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Driving Lumileds® LEDs with Microchip Microcontrollers

 Driving Lumileds® LEDs with Microchip Microcontrollers Slide 1

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Agenda

- Review of LED drive requirements
- Driver Topologies
- System Software
- Flash Sequence Control Codes
- Development Tools
- Tour of the programming GUI
- Step-by-Step Programming sequence
- Trouble shoot Guide

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Hi-Power LED Drive Requirements

- 1 Watt LED
  - Full intensity 350mA, Maximum current 500mA
  - 2.8VDC, typical forward voltage at 350mA
- 3 Watt LED
  - Full intensity 700mA, Maximum current 1A
  - 4.3VDC, typical forward voltage at 700mA
- 5 Watt LED
  - Full intensity 700mA, Maximum current 1A
  - 7.1VDC, typical forward voltage at 700mA

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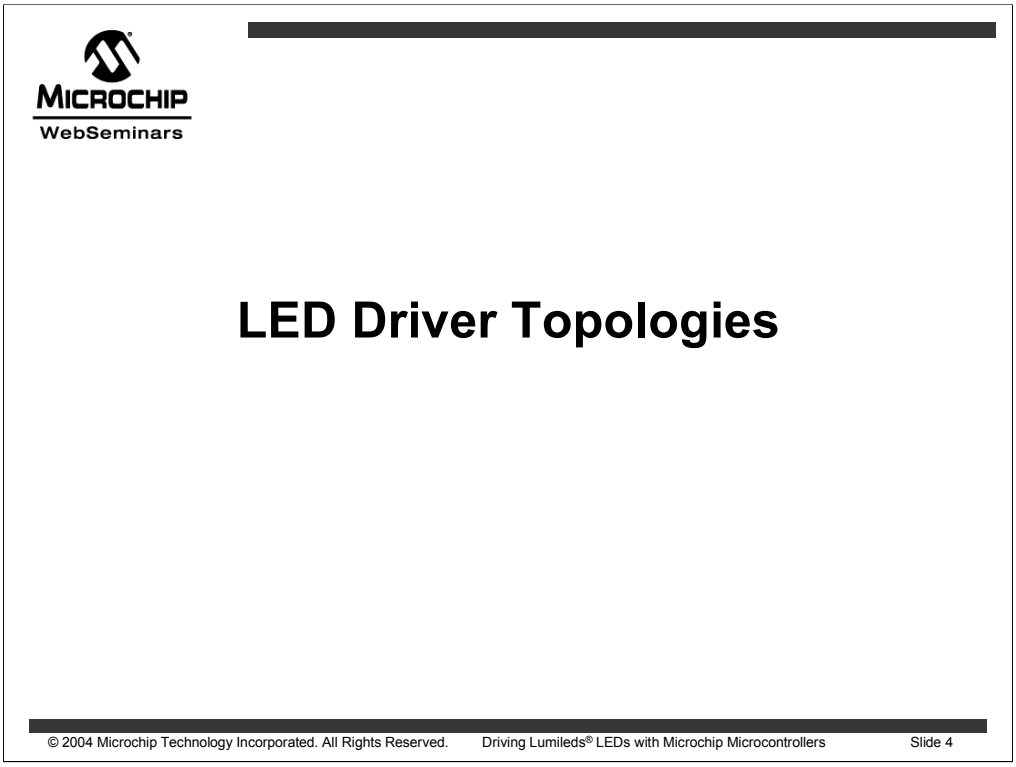
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LED Driver Topologies
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Design Requirements

- Simple and inexpensive
- One button control interface
- Efficient drive of 1, 3 & 5 Watt LEDs
- Battery operation with Intensity compensation
- Intensity control
- Programmable Flash Sequences
- Use small inexpensive microcontroller
- Ease of programming

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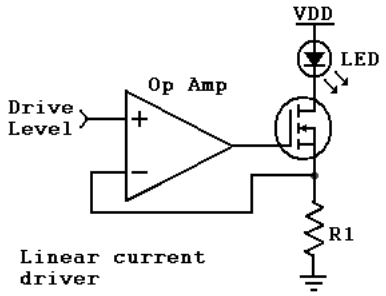
Competing Driver Topologies
Linear Current Driver

- Upside
  - DC current drive
  - Easy to control intensity
- Downside
  - Inefficient power transfer to LED
  - Heat dissipation in the MOSFET
  - No advanced features



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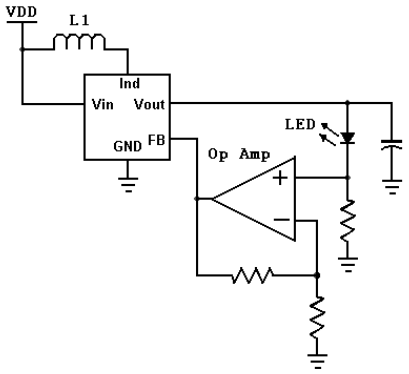
Competing Driver Topologies Single Chip Switchers

- Upside
  - Efficient power drive
- Downside
  - Two chip solution due to reference voltage
  - Difficult to control Intensity
  - No Advanced features



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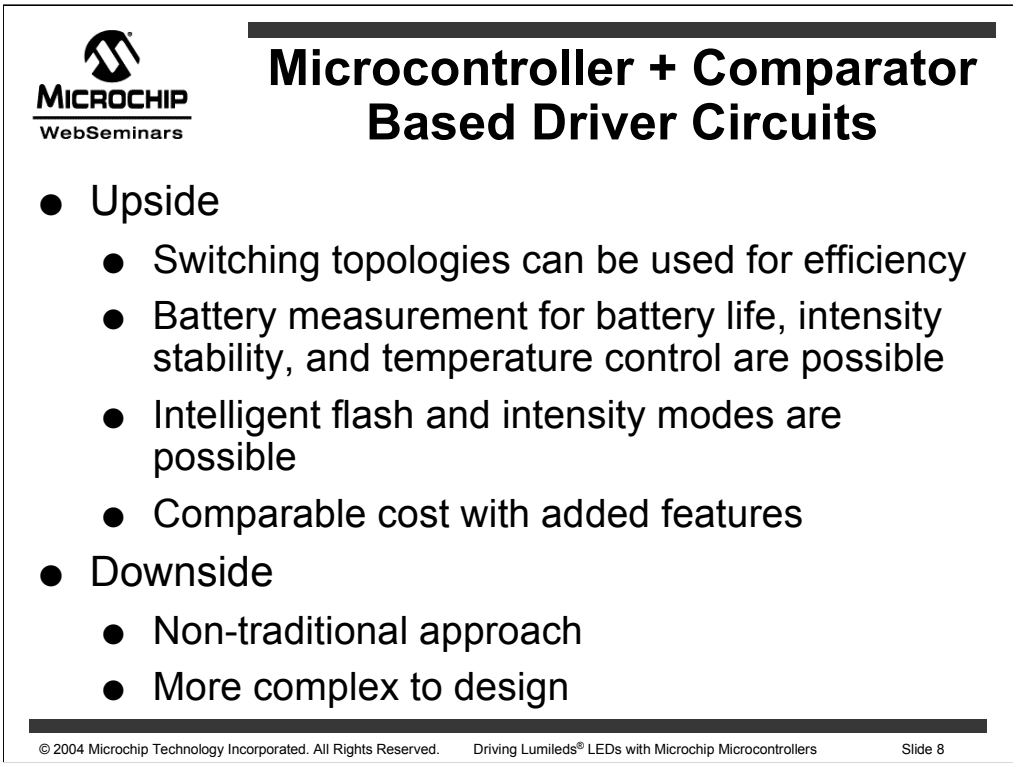
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Microcontroller + Comparator Based Driver Circuits
Upside
Switching topologies can be used for efficiency
Battery measurement for battery life, intensity stability, and temperature control are possible
Intelligent flash and intensity modes are possible
Comparable cost with added features
Downside
Non-traditional approach
More complex to design
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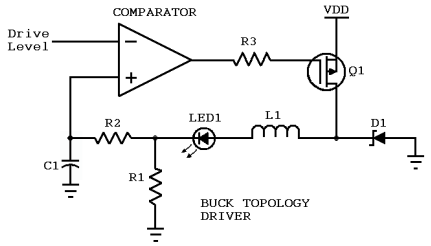
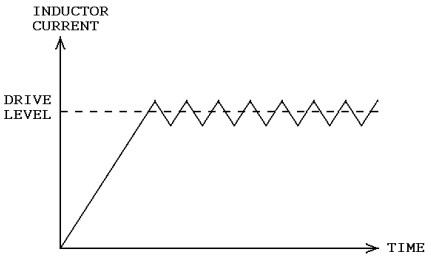
Single Comparator Buck Topology Driver

- At startup, Q1 is on
- The inductor/LED current climbs
- Just above the Drive Level, Q1 is off
- The inductor/LED current falls
- Just below the Drive Level, Q1 is back on





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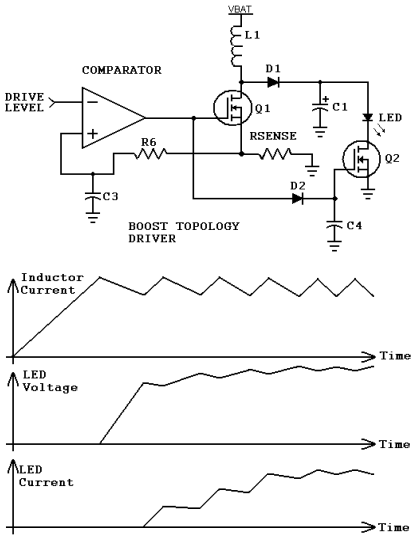
Single Comparator Boost Topology Driver

- The inductor charges in the first phase
- And discharged into C2 in the second phase
- The capacitor voltage climbs until the LED conducts
- The LED acts as a shunt regulator on C1's voltage



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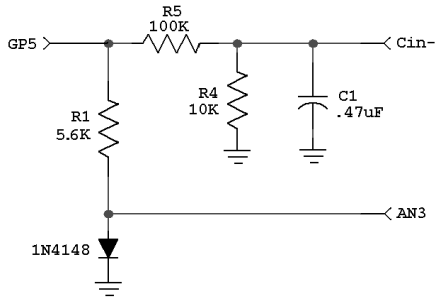
Drive Level Output and Battery Monitor

- GP5 drives the PWM low pass filter for the Drive Level signal
- GP5 also drives the diode reference for battery measurement
- Battery voltage is used to compensate the PWM output



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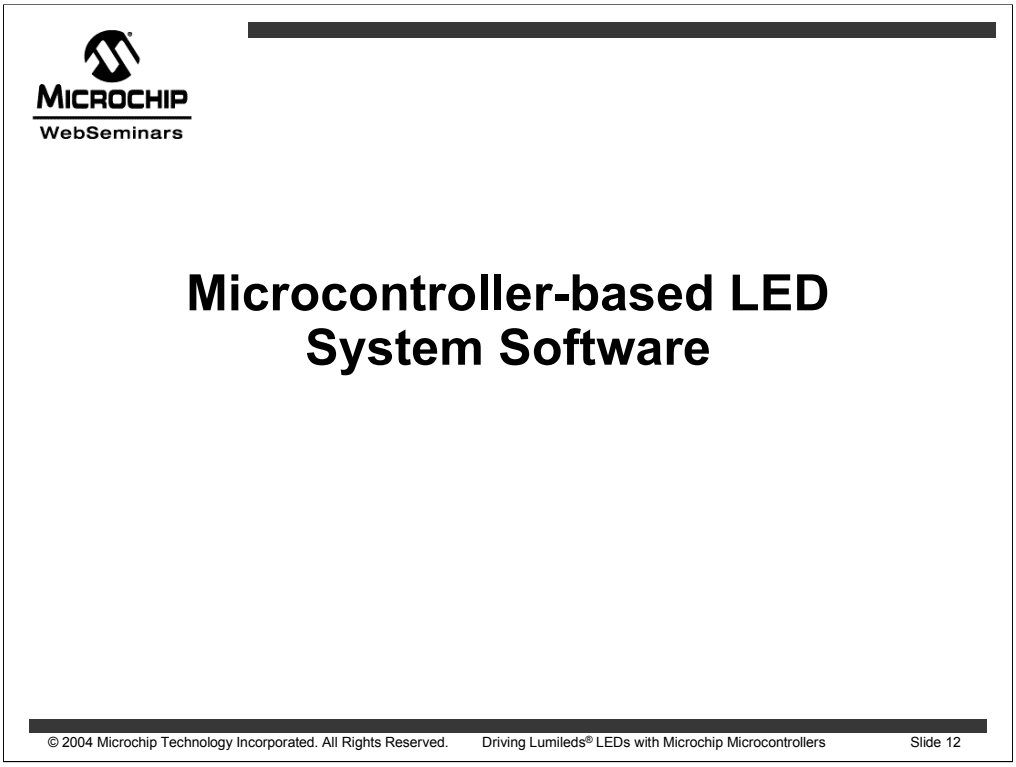
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Microcontroller-based LED System Software
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Two Versions of Demo Software

- Full Version of Software
  - Virtual button commands for intensity set
  - Virtual buttons to select flash sequences
  - Virtual button for power on and off
- Demo Version of Software
  - First Button press turns board on in continuous mode
  - Next Button presses select flash sequences
  - After the last flash sequence, the board turns off

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Virtual Button User Interface

- VPRESS: press the push button < 1.5 sec.
  - Increments or decrements intensity.
- VPUSH: press the push button > 1.5 sec. But < 3.0 sec.
  - Toggles increment / decrement function
  - A double VPUSH causes a Power down
- VHOLD: press and hold the push button for > 3.0 sec. (function auto repeat function)
  - Cycles through flash light and flash sequence modes.

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Control Software

- Software design used 5 tasks in a multi-tasking design
  - PWM: Generates Drive Level output and controls system timing
  - KEY: Monitors the push button and decodes virtual buttons
  - ADC: Monitor the battery and calculates compensation constants
  - CONTROL: Decodes virtual button commands
  - AUTOSEQ: Accesses and executes programmed flash sequences.

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Preprogrammed Flash Sequences

- Preprogrammed flash sequences automatically execute 1 of 4 possible flash light sequences.
- Control Codes available for Set Intensity, Delay Time, Goto step, Shutdown and Repeat/Return
  - Repeat Return can be nested up to 4 levels deep
- Provisions for 4 sequences are available
- Each sequence must be less than 64 opcodes
  - Total number of opcodes must be < 120

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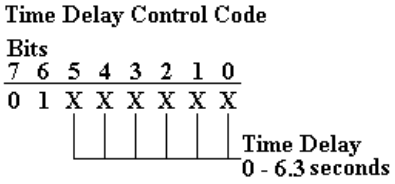
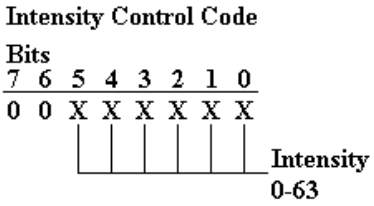
Time Delay and Intensity Set Control Codes

- Time delay can be set between 0 and 6.3 Seconds



- Intensity can be set between 0 and 63.
- 0 turns off the LED.
- 63 results in the maximum brightness.



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GOTO and Shutdown Control Codes

- A GOTO jumps to the destination control code specified
- GOTOs must jump to valid instructions in the same sequence
- Sequences start with control code #1
- The Shutdown control code is a GOTO to location 0

GOTO Control Code

Bits	7	6	5	4	3	2	1	0
	1	1	X	X	X	X	X	X

Destination

Shutdown Control Code

Bits	7	6	5	4	3	2	1	0
	1	1	0	0	0	0	0	0

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Repeat and Return OpCodes

- A Repeat loops the codes between the Repeat and Return the specified number of times
- The number of cycles must be between 1 and 63
- Repeats can be nested 4 deep.

Repeat Control Code

Bits							
7	6	5	4	3	2	1	0
1	0	X	X	X	X	X	X

Number of cycles

- A return code will cause a loop back to the most recent Repeat code.

Return Control Code

Bits							
7	6	5	4	3	2	1	0
1	0	0	0	0	0	0	0

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Examples

- Set intensity to maximum

```
Bright = 63
Goto      2
```

- Set maximum intensity for 3 seconds then stop

```
Bright = 63
Time   = 3.0
Bright = 0
Goto   4
```

- Flash LED at 1 Hz rate
- Flash 5 times
- Then delay 5 seconds and start over

```
Repeat = 5
Bright = 63
Time   = 0.5
Bright = 0
Time   = 0.5
Return
Time   = 5.0
Goto   = 1
```

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More Examples

- Delay 30 seconds

```
Repeat     = 6
Time       = 5.0
Return
```

- Flash at 1Hz
- Flash 5 Times
- Then shutdown

```
Repeat     = 5
Intensity  = 63
Time       = 0.5
Intensity  = 0
Time       = 0.5
Return
Shutdown
```

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Development Tools
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PICkit™ 1 Development Kit

- The PICkit™ 1 is designed to be a low cost programmer/development board for Microchip's low pin count flash parts
- The LED demo board is designed to plug into the 14-pin expansion header
- The PICkit™ GUI is replaced with the LED demo board programming GUI to program the demo board

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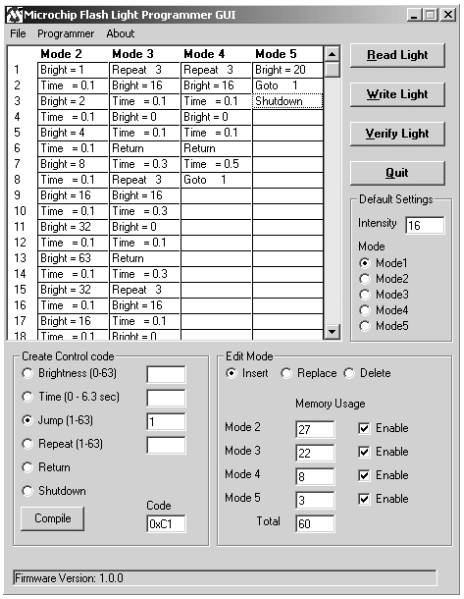
Programming GUI

- Graphical control code builder
- Drag and Drop editor modes
- Default settings
- Sequence size status display
- Read, Write, and Verify
- File Load, Save, and Update



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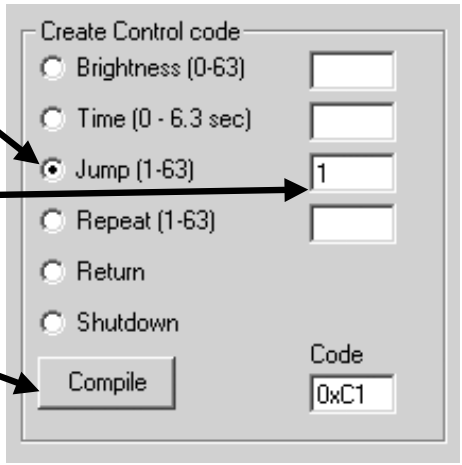
Create the Control Codes

- Click to select the required control
- Or, enter data in the associated box
- Click “Compile” to create the control code



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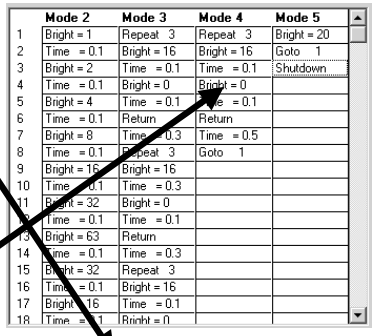
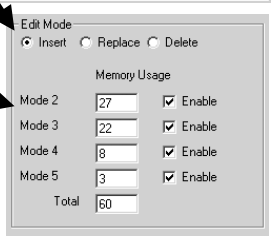
Insert/Delete/Replace the control code into the sequence

- Select the appropriate edit mode
- And click to place the control code in the sequence
- Remember only 64 codes per sequence and 120 total



	Mode 2	Mode 3	Mode 4	Mode 5
1	Bright = 1	Repeat 3	Repeat 3	Bright = 20
2	Time = 0.1	Bright = 16	Bright = 16	Goto 1
3	Bright = 2	Time = 0.1	Time = 0.1	Shutdown
4	Time = 0.1	Bright = 0	Bright = 0	
5	Bright = 4	Time = 0.1	Time = 0.1	
6	Time = 0.1	Return	Return	
7	Bright = 8	Time = 0.3	Time = 0.5	
8	Time = 0.1	Repeat 3	Goto 1	
9	Bright = 16	Bright = 16		
10	Time = 0.1	Time = 0.3		
11	Bright = 32	Bright = 0		
12	Time = 0.1	Time = 0.1		
13	Bright = 63	Return		
14	Time = 0.1	Time = 0.3		
15	Bright = 32	Repeat 3		
16	Time = 0.1	Bright = 16		
17	Bright 16	Time = 0.1		
18	Time = 0.1	Bright = 0		



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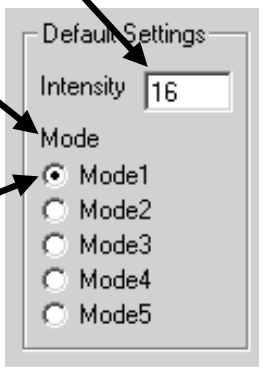
Default Settings

- Determines the starting intensity
  - Changes to the intensity are retained through power down
- Determines the starting mode
  - New mode selections are retained through power down
  - Only enabled modes can be selected
- Mode1 is the continuous intensity mode (no flash)



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Program/Verify/Read the program in the demo board

- "Read" copies the current code from the demo board into the GUI
- "Write" programs the current GUI configuration and code into the board
- "Verify" compares the code in the demo against the GUI configuration
- "Quit" ends the GUI program

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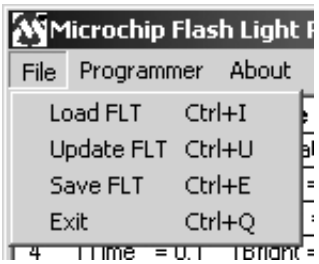
Save Load and UpGrade

- The file pull down menu contains all file commands
  - All configuration files have the extension *.FLT
  - “Load” imports both programming and configuration information
  - “Update” imports only programming, leaving configuration unchanged
  - “Save” exports both programming and configuration information
  - “Exit” ends the GUI program



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Programming Sequence

- Remove one battery and J1.
- Insert the Demo board into the PICkit™ programmer with the LED facing the USB cable
- Load and Start the GUI.
- Load the desired base software (full or demo)
- Create the desired configuration.
- Click PROGRAM.
- When complete remove the Demo board.
- Press and hold the push button for 5 seconds.
- Replace J1 and then replace the battery.

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Trouble Shooting Problems

- Board programs but does not run
  - Remove a battery, press the button, replace the battery
- Flash sequence starts, then hangs
  - Check sequence for a REPEAT with out a corresponding RETURN
- LED flashes momentarily then unit turns off
  - Replace batteries
- Board fails to program
  - Remember to remove jumper J1

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Trouble Shooting Problems continued

- With Demo Software, After power up Unit turns off immediately
  - If the last enabled flash sequence starts with a shutdown command, reprogram the board with the last sequence disabled
  - If the last enabled flash sequence does not use the shutdown command, replace the batteries
- NOTE: at full intensity, the maximum battery life is between 2 and 6.5 hours depending on battery chemistry

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Summary

- Driving High Power LEDs present a number of design challenges.
- Microcontroller based drivers are efficient, simple, and add value to the final product.
- The example software provides a wealth of features using only a single button for control.
- The pre-programmed flash sequence capability provides user customizable features to the light.
- The GUI programming interface simplifies the design and loading of the flash sequences.

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Resources

- Small Pin-Count Flash Microcontroller Data Books
  - PIC12F629/675 DS41190C
  - PIC16F630/676 DS40093C
- Application notes
  - AN874 Buck Configuration Hi-Power LED Driver (DS00874)
  - Thermal Design Using Luxeon™ Power Light Sources AB05 (available from the Lumileds Web page)
  - 8-Pin Tips-n-Tricks Booklet (DS40040)
  - Comparator Tips-n-Tricks Booklet (DS41215)
- Development tools
  - MPLAB® Integrated Design Environment
  - PICkit™ 1 Flash Starter Kit
- Web Pages
  - Microchip Technology Inc. www.Microchip.com
  - Lumileds Lighting, LLC www.Lumileds.com

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Thank you