibration 298
SFR Definition 23.4. OSCXCN: External Oscillator Control 299
SFR Definition 24.1. RTC0KEY: SmaRTClock Lock and Key 303
SFR Definition 24.2. RTC0ADR: SmaRTClock Address 303
SFR Definition 24.3. RTC0DAT: SmaRTClock Data 304
Internal Register Definition 24.4. RTC0CN: SmaRTClock Control 311
Internal Register Definition 24.5. RTC0XCN: SmaRTClock Oscillator Control 312
Internal Register Definition 24.6. RTC0XCF: SmaRTClock Oscillator Configuration 313
Internal Register Definition 24.7. RTC0CF: SmaRTClock Configuration 314
Internal Register Definition 24.8. CAPTUREn: SmaRTClock Timer Capture 315
Internal Register Definition 24.9. ALARM0Bn: SmaRTClock Alarm 0 Match Value 315
Internal Register Definition 24.10. ALARM1Bn: SmaRTClock Alarm 1 Match Value 316
Internal Register Definition 24.11. ALARM2Bn: SmaRTClock Alarm 2 Match Value 316
SFR Definition 25.1. PC0MD: PC0 Mode Configuration 326
SFR Definition 25.2. PC0PCF: PC0 Mode Pull-Up Configuration 327
SFR Definition 25.3. PC0TH: PC0 Threshold Configuration 328
SFR Definition 25.4. PC0STAT: PC0 Status 329
SFR Definition 25.5. PC0DCH: PC0 Debounce Configuration High 330
SFR Definition 25.6. PC0DCL: PC0 Debounce Configuration Low 331
SFR Definition 25.7. PC0CTR0H: PC0 Counter 0 High (MSB) 332
SFR Definition 25.8. PC0CTR0M: PC0 Counter 0 Middle 332
SFR Definition 25.9. PC0CTR0L: PC0 Counter 0 Low (LSB) 332
SFR Definition 25.10. PC0CTR1H: PC0 Counter 1 High (MSB) 333
SFR Definition 25.11. PC0CTR1M: PC0 Counter 1 Middle 333
SFR Definition 25.12. PC0CTR1L: PC0 Counter 1 Low (LSB) 333
SFR Definition 25.13. PC0CMP0H: PC0 Comparator 0 High (MSB) 334

SFR Definition 25.14. PC0CMP0M: PC0 Comparator 0 Middle 334
SFR Definition 25.15. PC0CMP0L: PC0 Comparator 0 Low (LSB) 334
SFR Definition 25.16. PC0CMP1H: PC0 Comparator 1 High (MSB) 335
SFR Definition 25.17. PC0CMP1M: PC0 Comparator 1 Middle 335
SFR Definition 25.18. PC0CMP1L: PC0 Comparator 1 Low (LSB) 335
SFR Definition 25.19. PC0HIST: PC0 History 336
SFR Definition 25.20. PC0INT0: PC0 Interrupt 0 337
SFR Definition 25.21. PC0INT1: PC0 Interrupt 1 338
SFR Definition 26.1. LCD0Dn: LCD0 Data 340
SFR Definition 26.2. LCD0CN: LCD0 Control Register 342
SFR Definition 26.3. LCD0CNTRST: LCD0 Contrast Adjustment 346
SFR Definition 26.4. LCD0MSCN: LCD0 Master Control 347
SFR Definition 26.5. LCD0MSCF: LCD0 Master Configuration 348
SFR Definition 26.6. LCD0PWR: LCD0 Power 348
SFR Definition 26.7. LCD0VBMCN: LCD0 VBAT Monitor Control 349
SFR Definition 26.8. LCD0CLKDIVH: LCD0 Refresh Rate Prescaler High Byte 350
SFR Definition 26.9. LCD0CLKDIVL: LCD Refresh Rate Prescaler Low Byte 350
SFR Definition 26.10. LCD0BLINK: LCD0 Blink Mask 351
SFR Definition 26.11. LCD0TOGR: LCD0 Toggle Rate 352
SFR Definition 26.12. LCD0CF: LCD0 Configuration 353
SFR Definition 26.13. LCD0CHPCN: LCD0 Charge Pump Control 353
SFR Definition 26.14. LCD0CHPCF: LCD0 Charge Pump Configuration 354
SFR Definition 26.15. LCD0CHPMD: LCD0 Charge Pump Mode 354
SFR Definition 26.16. LCD0BUFCN: LCD0 Buffer Control 354
SFR Definition 26.17. LCD0BUFCF: LCD0 Buffer Configuration 355
SFR Definition 26.18. LCD0BUFMD: LCD0 Buffer Mode 355
SFR Definition 26.19. LCD0VBMCF: LCD0 VBAT Monitor Configuration 355
SFR Definition 27.1. XBR0: Port I/O Crossbar Register 0 363
SFR Definition 27.2. XBR1: Port I/O Crossbar Register 1 364
SFR Definition 27.3. XBR2: Port I/O Crossbar Register 2 365
SFR Definition 27.4. P0MASK: Port0 Mask Register 366
SFR Definition 27.5. P0MAT: Port0 Match Register 366
SFR Definition 27.6. P1MASK: Port1 Mask Register 367
SFR Definition 27.7. P1MAT: Port1 Match Register 367
SFR Definition 27.8. P0: Port0 369
SFR Definition 27.9. P0SKIP: Port0 Skip 369
SFR Definition 27.10. P0MDIN: Port0 Input Mode 370
SFR Definition 27.11. P0MDOUT: Port0 Output Mode 370
SFR Definition 27.12. P0DRV: Port0 Drive Strength 371
SFR Definition 27.13. P1: Port1 371
SFR Definition 27.14. P1SKIP: Port1 Skip 372
SFR Definition 27.15. P1MDIN: Port1 Input Mode 372
SFR Definition 27.16. P1MDOUT: Port1 Output Mode 373
SFR Definition 27.17. P1DRV: Port1 Drive Strength 373
SFR Definition 27.18. P2: Port2 374

SFR Definition 27.19. P2SKIP: Port2 Skip 374
SFR Definition 27.20. P2MDIN: Port2 Input Mode 375
SFR Definition 27.21. P2MDOUT: Port2 Output Mode 375
SFR Definition 27.22. P2DRV: Port2 Drive Strength 376
SFR Definition 27.23. P3: Port3 376
SFR Definition 27.24. P3MDIN: Port3 Input Mode 377
SFR Definition 27.25. P3MDOUT: Port3 Output Mode 377
SFR Definition 27.26. P3DRV: Port3 Drive Strength 378
SFR Definition 27.27. P4: Port4 378
SFR Definition 27.28. P4MDIN: Port4 Input Mode 379
SFR Definition 27.29. P4MDOUT: Port4 Output Mode 379
SFR Definition 27.30. P4DRV: Port4 Drive Strength 380
SFR Definition 27.31. P5: Port5 380
SFR Definition 27.32. P5MDIN: Port5 Input Mode 381
SFR Definition 27.33. P5MDOUT: Port5 Output Mode 381
SFR Definition 27.34. P5DRV: Port5 Drive Strength 382
SFR Definition 27.35. P6: Port6 382
SFR Definition 27.36. P6MDIN: Port6 Input Mode 383
SFR Definition 27.37. P6MDOUT: Port6 Output Mode 383
SFR Definition 27.38. P6DRV: Port6 Drive Strength 384
SFR Definition 27.39. P7: Port7 384
SFR Definition 27.40. P7MDOUT: Port7 Output Mode 385
SFR Definition 27.41. P7DRV: Port7 Drive Strength 385
SFR Definition 28.1. SMB0CF: SMBus Clock/Configuration 392
SFR Definition 28.2. SMB0CN: SMBus Control 394
SFR Definition 28.3. SMB0ADR: SMBus Slave Address 396
SFR Definition 28.4. SMB0ADM: SMBus Slave Address Mask 397
SFR Definition 28.5. SMB0DAT: SMBus Data 398
SFR Definition 29.1. SCON0: Serial Port 0 Control 412
SFR Definition 29.2. SBUF0: Serial (UART0) Port Data Buffer 413
SFR Definition 30.1. SPI0CFG: SPI0 Configuration 423
SFR Definition 30.2. SPI0CN: SPI0 Control 424
SFR Definition 30.3. SPI0CKR: SPI0 Clock Rate 425
SFR Definition 30.4. SPI0DAT: SPI0 Data 425
SFR Definition 31.1. SPI1CFG: SPI1 Configuration 442
SFR Definition 31.2. SPI1CN: SPI1 Control 443
SFR Definition 31.3. SPI1CKR: SPI1 Clock Rate 444
SFR Definition 31.4. SPI1DAT: SPI1 Data 444
SFR Definition 32.1. CKCON: Clock Control 449
SFR Definition 32.2. TCON: Timer Control 454
SFR Definition 32.3. TMOD: Timer Mode 455
SFR Definition 32.4. TL0: Timer 0 Low Byte 456
SFR Definition 32.5. TL1: Timer 1 Low Byte 456
SFR Definition 32.6. TH0: Timer 0 High Byte 457
SFR Definition 32.7. TH1: Timer 1 High Byte 457

SFR Definition 32.8. TMR2CN: Timer 2 Control 461
SFR Definition 32.9. TMR2RLL: Timer 2 Reload Register Low Byte 462
SFR Definition 32.10. TMR2RLH: Timer 2 Reload Register High Byte 462
SFR Definition 32.11. TMR2L: Timer 2 Low Byte 463
SFR Definition 32.12. TMR2H Timer 2 High Byte 463
SFR Definition 32.13. TMR3CN: Timer 3 Control 467
SFR Definition 32.14. TMR3RLL: Timer 3 Reload Register Low Byte 468
SFR Definition 32.15. TMR3RLH: Timer 3 Reload Register High Byte 468
SFR Definition 32.16. TMR3L: Timer 3 Low Byte 469
SFR Definition 32.17. TMR3H Timer 3 High Byte 469
SFR Definition 33.1. PCA0CN: PCA Control 484
SFR Definition 33.2. PCA0MD: PCA Mode 485
SFR Definition 33.3. PCA0PWM: PCA PWM Configuration 486
SFR Definition 33.4. PCA0CPMn: PCA Capture/Compare Mode 487
SFR Definition 33.5. PCA0L: PCA Counter/Timer Low Byte 488
SFR Definition 33.6. PCA0H: PCA Counter/Timer High Byte 488
SFR Definition 33.7. PCA0CPLn: PCA Capture Module Low Byte 489
SFR Definition 33.8. PCA0CPHn: PCA Capture Module High Byte 489
C2 Register Definition 34.1. C2ADD: C2 Address 490
C2 Register Definition 34.2. DEVICEID: C2 Device ID 491
C2 Register Definition 34.3. REVID: C2 Revision ID 491
C2 Register Definition 34.4. FPCTL: C2 Flash Programming Control 492
C2 Register Definition 34.5. FPDAT: C2 Flash Programming Data 492

1. System Overview

C8051F96x devices are fully integrated mixed-signal System-on-a-Chip MCUs. Highlighted features are listed below. Refer to Table 2.1 for specific product feature selection and part ordering numbers.

- Power efficient on-chip dc-dc buck converter.
- High-speed pipelined 8051-compatible microcontroller core (up to 25 MIPS)
- In-system, full-speed, non-intrusive debug interface (on-chip)
- True 10-bit 300 ksps, or 12-bit 75 ksps single-ended ADC with 16 external analog inputs and 4 internal inputs such as various power supply voltages and the temperature sensor.
- 6-Bit Programmable Current Reference
- Precision programmable 24.5 MHz internal oscillator with spread spectrum technology.
- 128 kB, 64 kB, 32 kB, or 16 kB of on-chip flash memory
- 8448 or 4352 bytes of on-chip RAM
- 128 Segment LCD Driver
- SMBus/I^2C, Enhanced UART, and two Enhanced SPI serial interfaces implemented in hardware
- Four general-purpose 16-bit timers
- Programmable Counter/Timer Array (PCA) with six capture/compare modules and Watchdog Timer function
- Hardware AES, DMA, and Pulse Counter
- On-chip Power-On Reset, V_{DD} Monitor, and Temperature Sensor
- Two On-chip Voltage Comparators.
- 57 or 34 Port I/O

With on-chip Power-On Reset, V_{DD} monitor, Watchdog Timer, and clock oscillator, the C8051F96x devices are truly stand-alone System-on-a-Chip solutions. The flash memory can be reprogrammed even in-circuit, providing non-volatile data storage, and also allowing field upgrades of the 8051 firmware. User software has complete control of all peripherals, and may individually shut down any or all peripherals for power savings.

The on-chip Silicon Labs 2-Wire (C2) Development Interface allows non-intrusive (uses no on-chip resources), full speed, in-circuit debugging using the production MCU installed in the final application. This debug logic supports inspection and modification of memory and registers, setting breakpoints, single stepping, run and halt commands. All analog and digital peripherals are fully functional while debugging using C2. The two C2 interface pins can be shared with user functions, allowing in-system debugging without occupying package pins.

Each device is specified for 1.8 to 3.8 V operation over the industrial temperature range (–40 to +85 °C). The Port I/O and $\overline{RST}$ pins are tolerant of input signals up to VIO + 2.0 V. The C8051F960/2/4/6/8 are available in a 76-pin DQFN package and an 80-pin TQFP package. The C8051F961/3/5/7/9 are available in a 40-pin QFN package. All package options are lead-free and RoHS compliant. See Table 2.1 for ordering information. Block diagrams are included in Figure 1.1 through Figure 1.16.

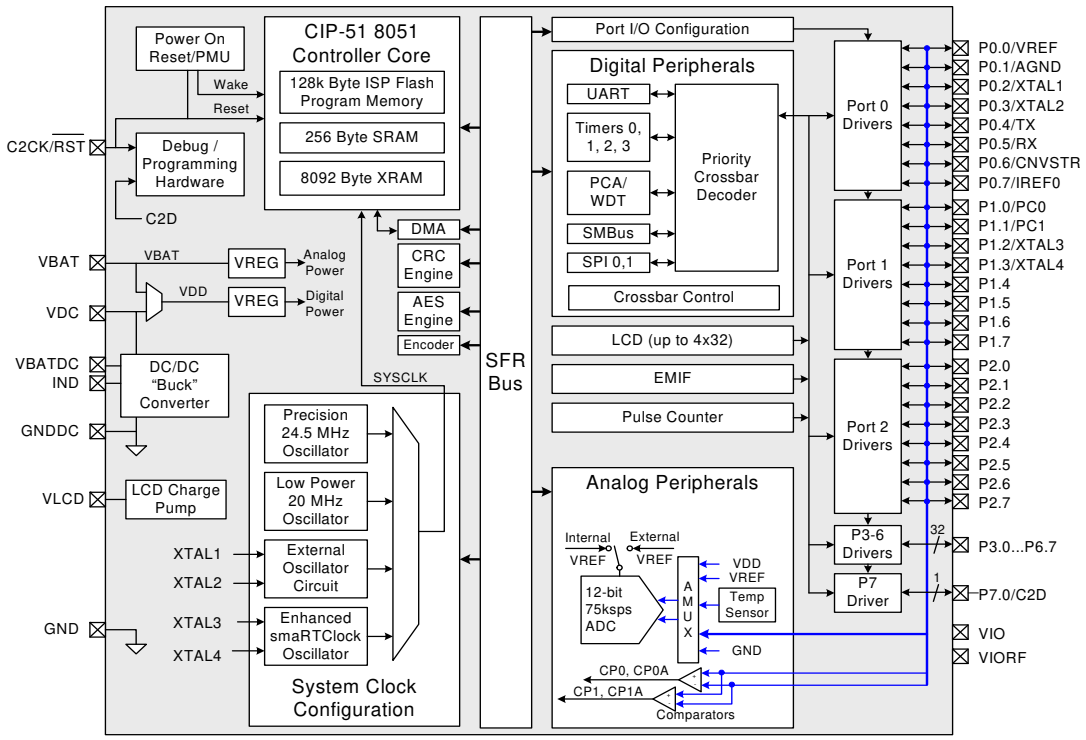

Figure 1.1. C8051F960 Block Diagram

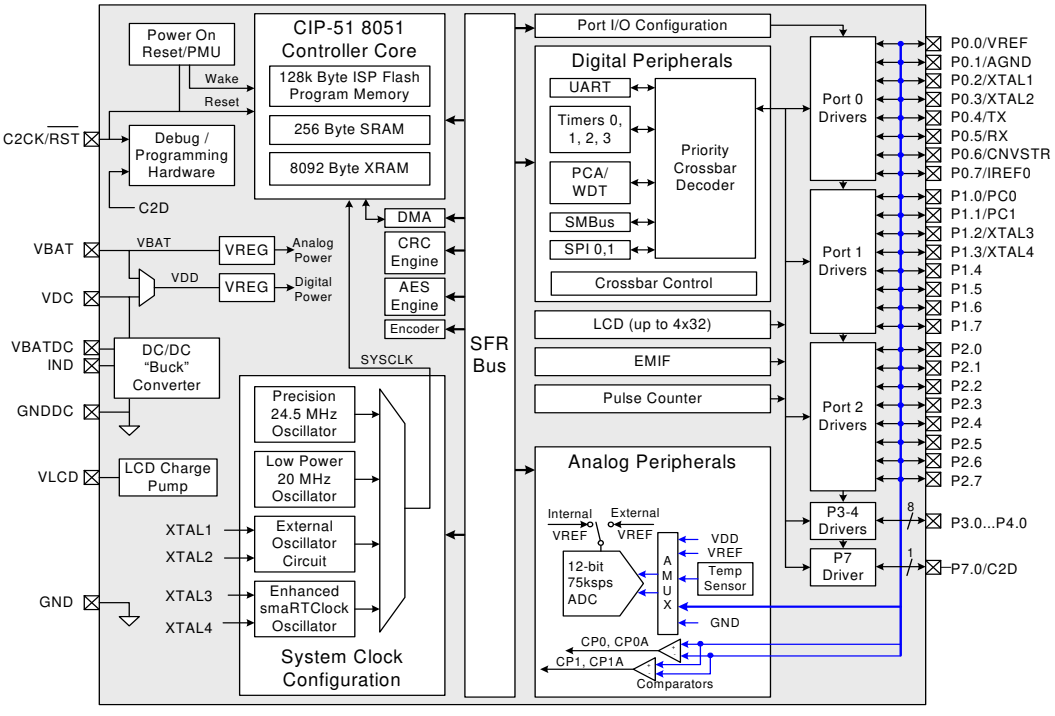

Figure 1.2. C8051F961 Block Diagram

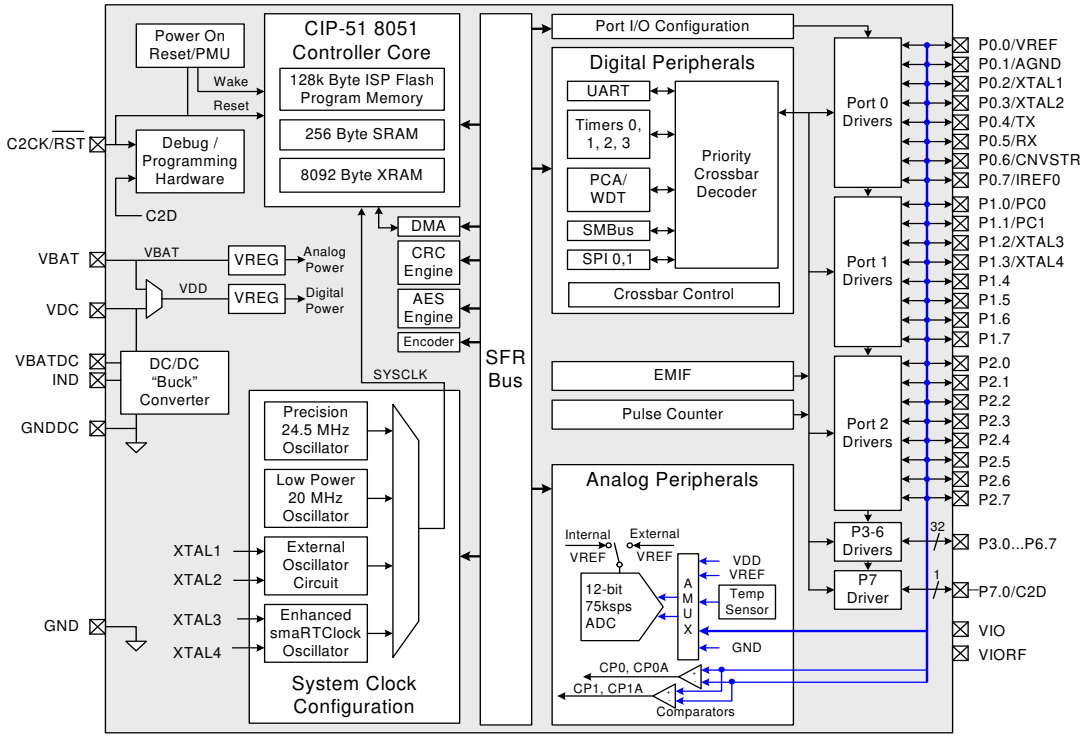

Figure 1.3. C8051F962 Block Diagram

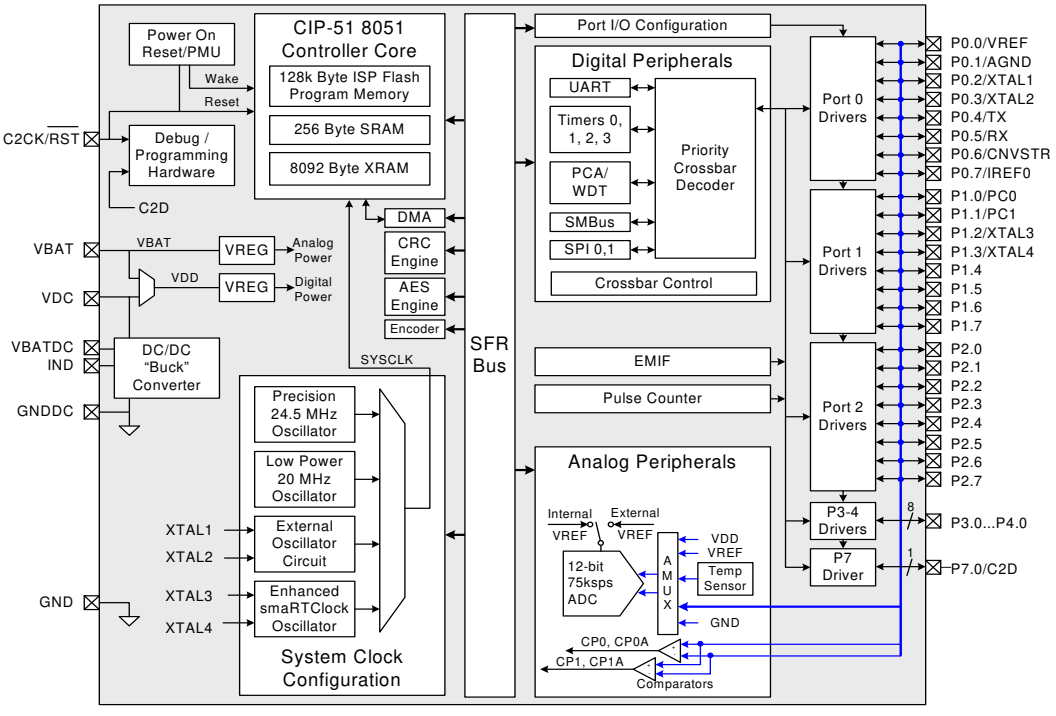

Figure 1.4. C8051F963 Block Diagram