ZiLOG Design Concepts

Z8 Application Ideas

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Introduction

Are you driven to design the best?

Co-sponsored with *CMP Media, Inc.*, ZiLOG's 1999 "Driven to Design" contest sought the most innovative and creative use of ZiLOG's award-winning Z8® or Z8Plus® OTP microcontroller.

The 47 abstracts contained in this book offer the designer a launching pad from which to prompt ideas and develop designs incorporating the ZiLOG Z8 or Z8Plus microcontrollers. They range in scope from helping blind individuals navigate busy intersections to providing increased protection for the handling and delivery of fragile packages.

Students and engineers from all over the world submitted the design concepts presented in this compendium. Each abstract includes block and schematic diagrams to help the designer comprehend the contestants' visions of products that are viable in today's connected world.

ZiLOG OTP Selection Guide

ROM (KB)	PACKAGE	PINS	OPERATING TEMPERATURE	OSCILLATOR	ZiLOG PART NUMBER	VOLTAGE RANGE	PROGRAMMING ADAPTER	EMULATOR/ ACCESS. KIT	FEATURES	ROM EQUIV.
0.5K	DIP	18	-40/105	Selectable	Z86E0208PEC1925	4.5V - 5.5V	Not Required	Z86CCP01ZEM**	1 Timer + WDT	Z86C02
			0/70		Z86E0208PSC1925	3.5V - 5.5V			2 Comparators	
	SOIC	18	-40/105		Z86E0208SEC1925	4.5V - 5.5V	Z86E0700ZDP		61 RAM + 14 I/O + POR	
			0/70		Z86E0208SSC1925	3.5V - 5.5V				
	SSOP	20	-40/105		Z86E0208HEC1925	4.5V - 5.5V	Z86E0800ZDH			
			0/70		Z86E0208HSC1925	3.5V - 5.5V				
	DIP	18	0/70	Selectable	Z86E0308PSC	4.5V - 5.5V	Z86E0601ZDP		1 Timer + Timer Out	Z86C03
	SOIC				Z86E0308SSC				2 Comparators + WDT	
									61 RAM + 14 I/O + POR	
	DIP	18	-40/105	XTAL	Z8E00010PEC	4.5V - 5.5V	Not Required	Z8ICE001ZEM	Z8Plus Core	None
			0/70		Z8E00010PSC	3.5V - 5.5V			1 Timer	
	SOIC	18	-40/105		Z8E00010SEC	4.5V - 5.5V	Z86E0700ZDP		WDT + Reset Pin	
			0/70		Z8E00010SSC	3.5V - 5.5V			32 RAM + 13 I/O	
	SSOP	20	-40/105		Z8E00010HEC	4.5V - 5.5V	Z8E00101ZDH			
			0/70		Z8E00010HSC	3.5V - 5.5V				
	DIP	18	-40/105	Selectable	Z8PE002PZ010EC	4.5V - 5.5V	Not Required		Z8Plus Core	
			0/70		Z8PE002PZ010SC	3.0V - 5.5V			3 Timers / PWM	
	SOIC	18	-40/105		Z8PE002SZ010EC	4.5V - 5.5V	Z86E0700ZDP		1 Comparator + WDT	
			0/70		Z8PE002SZ010SC	3.0V - 5.5V			64 RAM + 14 I/O + POR	
	SSOP	20	-40/105		Z8PE002HZ010EC	4.5V - 5.5V	Z8E00101ZDH			
			0/70		Z8PE002HZ010SC	3.0V - 5.5V				
1K	DIP	18	-40/105	XTAL	Z86E0412PEC	4.5V - 5.5V	Not Required	Z86CCP01ZEM**	2 Timers + WDT	Z86C04
				RC	Z86E0412PEC1903				2 Comparators	
			0/70	XTAL	Z86E0412PSC1866				125 RAM + 14 I/O + POR	
				RC	Z86E0412PSC1903					
	SOIC	18	-40/105	XTAL	Z86E0412SEC		Z86E0700ZDP			
				RC	Z86E0412SEC1903					
			0/70	XTAL	Z86E0412SSC1866					
				RC	Z86E0412SSC1903					
	SSOP	20	-40/105	XTAL	Z86E0412HEC1866		Z86E0800ZDH			
					Z86E0412HSC1866					
	DIP	18	0/70	Selectable	Z86E0612PSC		Z86E0601ZDP		2 Timers + SPI + WDT	Z86C06
	SOIC				Z86E0612SSC				2 Comparators + 125 RAM	
									Timer Out + 14 I/O + POR	
	DIP	18	-40/105	XTAL	Z8E00110PEC	4.5V - 5.5V	Not Required	Z8ICE001ZEM	Z8Plus Core	None
			0/70		Z8E00110PSC	3.5V - 5.5V			3 Timers / PWM	
	SOIC	18	-40/105		Z8E00110SEC	4.5V - 5.5V	Z86E0700ZDP		1 Comparator + WDT	
			0/70		Z8E00110SSC	3.5V - 5.5V			Reset Pin	
	SSOP	20	-40/105		Z8E00110HEC	4.5V - 5.5V	Z8E00101ZDH		64 RAM + 13 I/O	
			0/70		Z8E00110HSC	3.5V - 5.5V				
	DIP	18	-40/105	Selectable	Z8PE003PZ010EC	4.5V - 5.5V	Not Required		Z8Plus Core	
			0/70		Z8PE003PZ010SC	3.0V - 5.5V			3 Timers / PWM	
	SOIC	18	-40/105		Z8PE003SZ010EC	4.5V - 5.5V	Z86E0700ZDP		1 Comparator + WDT	
			0/70		Z8PE003SZ010SC	3.0V - 5.5V			Reset Pin	
	SSOP	20	-40/105		Z8PE003HZ010EC	4.5V - 5.5V	Z8E00101ZDH		64 RAM + 14 I/O + POR	
			0/70		Z8PE003HZ010SC	3.0V - 5.5V				
2K	DIP	18	-40/105	XTAL	Z86E0812PEC	4.5V - 5.5V	Not Required	Z86CCP01ZEM**	2 Timers + WDT	Z86C08
				RC	Z86E0812PEC1903				2 Comparators	
			0/70	XTAL	Z86E0812PSC1866				125 RAM + 14 I/O + POR	
				RC	Z86E0812PSC1903					
	SOIC	18	-40/105	XTAL	Z86E0812SEC		Z86E0700ZDP			
				RC	Z86E0812SEC1903					
			0/70	XTAL	Z86E0812SSC1866					
				RC	Z86E0812SSC1903					
	SSOP	20	-40/105	XTAL	Z86E0812HEC1866		Z86E0800ZDH			
					Z86E0812HSC1866					
	DIP	28	-40/105	Selectable	Z86E3116PEC	4.5V - 5.5V	Not Required	Z86CCP01ZEM**	2 Timers + WDT	Z86C31
			0/70		Z86E3116PSC	3.5V - 5.5V		and	2 Comparators	
	SOIC	28	-40/105		Z86E3116SEC	4.5V - 5.5V	Z86C3000ZAC	Z86CCP00ZAC	125 RAM + 24 I/O + POR	
			0/70		Z86E3116SSC	3.5V - 5.5V				
	PLCC	28	-40/105		Z86E3116VEC	4.5V - 5.5V				
			0/70		Z86E3116VSC	3.5V - 5.5V				
4K	DIP	28	-40/105	Selectable	Z86E132PZ016EC[1]	3.0V - 5.5V	ZICSP000100ZDP	Z86C3600ZEM	UART + 2 Comparators	Z86C34***
			0/70		Z86E132PZ016SC			+	ICSP OTP Programming	(16K ROM)
	SOIC	28	-40/105		Z86E132SZ016EC[1]		ZICSP000300ZDS	ZLGICSP0100ZPR	2 Timers + 237 RAM,	
			0/70		Z86E132SZ016SC				24 I/O + WDT + POR	
	DIP	40	-40/105	Selectable	Z86E142PZ016EC[1]		ZICSP000400ZDP	Z86C3600ZEM	UART + 2 Comparators	Z86C44****
			0/70		Z86E142PZ016SC			+	ICSP OTP Programming	(16K ROM)
	QFP	44	-40/105		Z86E142FZ016EC		ZICSP000600ZDF	ZLGICSP0100ZPR	2 Timers + 236 RAM,	
			0/70		Z86E142FZ016SC				32 I/O + WDT + POR	
	DIP	28	-40/105	Selectable	Z86E3016PEC	4.5V - 5.5V	Not Required	Z86CCP01ZEM**	2 Timers + WDT	Z86C30
			0/70		Z86E3016PSC	3.5V - 5.5V			2 Comparators	
	SOIC	28	0/70		Z86E3016SEC	4.5V - 5.5V	Z86C3000ZAC		237 RAM + 24 I/O + POR	
					Z86E3016SSC	3.5V - 5.5V				
	PLCC	28	0/70		Z86E3016VEC	4.5V - 5.5V				
					Z86E3016VSC	3.5V - 5.5V				
	DIP	28	0/70	Selectable	Z86E3312PSC	3.5V - 5.5V	Z86E3400ZDP	Z86CCP01ZEM**	Clock-free WDT Reset	Z86C33
	SOIC				Z86E3312SSC		Z86E3400ZDS	and	237 RAM + 2 Comparators	
	PLCC				Z86E3312VSC		Z86E3400ZDV	Z86CCP00ZAC	2 Timers + 24 I/O + POR	
	DIP	40	0/70	RC	Z86E1505PSC	4.5V - 5.5V	Z86E1500ZDP	Z86CCP01ZEM+	1 Timer + WDT	Z86K15/K16
									188 RAM + 32 I/O	(K16=5K ROM)
	QFP	44	-40/105	Selectable	Z86E4016FEC	4.5V - 5.5V	Z86E4001ZDF	Z86CCP01ZEM**	2 Timers + WDT	Z86C40
			0/70		Z86E4016FSC	3.5V - 5.5V		and	2 Comparators	
	DIP	40	-40/105		Z86E4016PEC	4.5V - 5.5V	Not Required	Z86CCP00ZAC	236 RAM + 32 I/O + POR	
			0/70		Z86E4016PSC	3.5V - 5.5V				
	PLCC	44	-40/105		Z86E4016VEC	4.5V - 5.5V	Z86E4001ZDV			
			0/70		Z86E4016VSC	3.5V - 5.5V				
	QFP	44	0/70	Selectable	Z86E4312FSC	3.5V - 5.5V	Z86E4400ZDF	Z86CCP01ZEM**	Clock-free WDT Reset	Z86C43
	DIP	40			Z86E4312PSC		Z86E4400ZDP		2 Timers + 2 Comparators	
	PLCC	44			Z86E4312VSC		Z86E4400ZDV		236 RAM + 32 I/O	
	DIP	28	-40/105	XTAL	Z86E8316PEC	4.5V - 5.5V	Z86E8300ZDP	Z86C8401ZEM	8 Bit - 8 Channel A/D	Z86C83
			0/70		Z86E8316PSC	3.5V - 5.5V			2 Timers + WDT	
	SOIC		-40/105		Z86E8316SEC	4.5V - 5.5V	Z86E8300ZDS		2 Comparators	
			0/70		Z86E8316SSC	3.5V - 5.5V			237 RAM + 21 I/O + POR	
	PLCC		-40/105		Z86E8316VEC	4.5V - 5.5V	Z86E8300ZDV			
			0/70		Z86E8316VSC	3.5V - 5.5V				

ROM (KB)	PACKAGE	PINS	OPERATING TEMPERATURE	OSCILLATOR	ZiLOG PART NUMBER	VOLTAGE RANGE	PROGRAMMING ADAPTER	EMULATOR/ ACCESS. KIT	FEATURES	ROM EQUIV.
8K	DIP	28	-40/105	Selectable	**Z86E133PZ016EC**[1]	3.0V - 5.5V	ZICSP000100ZDP	Z86C3600ZEM	UART + 2 Comparators	Z86C34***
			0/70		**Z86E133PZ016SC**			+	ICSP OTP Programming	(16K ROM)
	SOIC	28	-40/105		**Z86E133SZ016EC**[1]		ZICSP000300ZDS	ZLGICSP0100ZPR	2 Timers + 237 RAM,	
			0/70		**Z86E133SZ016SC**				24 I/O + WDT + POR	
	DIP	40	-40/105	Selectable	**Z86E143PZ016EC**[1]		ZICSP000400ZDP	Z86C3600ZEM	UART + 2 Comparators	Z86C44****
	0/70				**Z86E143PZ016SC**			+	ICSP OTP Programming	(16K ROM)
	QFP	44	-40/105		**Z86E143FZ016EC**		ZICSP000600ZDF	ZLGICSP0100ZPR	2 Timers + 236 RAM	
			0/70		**Z86E143FZ016SC**				32 I/O + WDT + POR	
	DIP	28	0/70	Selectable	**Z8673312PSC**	3.5V - 5.5V	Z86E3400ZDP	Z86CCP01ZEM**	2 Timers + WDT	Z86233
	SOIC				**Z8673312SSC**		Z86E3400ZDS		2 Comparators	
	PLCC				**Z8673312VSC**		Z86E3400ZDV		237 RAM + 24 I/O + POR	
	QFP	44	0/70	Selectable	**Z8674312FSC**		Z86E4400ZDF		2 Timers + WDT	Z86243
	DIP	40			**Z8674312PSC**		Z86E4400ZDP		2 Comparators	
	PLCC	44			**Z8674312VSC**		Z86E4400ZDV		236 RAM + 32 I/O + POR	
	QFP	44	0/70	XTAL	**Z86E2112FSC**	4.5V - 5.5V	Z86E2101ZDF	Z86C1200ZEM	2 Timers + UART + WDT	Z86C21
	DIP	40			**Z86E2112PSC**		Z86E2301ZDP		8 Open Drain Outputs	
	PLCC	44			**Z86E2112VSC**		Z86E2101ZDV		236 RAM + 32 I/O	
16K	DIP	28	-40/105	Selectable	**Z86E134PZ016EC**[1]	3.0V - 5.5V	ZICSP000100ZDP	Z86C3600ZEM	UART + 2 Comparators	Z86C34
			0/70		**Z86E134PZ016SC**			+	ICSP OTP Programming	
	SOIC	28	-40/105		**Z86E134SZ016EC**[1]		ZICSP000300ZDS	ZLGICSP0100ZPR	2 Timers + 237 RAM	
			0/70		**Z86E134SZ016SC**				24 I/O + WDT + POR	
	DIP	40	-40/105	Selectable	**Z86E144PZ016EC**[1]		ZICSP000400ZDP	Z86C3600ZEM	UART + 2 Comparators	Z86C44
	0/70				**Z86E144PZ016SC**			+	ICSP OTP Programming	
	QFP	44	-40/105		**Z86E144FZ016EC**		ZICSP000600ZDF	ZLGICSP0100ZPR	2 Timers + 236 RAM,	
			0/70		**Z86E144FZ016SC**				32 I/O + WDT + POR	
	DIP	28	0/70	Selectable	**Z86E3412PSC**	3.5V - 5.5V	Z86E3400ZDP	Z86CCP01ZEM**	2 Timers + WDT	Z86C34
	SOIC				**Z86E3412SSC**		Z86E3400ZDS	(Must be modified	2 Comparators	
	PLCC				**Z86E3412VSC**		Z86E3400ZDV	see website)	237 RAM + 24 I/O + POR	
	QFP	44	0/70	Selectable	**Z86E4412FSC**		Z86E4400ZDF	or	2 Timers + WDT	Z86C44
	DIP	40			**Z86E4412PSC**		Z86E4400ZDP	Z86C5000ZEM	2 Comparators	
	PLCC	44			**Z86E4412VSC**		Z86E4400ZDV		236 RAM + 32 I/O + POR	
	QFP	44	0/70	XTAL	**Z86E6116FSC**	4.5V - 5.5V	Z86E2101ZDF	Z86C1200ZEM	2 Timers + UART	Z86C61
	DIP	40			**Z86E6116PSC**		Z86E2301ZDP		236 RAM + 32 I/O	
	PLCC	44			**Z86E6116VSC**		Z86E2101ZDV			
	QFP	44	0/70	Selectable	**Z86E7216FSC**		Included With Emulator	Z86L7103ZEM	2 Adv. Timers + WDT	Z86C72
	PDIP	40			**Z86E7216PSC**				2 Comparators	
	PLCC	44			**Z86E7216VSC**				738 RAM +31 I/O	
32K	DIP	28	-40/105	Selectable	**Z86E135PZ016EC**[1]	3.0V - 5.5V	ZICSP000100ZDP	Z86C3600ZEM	UART + 2 Comparators	Z86C35
			0/70		**Z86E135PZ016SC**			+	ICSP OTP Programming	
	SOIC	28	-40/105		**Z86E135SZ016EC**[1]		ZICSP000300ZDS	ZLGICSP0100ZPR	2 Timers + 237 RAM,	
			0/70		**Z86E135SZ016SC**				24 I/O + WDT + POR	
	DIP	40	-40/105	Selectable	**Z86E145PZ016EC**[1]		ZICSP000400ZDP	Z86C3600ZEM	UART + 2 Comparators	Z86C45
	0/70				**Z86E145PZ016SC**			+	ICSP OTP Programming	
	QFP	44	-40/105		**Z86E145FZ016EC**		ZICSP000600ZDF	ZLGICSP0100ZPR	2 Timers + 236 RAM,	
			0/70		**Z86E145FZ016SC**				32 I/O + WDT + POR	
	QFP	44	0/70	XTAL	**Z86E6316FSC**	4.5V - 5.5V	Z86E2101ZDF	Z86C1200ZEM	2 Timers + UART	Z86C63
	DIP	40			**Z86E6316PSC**		Z86E2301ZDP		236 RAM + 32 I/O	
	PLCC	44			**Z86E6316VSC**		Z86E2101ZDV			
	PDIP	40	0/70	Selectable	**Z86D7308PSC**	2.0V - 3.6V	Included With Emulator	Z86L9800ZEM	2 Adv. Timers + WDT	Z86L87 (16K ROM)
	PLCC	44			**Z86D7308VSC**				2 Comparators	Z86L89 (24K ROM)
									236 RAM + 31 I/O	Z86L73 (32K ROM)
	PDIP	28	0/70	Selectable	**Z86D8608PSC**		Included With Emulator	Z86L9800ZEM	2 Adv. Timers + WDT	Z86L82 (4K ROM)
	SOIC	28			**Z86D8608SSC**				2 Comparators	Z86L85 (8K ROM)
									236 RAM + 23 I/O	Z86L88 (16K ROM)
										Z86L81 (24K ROM)
										Z86L86 (32K ROM)
	SSOP	48	0/70	Selectable	**Z86D990HZ008SC**	3.0V - 5.5V	TBD	Z86L9900100ZEM	2 Adv. Timers + 1GPTimer	Z86L990
	PDIP	40			**Z86D990PZ008SC**		Included With Emulator		WDT + 2 Comparators	(16K ROM)
									4 Ch 8-bit ADC	
									489 RAM + 32 I/O	
	PDIP	28	0/70	Selectable	**Z86D991PZ008SC**		Included With Emulator		2 Adv. Timers + 1GPTimer	Z86L991
	SOIC	28			**Z86D991SZ008SC**				WDT + 2 Comparators	(16K ROM)
									4 Ch 8-bit ADC	
									489 RAM + 23 I/O	
	QFP	44	0/70	Selectable	**Z86E7316FSC**	4.5V - 5.5V	Included With Emulator	Z86L7103ZEM	2 Adv. Timers + WDT	Z86C88
	PDIP	40			**Z86E7316PSC**				2 Comparators	(16K ROM)
	PLCC	44			**Z86E7316VSC**				236 RAM + 31 I/O	
64K	DIP	28	-40/105	Selectable	**Z86E136PZ016EC**[1]	3.0V - 5.5V	ZICSP000100ZDP	Z86C3600ZEM	UART + 2 Comparators	Z86C36
			0/70		**Z86E136PZ016SC**			+	ICSP OTP Programming	
	SOIC	28	-40/105		**Z86E136SZ016EC**[1]		ZICSP000300ZDS	ZLGICSP0100ZPR	2 Timers + 237 RAM	
			0/70		**Z86E136SZ016SC**				24 I/O + WDT + POR	
	DIP	40	-40/105	Selectable	**Z86E146PZ016EC**[1]		ZICSP000400ZDP	Z86C3600ZEM	UART + 2 Comparators	Z86C46
	0/70				**Z86E146PZ016SC**			+	ICSP OTP Programming	
	QFP	44	-40/105		**Z86E146FZ016EC**		ZICSP000600ZDF	ZLGICSP0100ZPR	2 Timers + 236 RAM,	
			0/70		**Z86E146FZ016SC**				32 I/O + WDT + POR	

[1] Extended Temperature Device will be available in Q4 2000.

* **Selectable Oscillator means Crystal or RC can be chosen**

** **The Z86CCP01ZEM is rated at 12 MHz. For speed above 12 MHz, use the Z86C5000ZEM emulator. For Z86C06 SPI Emulation, use the Z86C5000ZEI**

*** **ROM device has 16K internal Program Memory.**

**** **ROM device has 16K internal Program Memory. External program & data memory access should start from 16K (address = 4000H)**

\+ The Z86CCP01ZEM is used only for programming the EPROM version, and the Z86K1500ZEM is used only for emulation of this part.

++ The Z86CCP01ZEM is used only for programming the EPROM version, and the Z86U1800ZEM is used only for emulation of this pa

DESCRIPTION OF Z8 ADAPTERS

Z86CCP00ZAC:	28 / 40-Pin DIP Accessory Kit Z86CCP01Z	Z86E2101ZDF:	44-Pin QFP to 40-Pin DIP Adapter	Z86C4001ZDV:	44-Pin PLCC to 40-Pin DIP Adapter
Z86C3000ZAC:	28-Pin SOIC/PLCC Accessory Kit for Z86C	Z86E2101ZDV:	44-Pin PLCC to 40-Pin DIP Adapter	Z86E4001ZDV:	44-Pin PLCC to 40-Pin DIP Adapter
Z86E0601ZDP:	18-Pin SOIC to 18-Pin DIP Adapter	Z86E3400ZDP:	28-Pin DIP to 18-Pin DIP Adapter	Z86E8300ZDP:	28-Pin DIP to 28-Pin DIP Adapter
Z86E0700ZDP:	18-Pin SOIC to 18-Pin DIP Adapter	Z86E3400ZDS:	28-Pin SOIC to 18-Pin DIP Adapter	Z86E8300ZDS:	28-Pin SOIC to 28-Pin DIP Adapter
Z86E0800ZDH:	20-Pin SSOP to 18-Pin DIP Adapter	Z86E3400ZDV:	28-Pin PLCC to 18-Pin DIP Adapter	Z86E8300ZDV:	28-Pin PLCC to 28-Pin DIP Adapter
Z86E1500ZDP:	40-Pin DIP Adapter	Z86E4400ZDF:	44-Pin QFP to 18-Pin DIP Adapter	Z8E00101ZDH:	20-Pin SSOP to 18-Pin DIP (Z8ICE) Adapter
ZLGICSP0100ZF	ICSP Programmer for Z8 MUZE Family	Z86E4400ZDP:	40-Pin DIP to 18-Pin DIP Adapter	Z8PE0030000ZDP:	Z8ICE000ZEM & Z8ICE010ZEM Upgrade Kit
ZICSP000100ZD	28-Pin DIP Programming Adapter for ICSP	ZICSP000400ZDP:	40-Pin DIP Programming Adapter for ICSP Programmer		
ZICSP000300ZD	28-Pin SOIC Programming Adapter for ICS	ZICSP000600ZDF:	QFP Programming Adapter for ICSP Programmer		

Automotive Rear Sonar

Submitted by: R. Hugo Vieira Neto and Francisco Eugenio Mauro

Abstract

The Automotive Rear Sonar is intended for automotive use. It is simple, effective, and inexpensive. Designed with a ZiLOG Z8 OTP microcontroller, this device measures the distance between the vehicle and any obstacle when in reverse gear. The driver is informed when a collision is about to occur.

The sonar utilizes a pair of ultrasonic transducers to send and receive 40-kHz wave bursts. The goal is to measure the time of flight of the ultrasonic burst if an echo occurs.

A Z86E08 microcontroller running at 8 MHz acts as the system control block. Some of the Z86E08s key features are:

- Short instruction execution times (generation of the 40-kHz ultrasonic signal by software)
- Onboard analog comparators (making ultrasonic detection simple and inexpensive)
- Onboard counter/timers with prescalers (making ultrasonic wave time-of-flight easy to measure)

Ultrasonic waves are strongly attenuated along their propagation in the air. That makes their detection quite difficult as distance increases. In order to achieve feasible detection, the transmitter is given as much power as possible, and the receiver circuit is furnished enough sensitivity to detect small-echo signals.

The transmitter driver is responsible for the excitation of the ultrasonic transmitter. For maximum output power, an H-bridge amplifier configuration is used to drive the transducer that is controlled by a pair of I/O pins of the Z8 port P2.

One of the Z8's onboard analog comparators implements the receiver detector. To adequately bias the comparator inputs, a resistive network is connected to the Z8 port P3, which features a sensitivity adjustment for the output amplitude of the receiver transducer.

Another transmitter driver circuit is implemented on another pair of I/O pins on port P2. A receiver detector is implemented using the other available analog comparator input on port P3. The resulting pair of ultrasonic transmitters and receivers is mechanically mounted on the left and right sides of the car's rear bumper for more safety.

A low-power voltage regulator IC supplies the 5 volts required by the Z8 from the vehicle's 12-volt battery. The car's reverse gear light circuit can also supply power, so that the sonar would he turned on when in reverse gear only.

User feedback is performed visually by means of an LED and/or audibly by a piezoelectric buzzer.

Figure 1. Automotive Rear Sonar Block Diagram

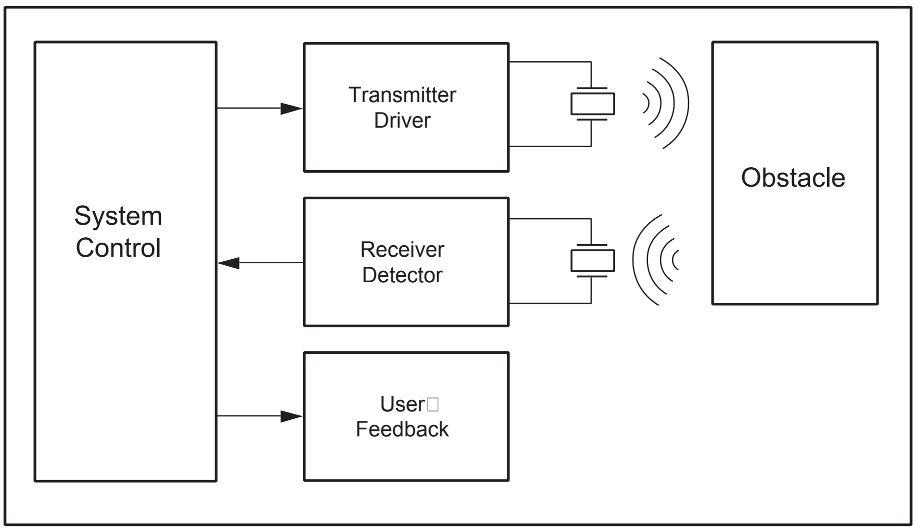
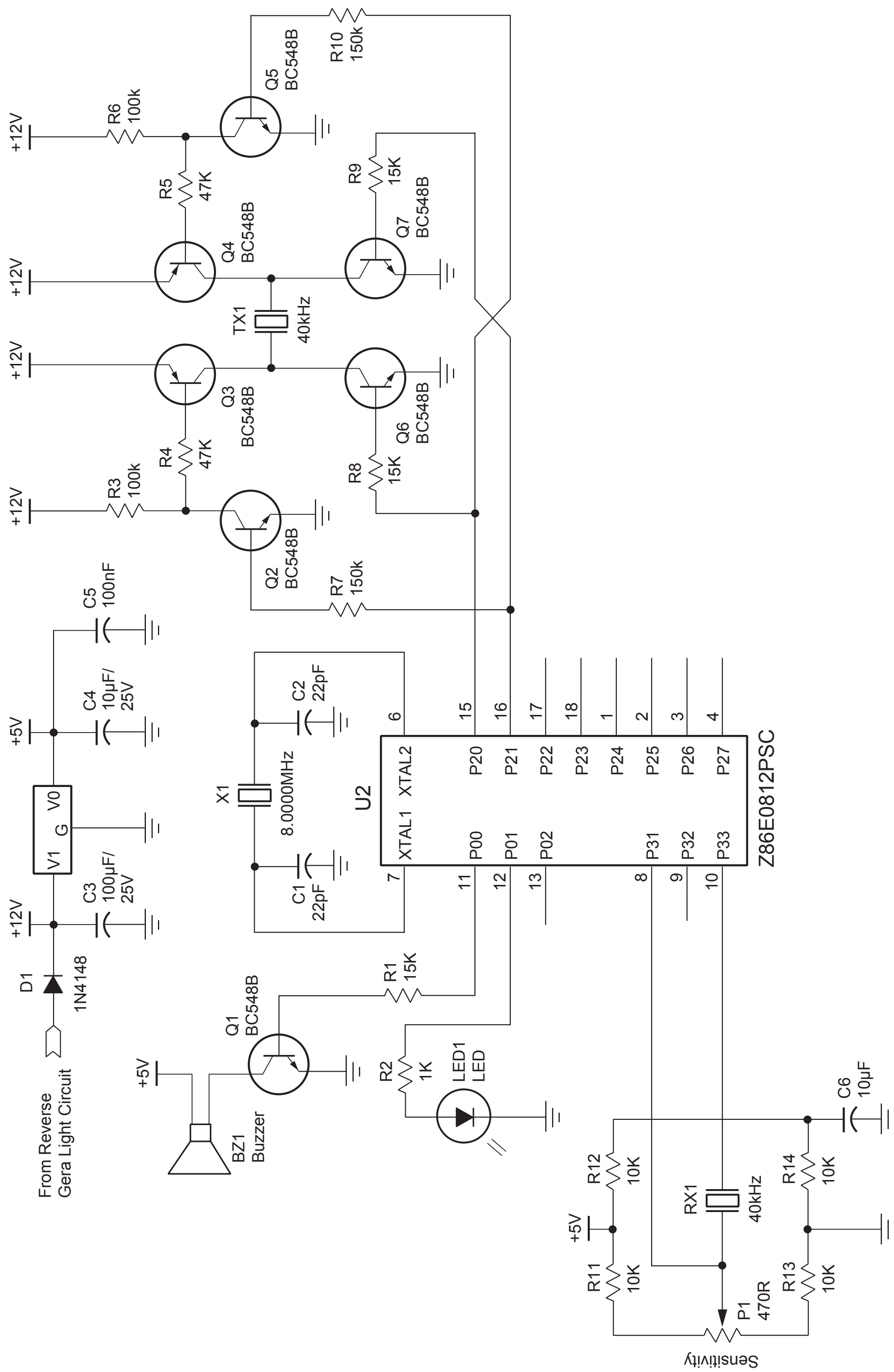


Figure 2. Automotive Rear Sonar Schematic Diagram



Automotive Speedometer, Odometer, and Tachometer

Submitted by: Niu Zhiming

Abstract

The automotive speedometer, odometer, and tachometer can provide the velocity, mileage, and rotational speed of an automobile engine. The central controlling unit is a Z86E04 microcontroller.

Air-Core (moving-magnet) meters are often favored over other movements as a result of their mechanical ruggedness. There are three basic pieces: a magnet and pointer attached to a freely-rotating axle, and two coils. Each coil is oriented at a right angle in respect to the other.

The air-core meter is voltage-driven. According to the measuring values of the automotive velocity and the engine rotational speed, ports P24, P25, P26, and P27 generate four PWM drive signals.

The only moving part is the axle assembly. The magnet aligns itself with the vector sum of the H field of each coil and extra magnetic fields, where H is the magnetic field strength vector.

Figure 3. Automotive Velometer, Mileometer, and Tachometer Block Diagram

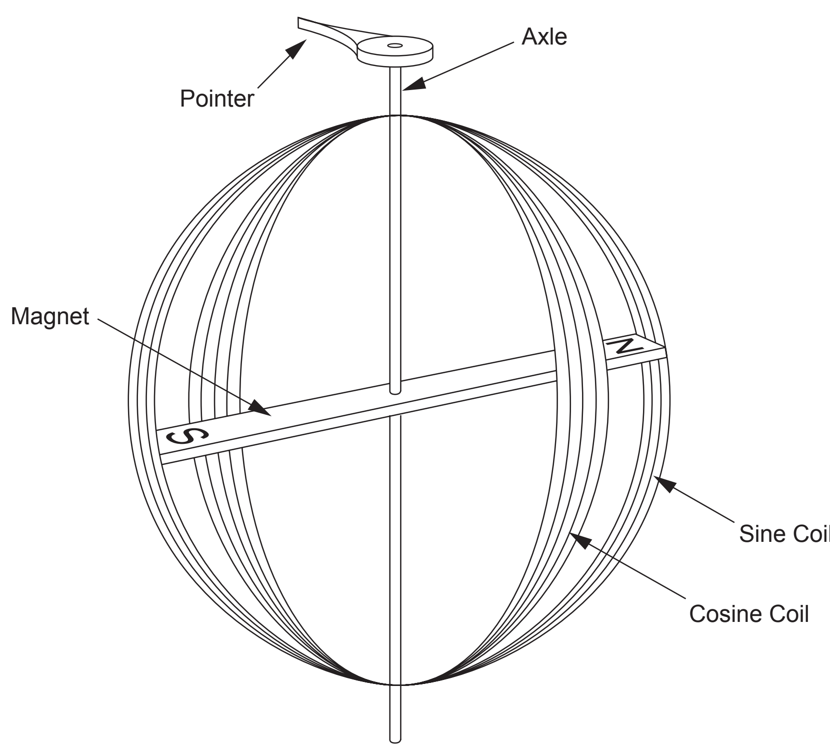
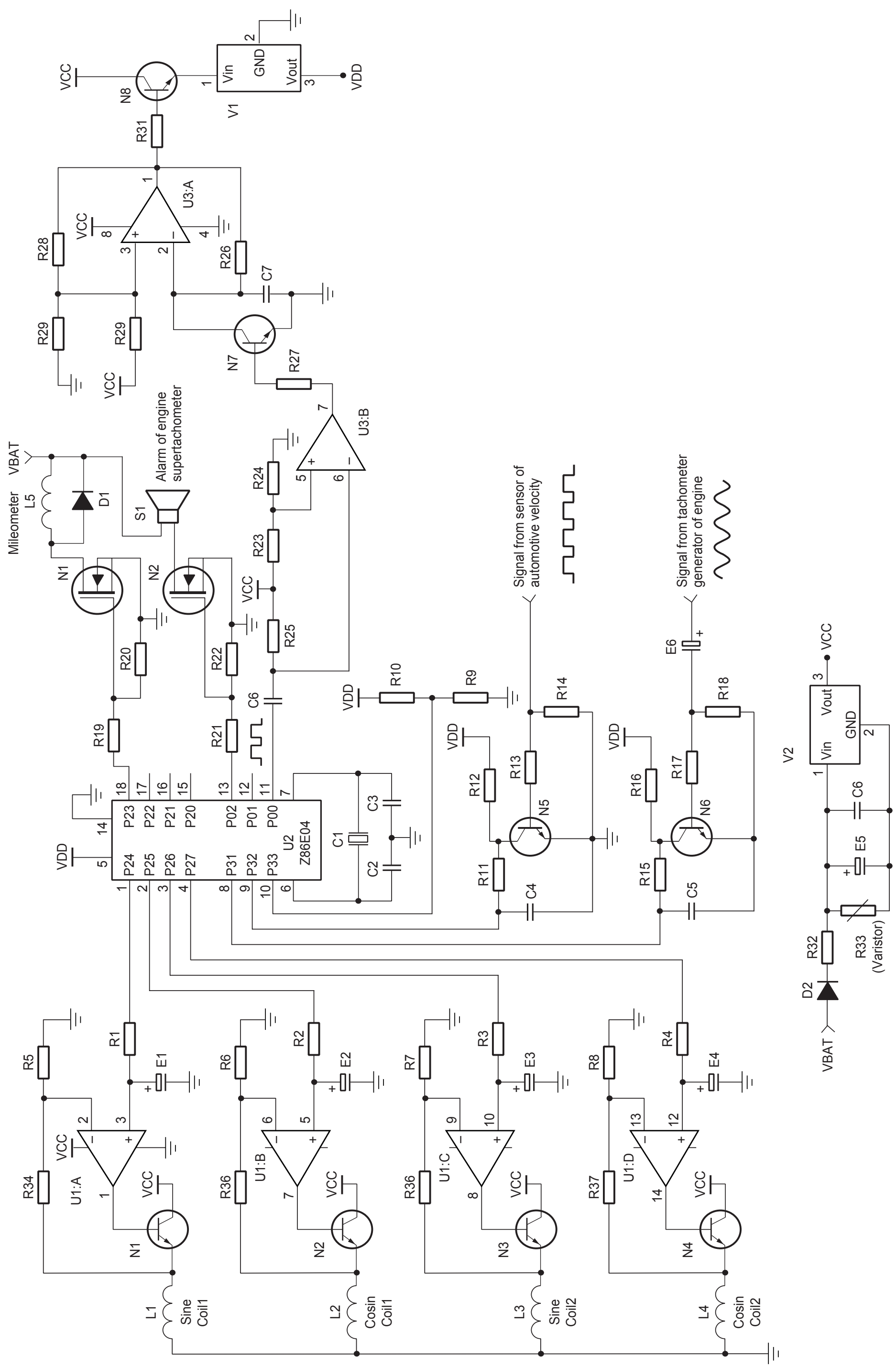


Figure 4. Automotive Velometer, Mileometer, and Tachometer Schematic Diagram



Autonomous Micro-Blimp Controller

Submitted by: Vadim Konradi

Abstract

This project utilizes multiple autonomous mobile nodes to interact via an infrared energy communications medium, with basic homing behavior and message passing. The implementation is micro-blimps, which are small, compact, and weight- and energy-efficient. Micro-blimps are generally one meter in length, with helium envelopes, pager-size motors driving propellers, IR transmitters, receivers, 3-DOF-drive system. The small size and low weight of Z8 microcontrollers and batteries also contributes to overall energy savings.

Consider a group of blimps, calmly buoyant near the ceiling like water beetles at the surface of the water. Suddenly, a prey object appears, drawing their attention. Each senses the infrared homing signal of the sender. They descend from the ceiling, each drawn to the sender, each recognizing and homing in on the signals emitted by each other's tails. The sender's signal is extinguished, and the blimps coalesce into self-organizing trains and nose-to-tail circles, following each other as they drift lazily back to the ceiling to perform again later.

U1 is a Z8 OTP from the General-Purpose Z8 Microcontroller family. Port 0 drives the propeller motors and addresses the bumper-switch matrix columns. Port 1 drives the resistor-summing junction, establishing the demodulation. Port 2 in open-drain mode selects mixer/demodulator channels, reads configuration switches to select operational modes, and addresses bumper-switch matrix rows. Port 3 inputs connect to the comparator system, measuring the mixer/demodulator output. Timer system outputs connect to Port 3, generating both modulated and reference carrier signals.

U2 operational amplifiers implement IR bandpass amplifiers. The U3 CMOS switch forms a mixer/demodulator. S1 sets options and S2–S5 are collision bumpers.

Figure 5. Autonomous Micro-Blimp Controller Block Diagram

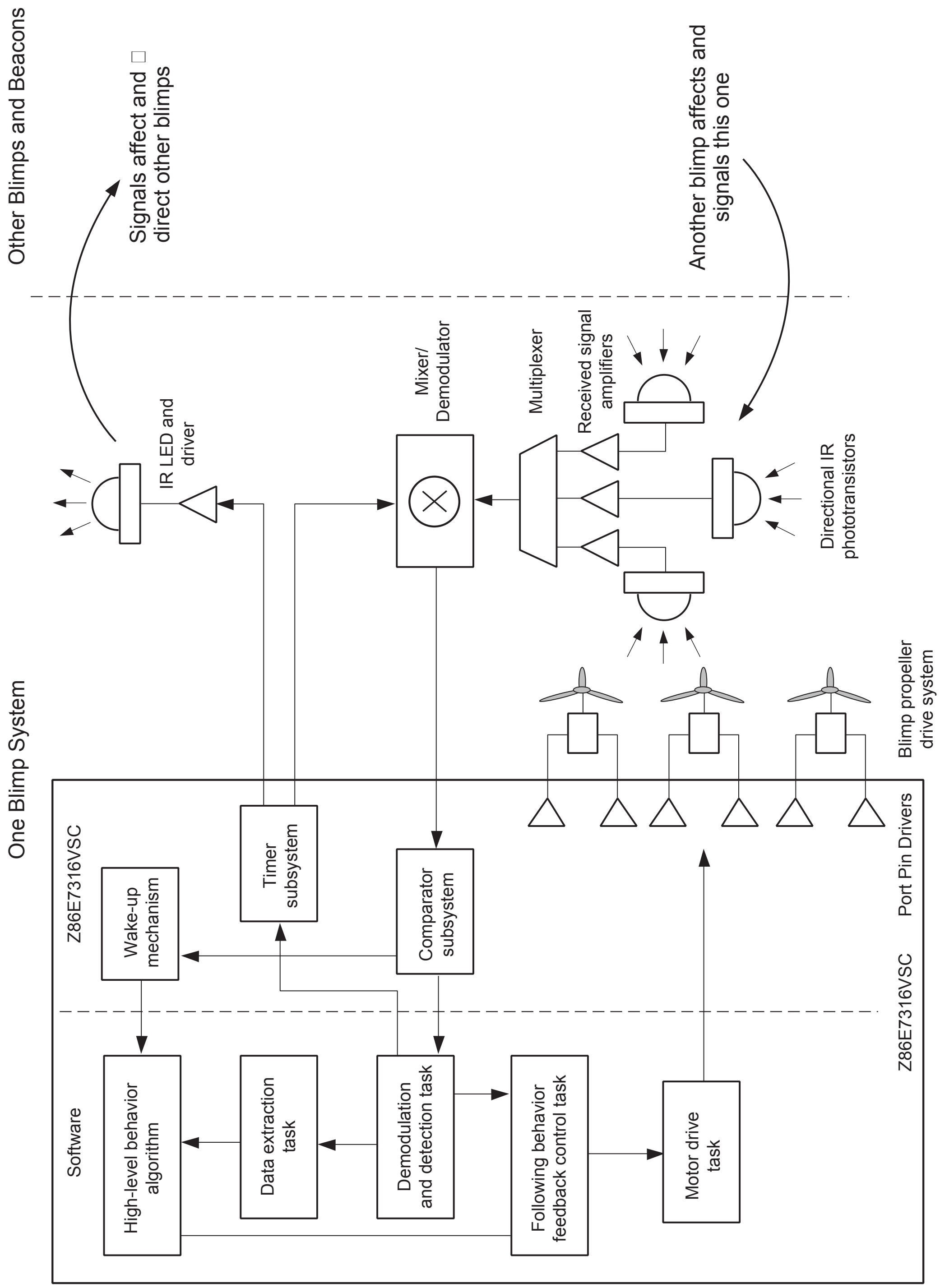
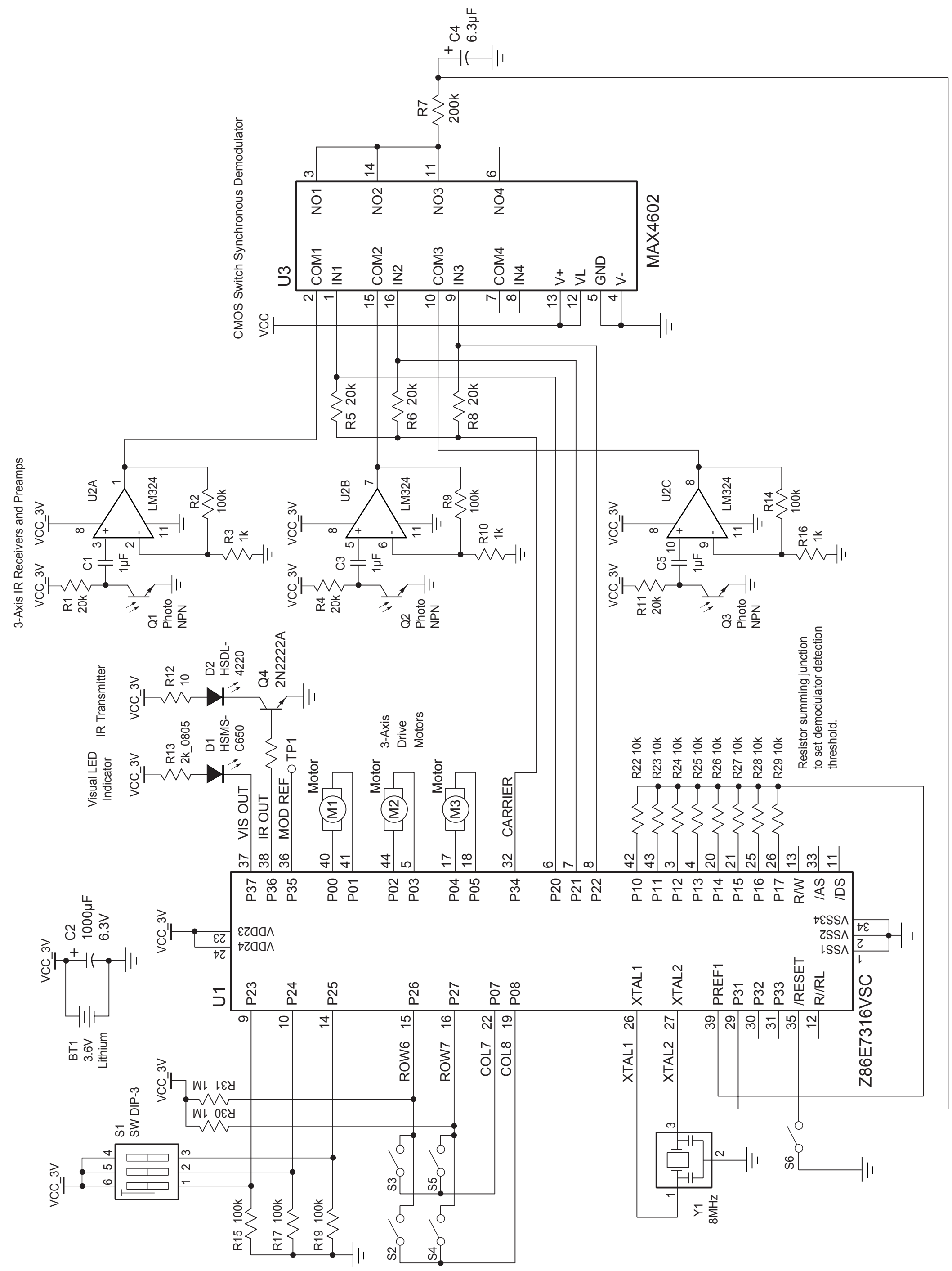


Figure 6. Autonomous Micro-Blimp Controller Schematic Diagram



Battery-Operated Door-Entry System

Submitted by: Steve Price

Abstract

The purpose of this Z8Plus-based system is to improve the security of an existing door. This simple low-cost entry system utilizes the Dallas Semiconductor D51990A iButton technology in addition to or instead of a conventional mechanical key. A battery system is preferred to eliminate complex wiring to the door.

The Z8Plus microcontroller is ideally suited to battery applications, due to its low quiescent current, which is typically 250 nA in STOP mode.

The Z8Plus is brought out of STOP mode by pressing the wake-up switch SW. This switch is an integral part of the iButton receptacle. The Z8Plus checks the battery voltage using a single on-chip comparator. The Z8Plus then looks for the presence of an iButton in the receptacle PL1. If an iButton is detected, then its 6-byte serial code is read via PB1 using a 1-wire power/data protocol.

iButton codes for up to 20 users can be stored in the EEPROM. The received code is checked against the table of stored codes in the EEPROM. If the correct code is found, the solenoid/actuator is activated for a short defined period that allows the door to be opened. The hi-color LED is green during this state. A flashing green warning indicates that battery voltage is low. At the end of this period, the peripherals are turned off and the Z8Plus returns to STOP mode.

Should the unit fail due to exhausted batteries, a provision exists to bring an emergency power terminal PL2 out to the front panel. A 9-volt battery can be connected between the power terminal and earth ground of the iButton receptacle, while a valid iButton is read. When the door is opened, the batteries can be replaced. A method of resetting the Z8Plus may also be required.

A predefined Master iButton places this system into LEARN mode. All user-button codes stored in the EEPROM are erased. The operator touches each new iButton within 10 seconds of each other, storing the new user-button codes into the system. The hi-color LED provides user feedback.

Monitoring of the battery supply rail is achieved using the on-chip comparator. A 5-volt reference is fed into one input of the comparator, while the other input monitors the battery rail via the potential divider R4 and R5. For the potential divider to function, the software must write a 0 to PB2. The resistor values provide a battery voltage of 6.5V that produces a 5-volt output from the potential divider. After the measurement, the software turns PB2 into an input that stops the current from flowing through the potential divider, thereby conserving current.

The solenoid must be chosen for the application, in addition to the values of the transistor TR1 and base resistor R8.

Figure 7. Battery-Operated Door-Entry System Block Diagram

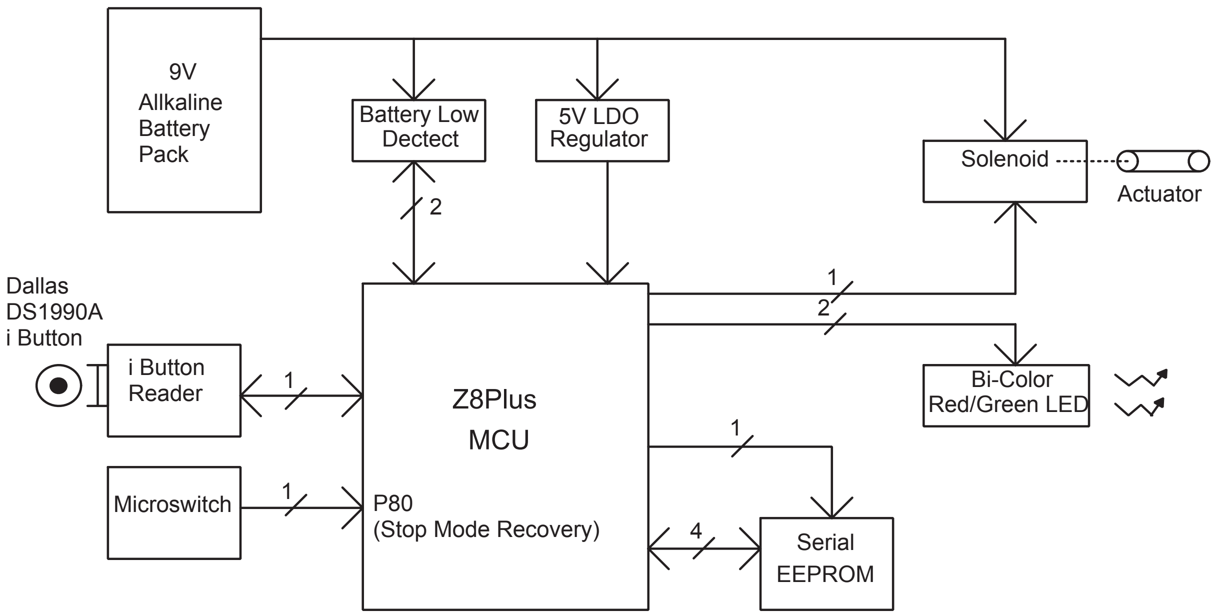
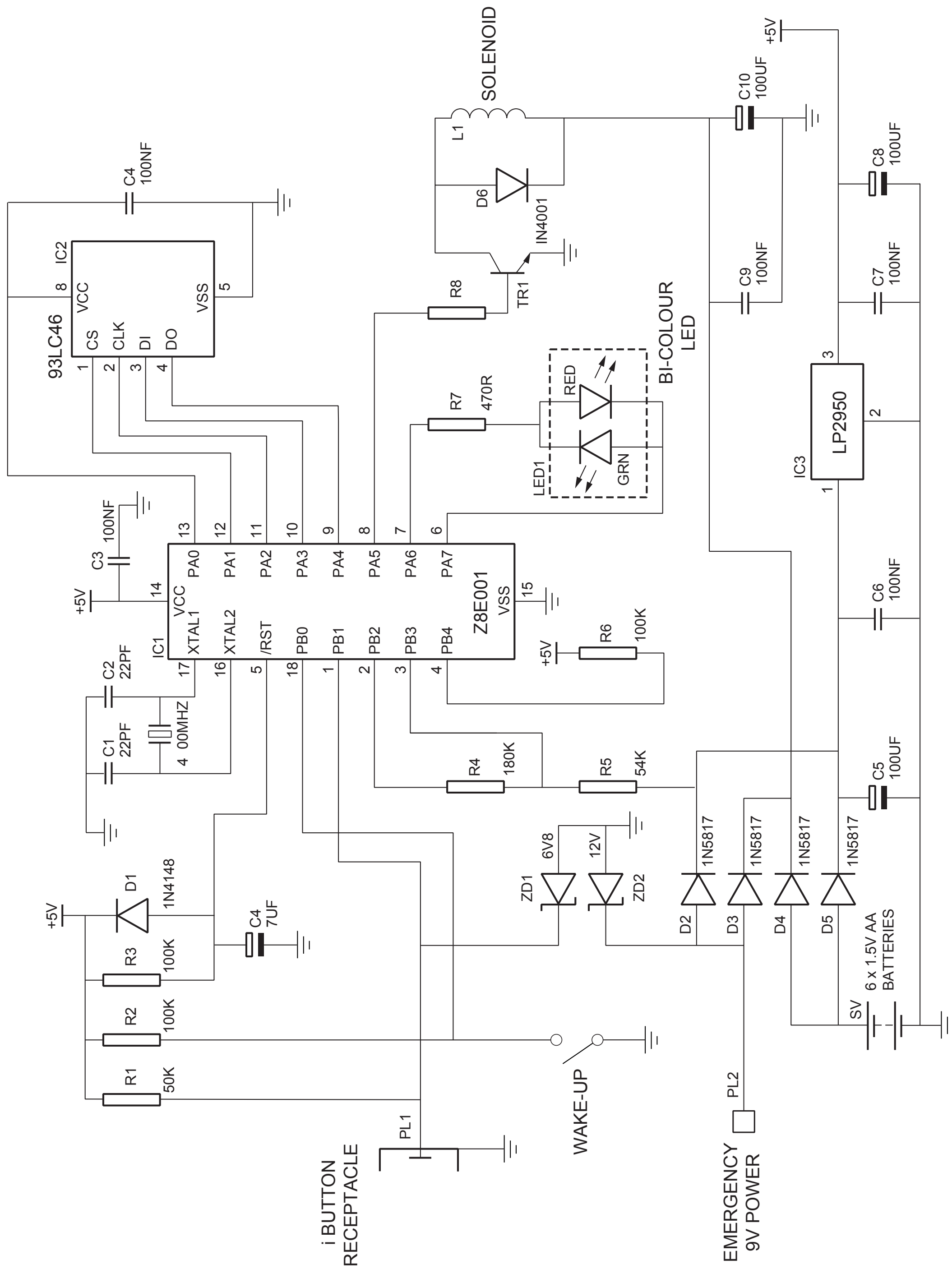


Figure 8. Battery-Operated Door-Entry System Schematic Diagram



The Crab

Submitted by: Andreas Voigt

Abstract

The Crab is an autonomous robot, featuring a low-cost design, and powered by three AA batteries, with motion provided by DC motors. Obstacle detection and bump switches are incorporated into the design. Speed and distance is monitored to facilitate vectored motion patterns that offer the ability to collect and move small objects. The robot features an LED, speaker, and wireless communication possibilities with other forms of life. Floor sensors are added to avoid accidental falls.

Infrared reflection sensors have proven their reliability. One standard for DC motor drive is an H-bridge, which is controlled by the PWM. Counting index holes in wheels allows the Crab to compute speed and distance. Wireless communication is implemented via a standard TV remote- control receiver chip and 40-kHz pulses from the infrared LEDs (IRLEDs).

The Z86E31 was chosen because it is powerful and easy to use, and for its low-cost development using a ZiLOG CCP emulator and ZDS. Programming this chip in assembler language is easy. To keep costs as low as possible, one design rule is to use software to emulate hardware.

Transmit IRLEDs are placed on the bottom left and right in front of the Crab to produce floor sensors. Two IRLEDs look forward to detect obstacles. The mouth can capture small objects and hold them in place, as long as no backward motion is performed. One IRLED and a phototransistor monitor the operation of the mouth, forming a photointerrupter with an IRLED at the back, operating together as a beacon. The IR receiver chip is placed above the mouth. This chip is used for communication and as detector for 40-kHz pulses, generated by the IRLEDs and reflected by any object, even the floor, and also detecting TV remote controls and other crabs. The phototransistors to the front monitor ambient light.

The top layer of the software consists of the mood model, the behavior layer below. Both are state-machines, and the action layer, the one executing motion or sound commands, is based upon the subsumption architecture, introduced by Professor Rodney Brooks. Transitions can be triggered, for example, depending on perception changes or elapsed time.

The prototype exhibits all kinds of moods, and demands attention from time to time. It gets hungry (for light) and may get very depressed if not provided enough stimuli or attention. The Crab may even demonstrate suicidal actions—for example, jumping off the desk on purpose.

Figure 9. The Crab Block Diagram

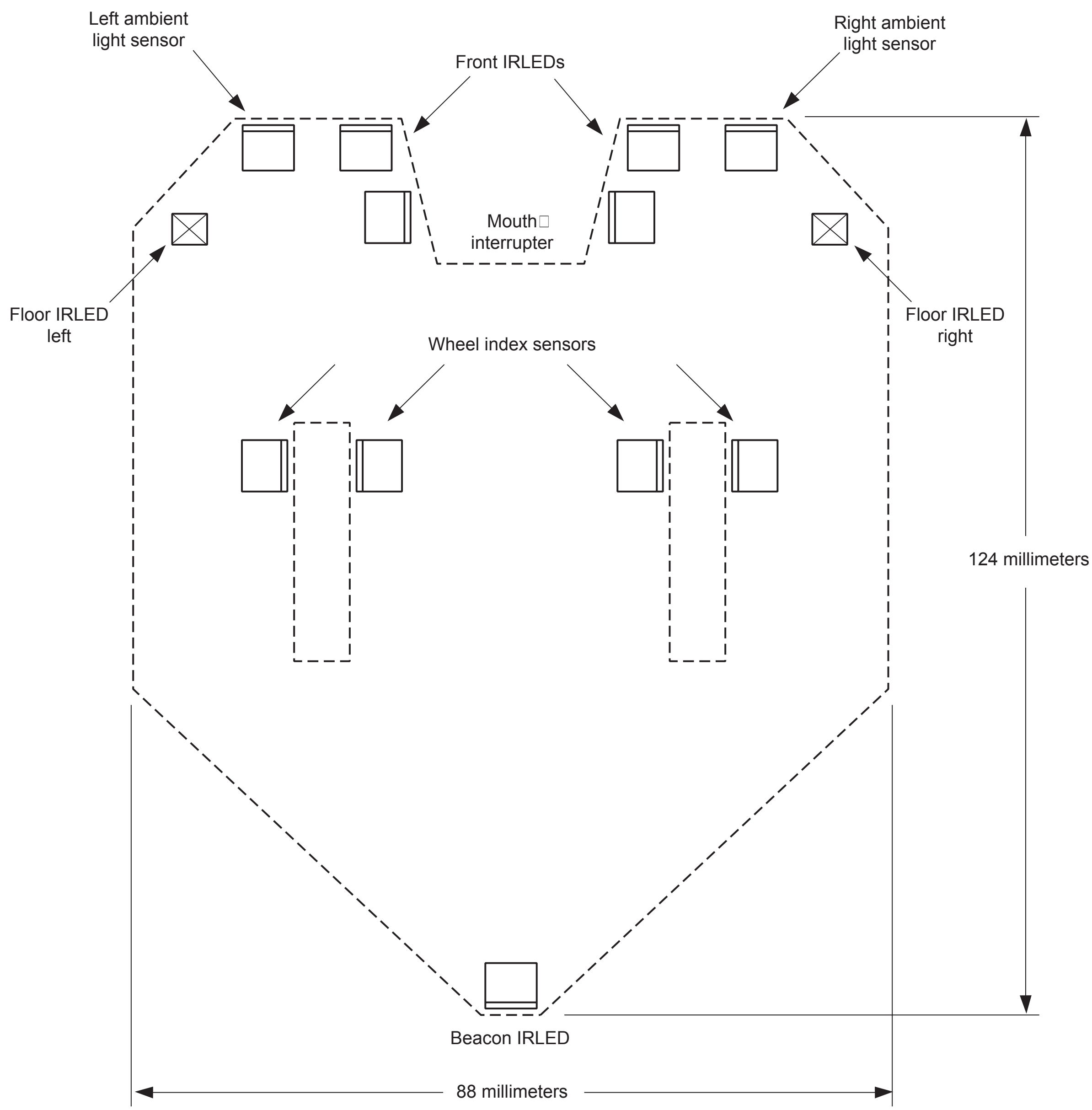
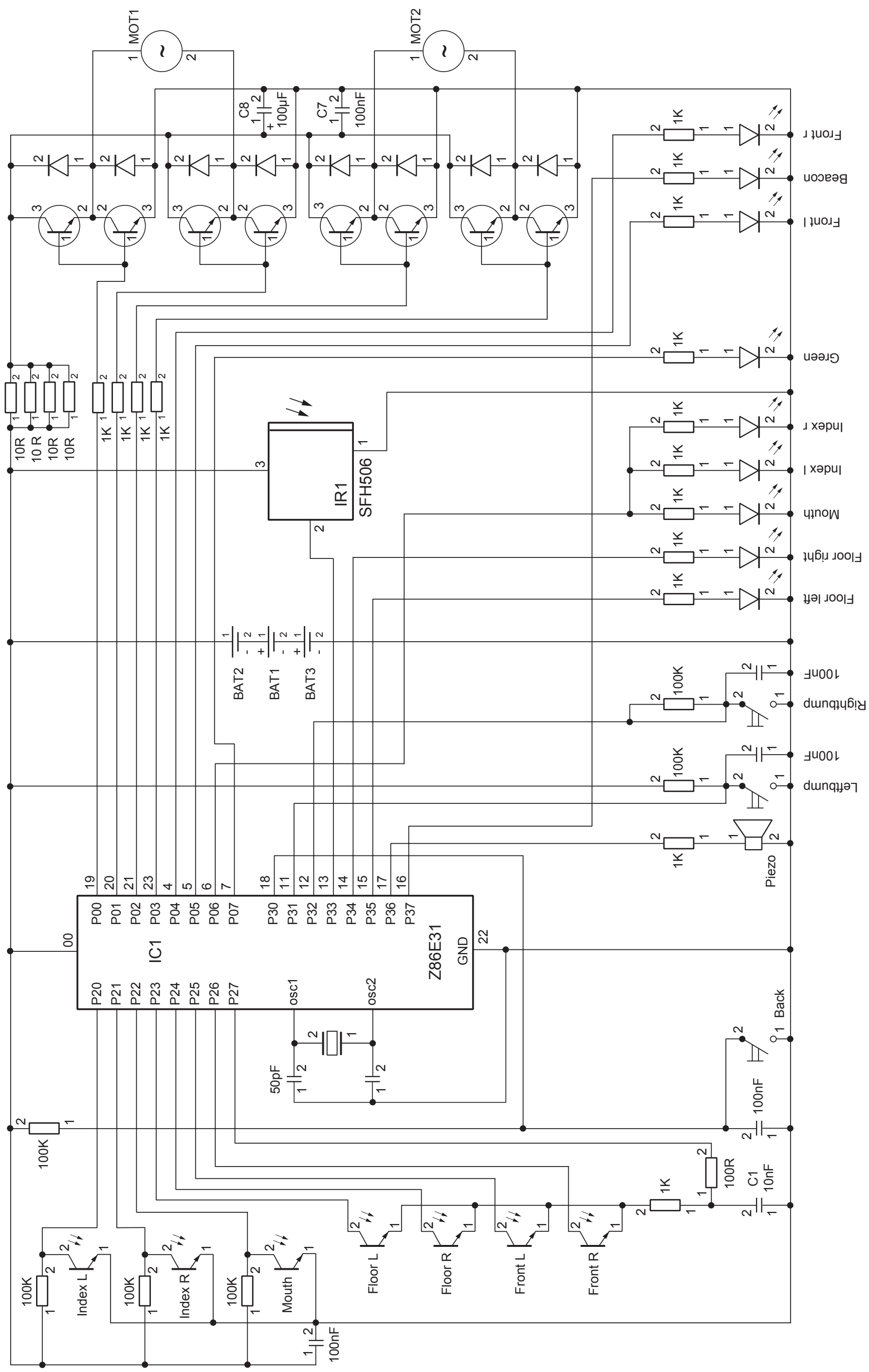


Figure 10. The Crab Schematic Diagram



Desktop Fountain

Submitted by: Don Deschane

Abstract

This project is a desktop-size pulsed water fountain with multiple jets. Each jet operates by quickly boiling a small amount of water at the bottom of a tube. The gas bubble created pushes the water in the tube a few inches up into the air. The same concept is used in coffee percolators and ink jet print heads. In this case, the largest jet is no more than 1 mm in diameter.

A Z8 microcontroller controls and monitors each jet individually, and causes an array of jets to pulse in various patterns and rhythms. Some jets point directly upwards, causing a splatter effect, while others are aimed at an angle, causing tubes or bubbles of water to fly up and follow a hyperbolic trajectory on the way back down into the fountain. Different incarnations of the product feature different numbers, sizes, and arrangement of jets and other options, such as underwater illumination and buttons to select patterns.

The heart of the fountain is the jet boiler, one per jet. The bottom surface contains a resistor, which heats up when power is applied. Water enters from the sides in one or more small tubes and exits primarily through the larger top opening when a steam bubble forms on the heaters. The microcontroller monitors the temperature of the heater in real time to determine when the bubble forms, and subsequently turns off the heater.

Each heating cycle begins with a cool temperature. When power is applied, the heater temperature increases gradually as the water warms, then quickly as the water boils and stops absorbing the heat. Power is turned off and as new water enters the chamber, the heater's temperature drops.

The heater temperature is measured using the Z8's A/D converter. The resistance varies with temperature. These changes are measured via the Z8 A/D converter connected to the jet's power drive sensor.

Each jet should fire in a fraction of a second, but with different size jets, the heating time probably is not consistent, so the Z8 firmware must schedule the start of heating properly so that each bubble forms at the correct time (especially important for simultaneous firings). This system can he fine-tuned using real-time operating information, which also compensates for variations in ambient water temperature, heater effectiveness, and power-supply voltage from unit to unit, over time.

Monitoring the jets can also detect when the fountain runs out of water, clogs up, or gets knocked over. If a heater heats up too quickly or fails to cool, the fountain shuts down.

Figure 11. Desktop Fountain Block Diagram

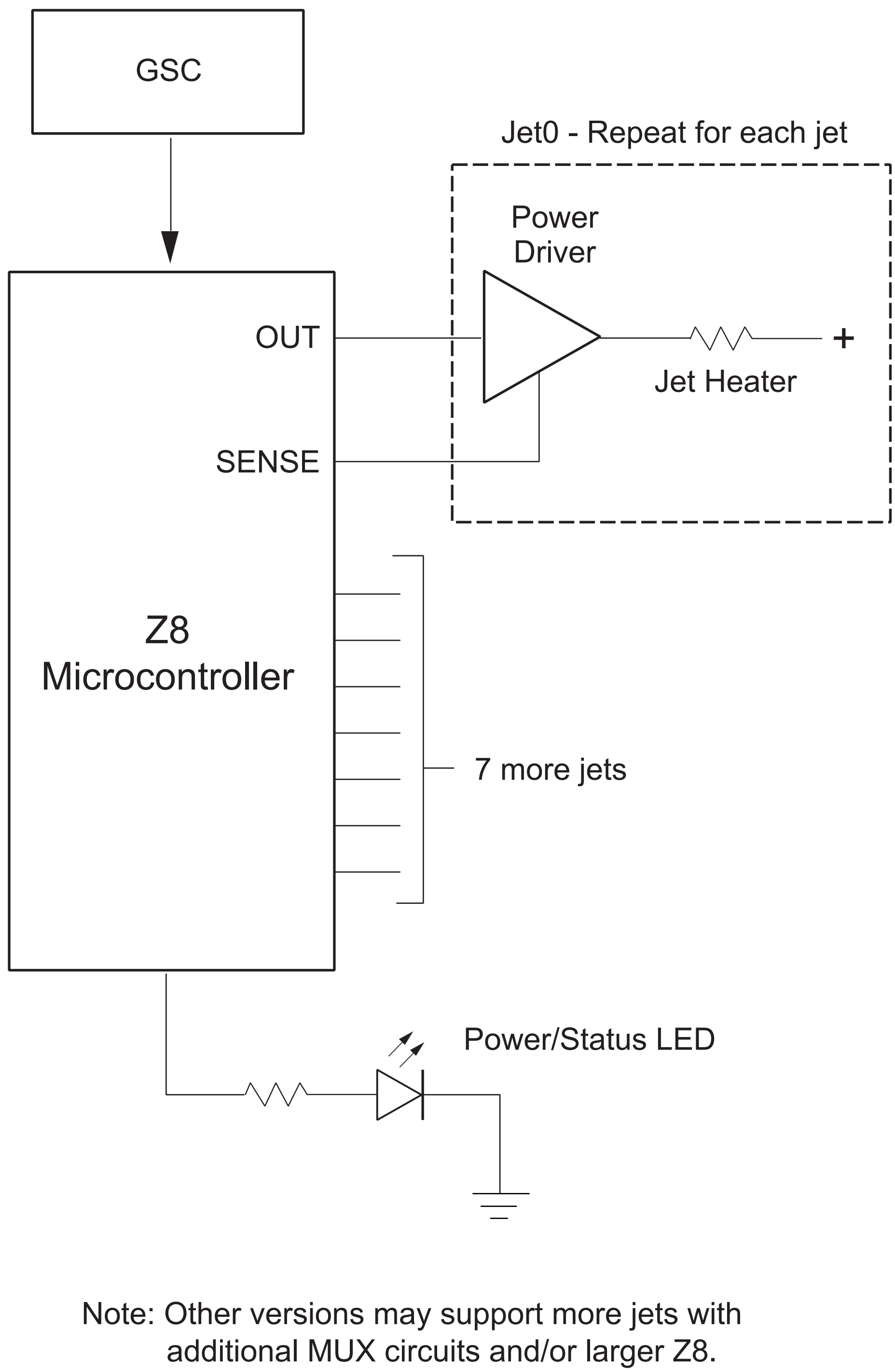
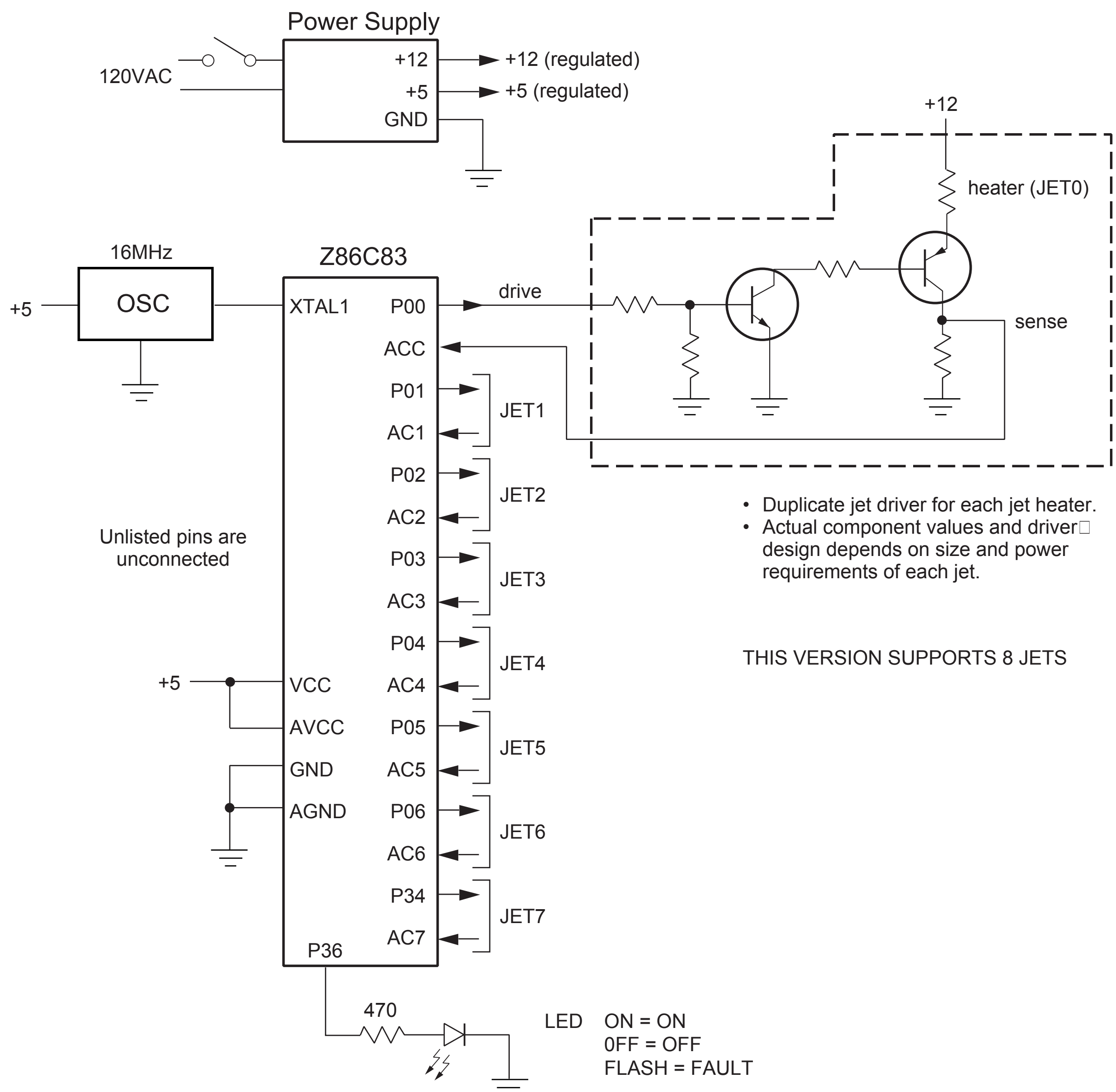


Figure 12. Desktop Fountain Schematic Diagram



DCF77 Clock

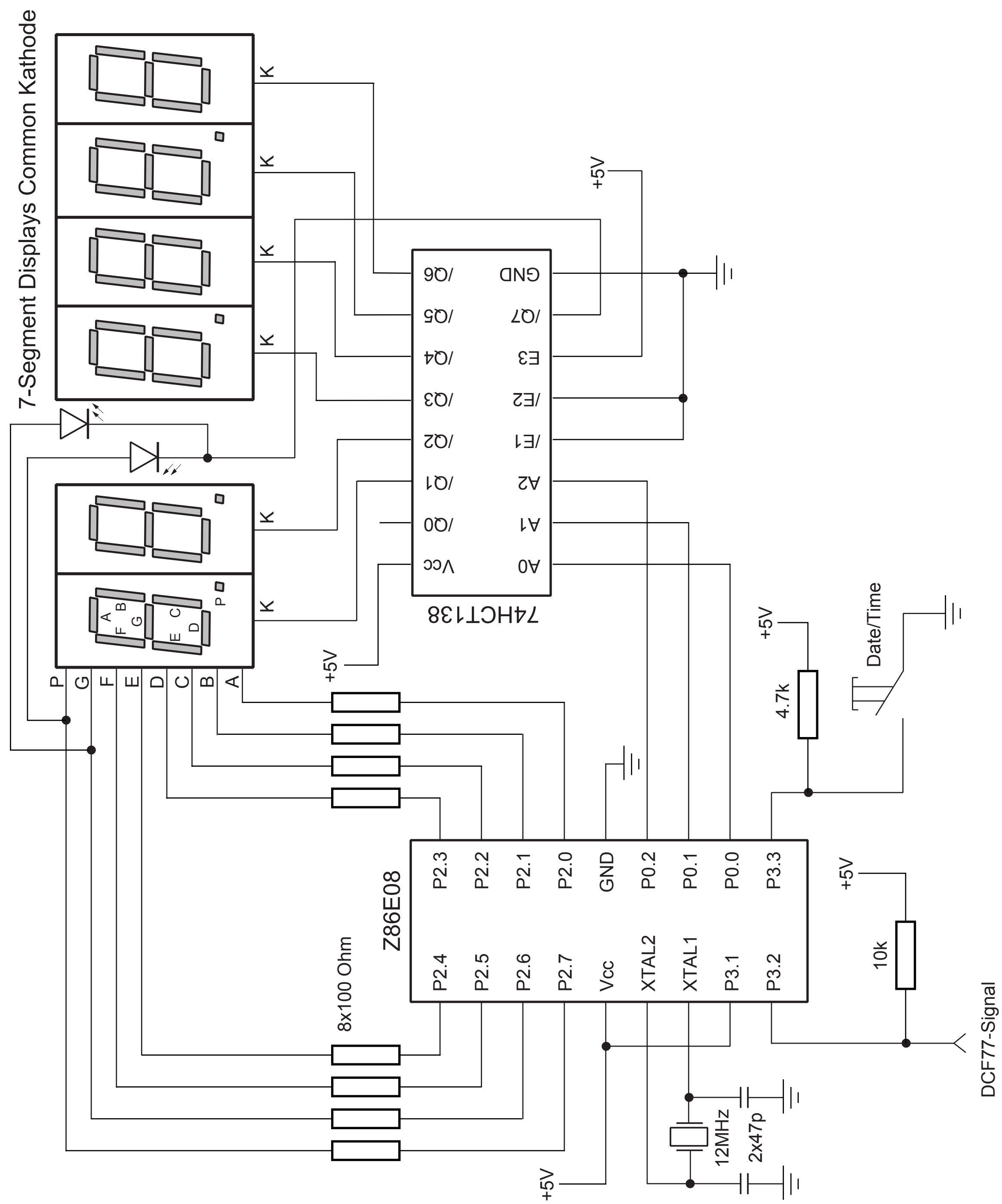
Submitted by: Andreas Richter

Abstract

This project describes a stand-alone clock. The clock uses a ZiLOG Z86E08, controlled by the DCF77 Time Radio Signal, which is used in Germany. The clock provides time functions to the exact second, and date functions (day, month, and year).

The display consists of a 6 x 7-segment LED display with a common cathode. By using the Z86E08, the hardware is reduced to a 74HC138 demultiplexer, resistors, and a DCF77 receiver (Conrad Electronics 64 1138). The software performs the display multiplexing, decodes the DCF77 signal, and generates a stand-alone clock. The clock is synchronized by the DCF77 signal.

Figure 13. DCF77 Clock Schematic Diagram



Diagnostic Compressor Protector

Submitted by: Mark E. Miller

Abstract

The majority of Heating, Ventilating, and Cooling (HVAC) system failures occur over a period of time. When a compressor fails to operate, it is usually after continuous operation while incurring a system fault. The product presented in this design is an early-warning device that monitors key parameters. It also functions as a compressor protector that inhibits operation in potentially damaging conditions such as electrical brown-outs, overheating, and overpressure. Using this device results in savings for the homeowner (minor repairs cost less than replacing a compressor), minimizes diagnostic time for the service person (diagnostic codes are output to several places), and reduces warranty returns to original equipment manufacturers (OEMs).

The control is a low-cost design that performs an anti-short cycle (ASC) function and diagnostics. The anti-short cycle operation is accomplished by monitoring when the compressor is being requested to run. After a run cycle completes, it is inhibited from running for 3–5 minutes, thereby allowing the pressure in the system to equalize before the run cycle starts again. As a diagnostic device, the control monitors the voltage, temperature, pressure, and vibration of a compressor's operation. A low threshold is established for each parameter to alert the owner that service is required prior to a catastrophic failure. A high threshold, also monitored, diagnoses fault conditions.

The most damaging system failures occur when more than one parameter goes out of range (an example would be high pressure and high temperature). Using triangulation of the fault parameters to lock out compressor operation reduces misdiagnosis and false lockouts.

The ZiLOG Z86C04/Z86C08 and Z86C03/Z86C06 microcontrollers lend themselves well to this design. The comparator inputs are invaluable for the analog inputs and are required for accurate thresholds. The programmable timer is also a key feature that is useful for some of the time-related thresholds. The ZiLOG pinout compatibility permits a single layout that can be populated in several ways, such as a low-cost minimum-protection device (Z86C03), an optional serial port for data logging/external interface (Z86C06), and added algorithms for extended compressor life (Z86C04/Z86C08).

Table 2. Sensor Inputs

Input Name	Low Threshold	High Threshold	Comments
24 VAC Control Voltage	The control voltage drops below 16 VAC	The control voltage is below 18 VAC and above 16 VAC	Monitors voltage to keep from operation during brownouts, eliminates contact chatter
Pressure Switch	The pressure switch cycles more than twice during six hours of run time	The pressure switch cycles more than five times during six hours of run time	Used to evaluate over-pressure conditions resulting from improper refrigerant charge or flow
Compressor Discharge Temperature	120ºF is the minimum discharge temperature; time below the threshold determines severity	250ºF is the maximum discharge temperature; time above threshold determines severity	Exceeding the threshold is early warning; duration and frequency determine severity
Vibration Sensor	A low-level threshold is set to monitor vibrations exceeding 10 G	Duration and frequency exceeding 10 G is used for high threshold	Ignored during startup and shut down periods

Figure 14. Diagnostic Compressor Protector Block Diagram

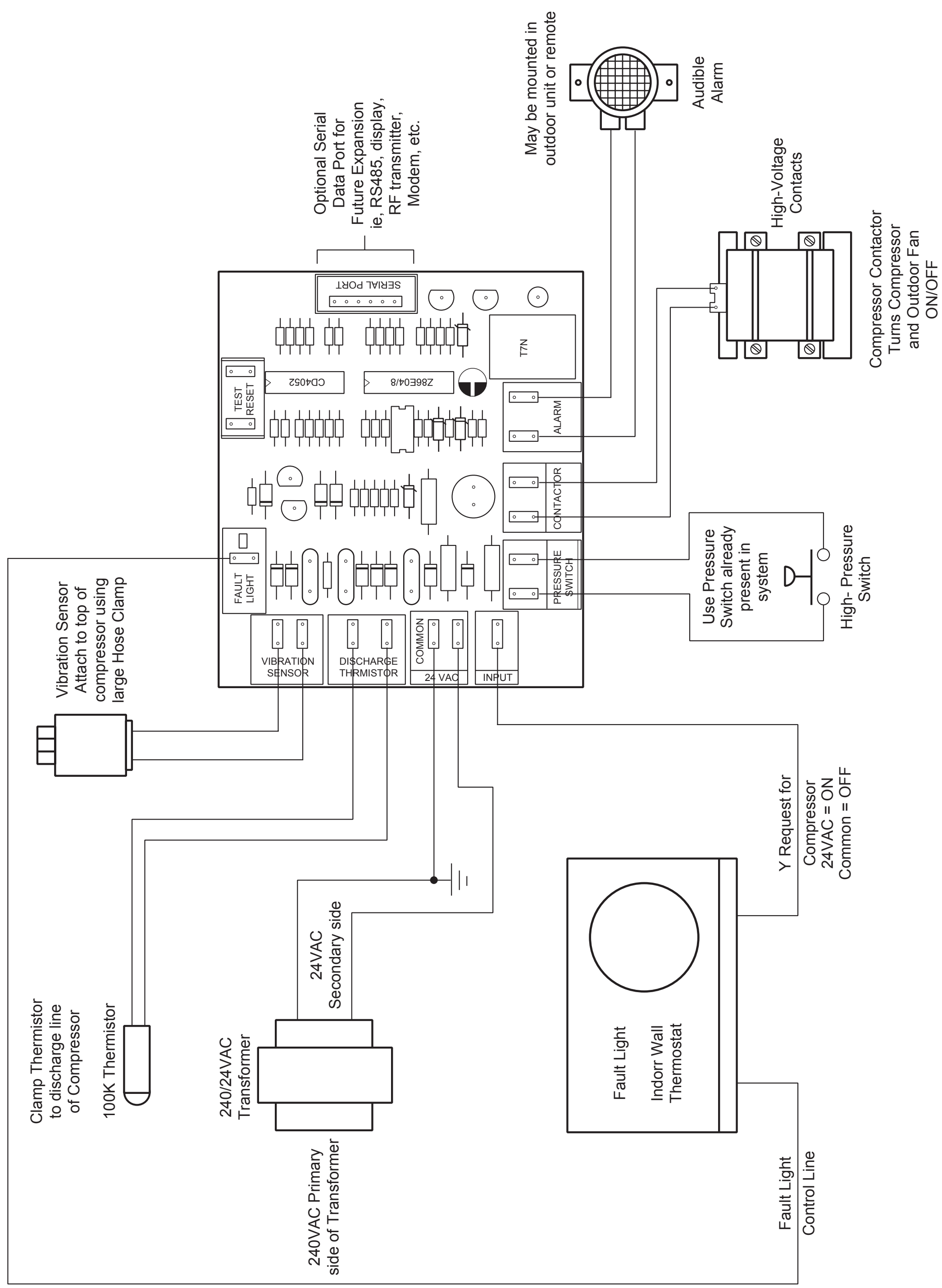
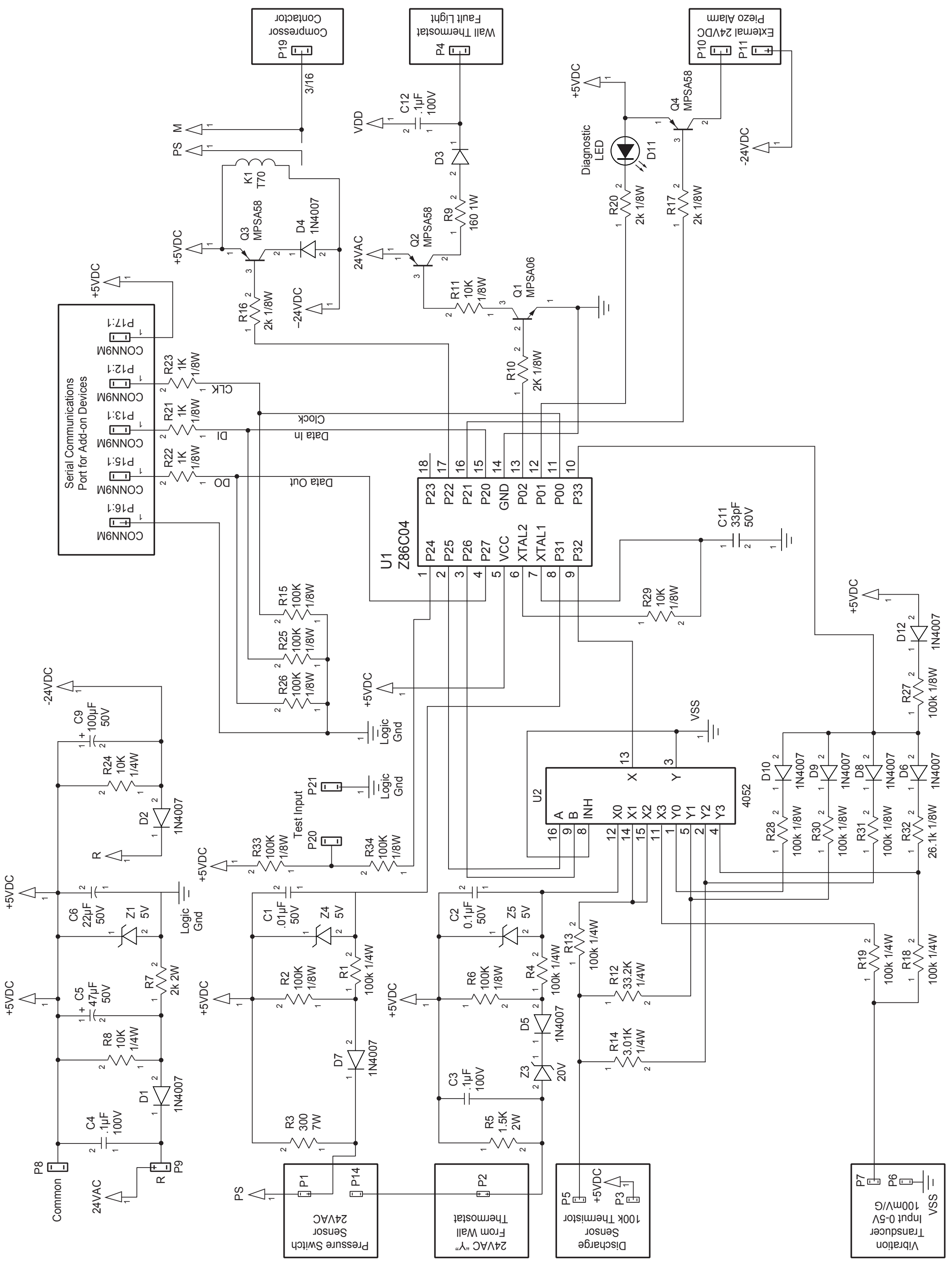


Figure 15. Diagnostic Compressor Protector Schematic Diagram



Digital Dimmer Box

Submitted by: R. Hugo Vieira Neto and Francisco Eugenio Mauro

Abstract

The Digital Dimmer Box is intended for stage illumination in theaters. It is simple and inexpensive. Designed with a ZiLOG Z8 OTP microcontroller, the device is completely compatible with older analog dimmer boxes and supports 4400-Watt loads.

In stage illumination, dimming of each incandescent lamp is controlled by an analog voltage (ranging from 0 to 10 volts) and is supplied by a remote console.

To achieve linear perception, a dimmer box should exhibit a nonlinear response to the control voltage. Older dimmer boxes employ analog processing for the task of compensation. The digital approach uses a simple software look-up table concept to implement response compensation. As a result, a dedicated external analog circuit is not required.

The system control block uses the Z86E08 microcontroller running at 12 MHz. Some of the Z86E08's key features are:

- Onboard counter/timers with prescalers (generation of phase-control signals)
- Onboard analog comparators (AC line zero-crossing detection and control voltage acquisition)
- ROM space (implementation of one or more look-up tables for visual response compensation)

To implement the A/D converter, an R-2R network is mounted on port P2. The output is used as the reference voltage (pin P33) for the Z8's onboard analog comparators on port P3. The analog control voltage is connected to the first analog comparator input (pin P31) and the A/D conversion is completed by software using a successive approximation technique.

The counter/timer generates a time delay between the zero-crossing of the line voltage and the TRIAC's triggering pulse. As a result, power is delivered to the load. At 12 MHz, it is possible to achieve delays from 0 to 8.33 ms with the correct settings of the counter/timer prescaler, which corresponds to the phase-triggering range for an AC line frequency of 60 Hz.

Figure 16. Digital Dimmer Box Block Diagram

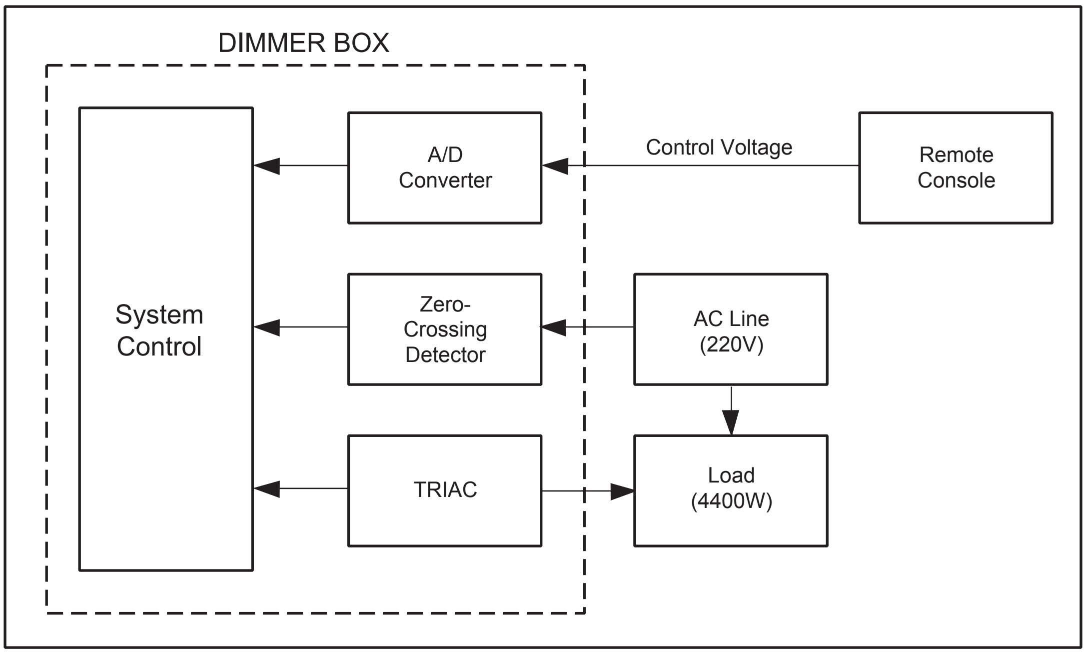
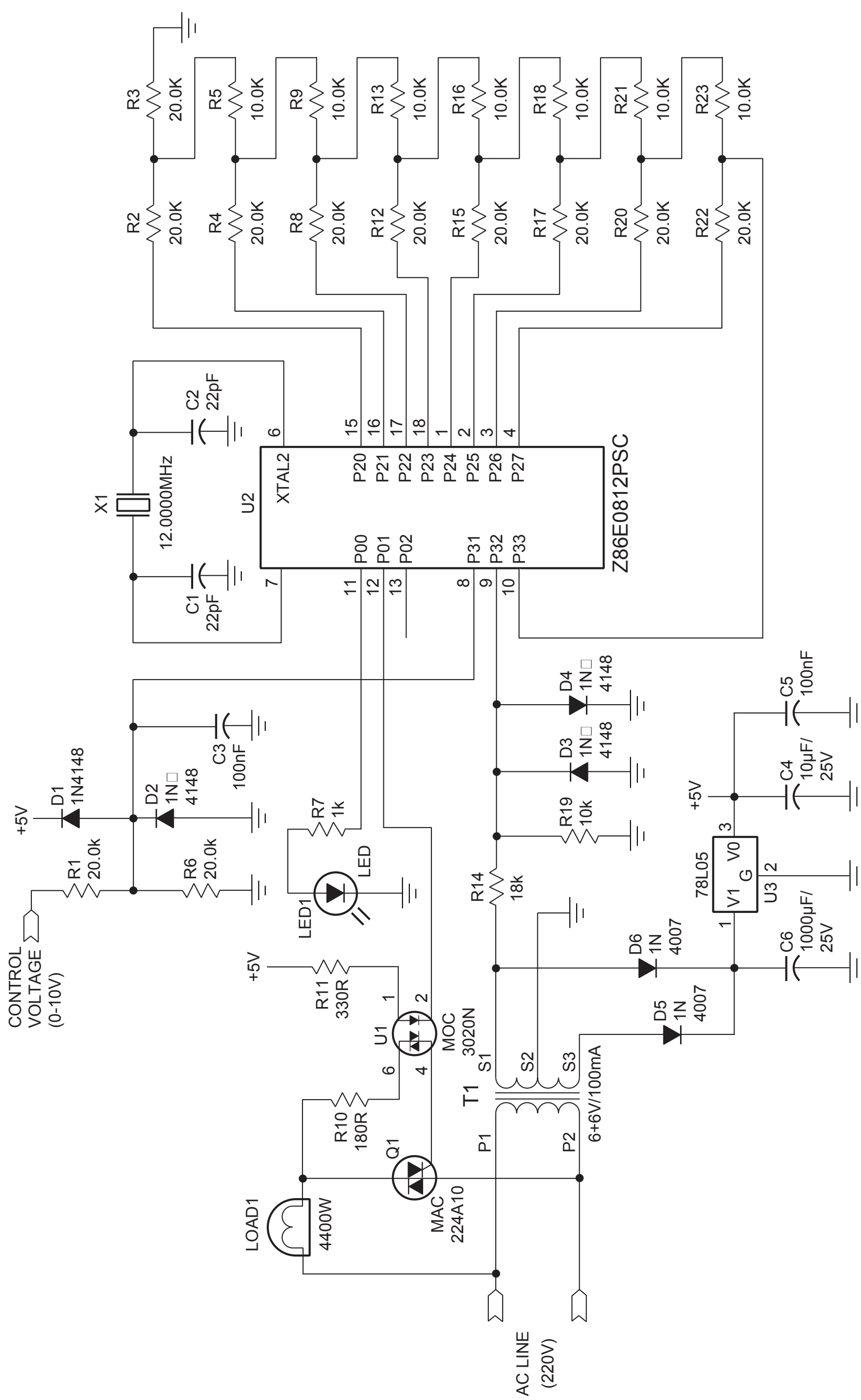


Figure 17. Digital Dimmer Box Schematic Diagram



Door Access Controller

Submitted by: Suksaeng Kukanok

Abstract

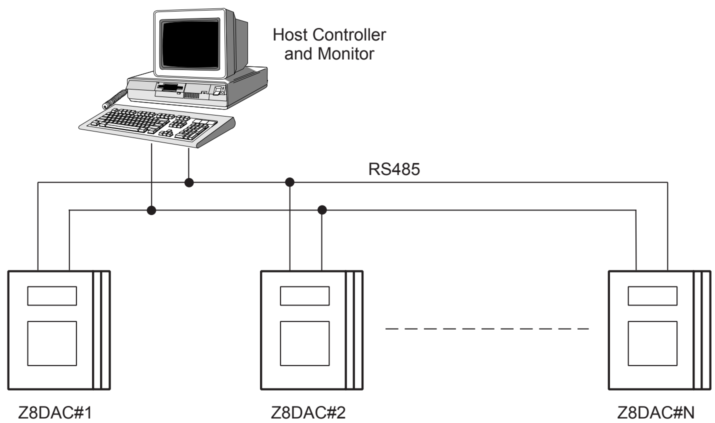
The Z8 Door Access Controller (Z8DAC) screens an authorized person for access to a restricted area. The Z8 microcontroller is used as the main controller. This application uses most of the on-chip resources, such as program memory, register, I/O, timer and interrupts.

The Z8DAC can be set up as a multiple Z8DAC configuration, using an RS-485 interface or one Z8DAC configuration using an RS-232 interface. The Z86E30 microcontroller configuration consists of a magnetic card reader, keyboard, LCD display, I^2C EEPROM, I^2C RTC, and an asynchronous bus and door control ports.

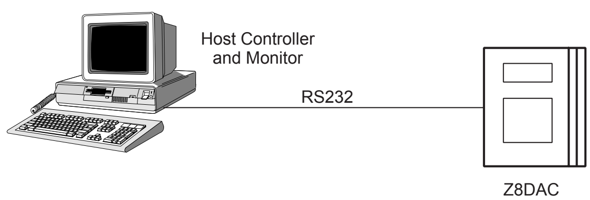
When using the magnetic card reader, The Z8 looks up the card ID using the ID parameter in the EEPROM. The content of the parameter provides the time allowed for access and the access key code (if necessary). If the controller requires a key code, the user must key in the access code within 30 seconds. If the unauthorized code is tried more times than the maximum number allowed, a panic signal is generated on P27. After the Z8 determines that access is allowed, the door unlocks itself. When the door opens, the door sensor sends a signal to the controller and locks the door.

The parameter and each authorized ID are downloaded to the target Z8DAC. The PC on the system can be connected online or offline. If it is an online connection, the PC monitors in real time. If the connection is offline, the PC monitors using a batch process.

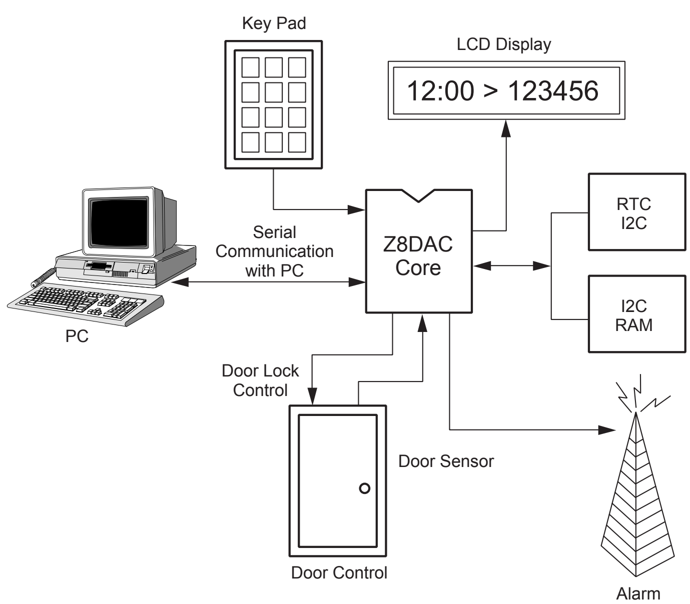
Figure 18. Door Access Controller Block Diagram



Block diagram when connected with PC via RS485

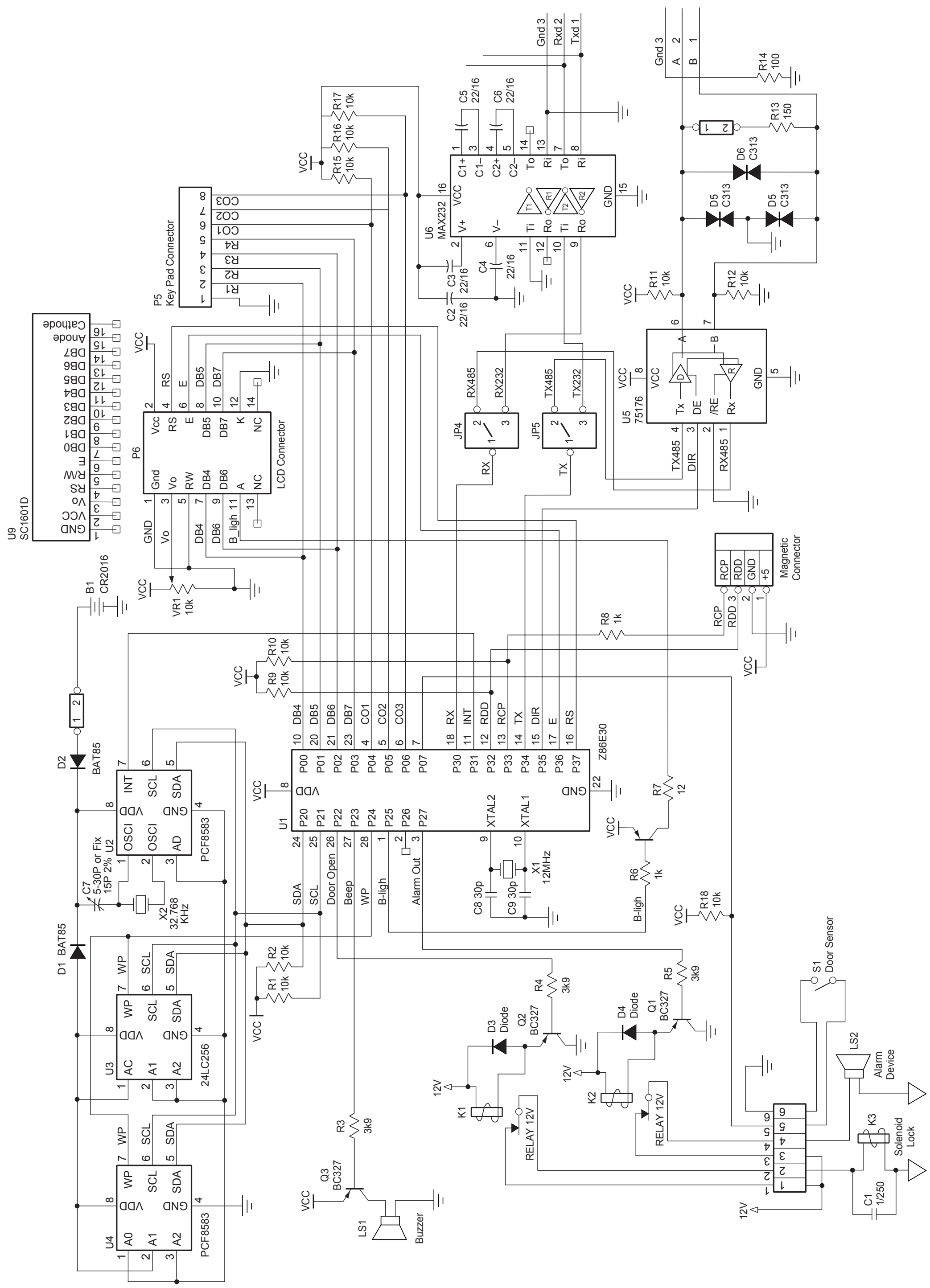


Block diagram when connected with PC via RS232



Functional block diagram

Figure 19. Door Access Controller Schematic Diagram



Electrolytic Capacitor ESR Meter

Submitted by: Bob Parker

Abstract

A major cause of electronic equipment failure is due to electrolytic capacitors developing excessive Equivalent Series Resistance (ESR). These capacitors may exhibit the characteristics of a normal capacitor, yet with a significant resistor in series. This design is for a digital meter that directly indicates the ESR of a capacitor.

A Z86E04 microcontroller, supported by a relatively small amount of hardware, allows the following features to be easily and economically implemented:

- Power on/off and test lead resistance zeroing with a single push-button
- Three automatically-selected measurement ranges
- Low battery voltage warning
- Automatic power switch-off

When pressed, the push-button initially forces Q1 to switch on. When running, the microcontroller switches to Q2. When the button is pressed again, Q2 is detected on P26. If the firmware measures the low resistance of shorted test leads, it subtracts their measured value from all future ESR readings. However, if the firmware detects an open circuit, it switches off Q2 and consequently Q1, turning off the battery supply.

A measurement begins when the microcontroller switches off the ramp-capacitor discharge transistor (Q11), allowing C10's voltage to increase linearly with time.

One of the Z86E04 timers initiates a series of 8-µs pulses spaced 500 µs apart, which drive either Q3, Q4, or Q5 to send current pulses of an amplitude dependent on the measurement range, through the capacitor under test. Between the pulses, Q6 is switched on to prevent the capacitor from accumulating a charge.

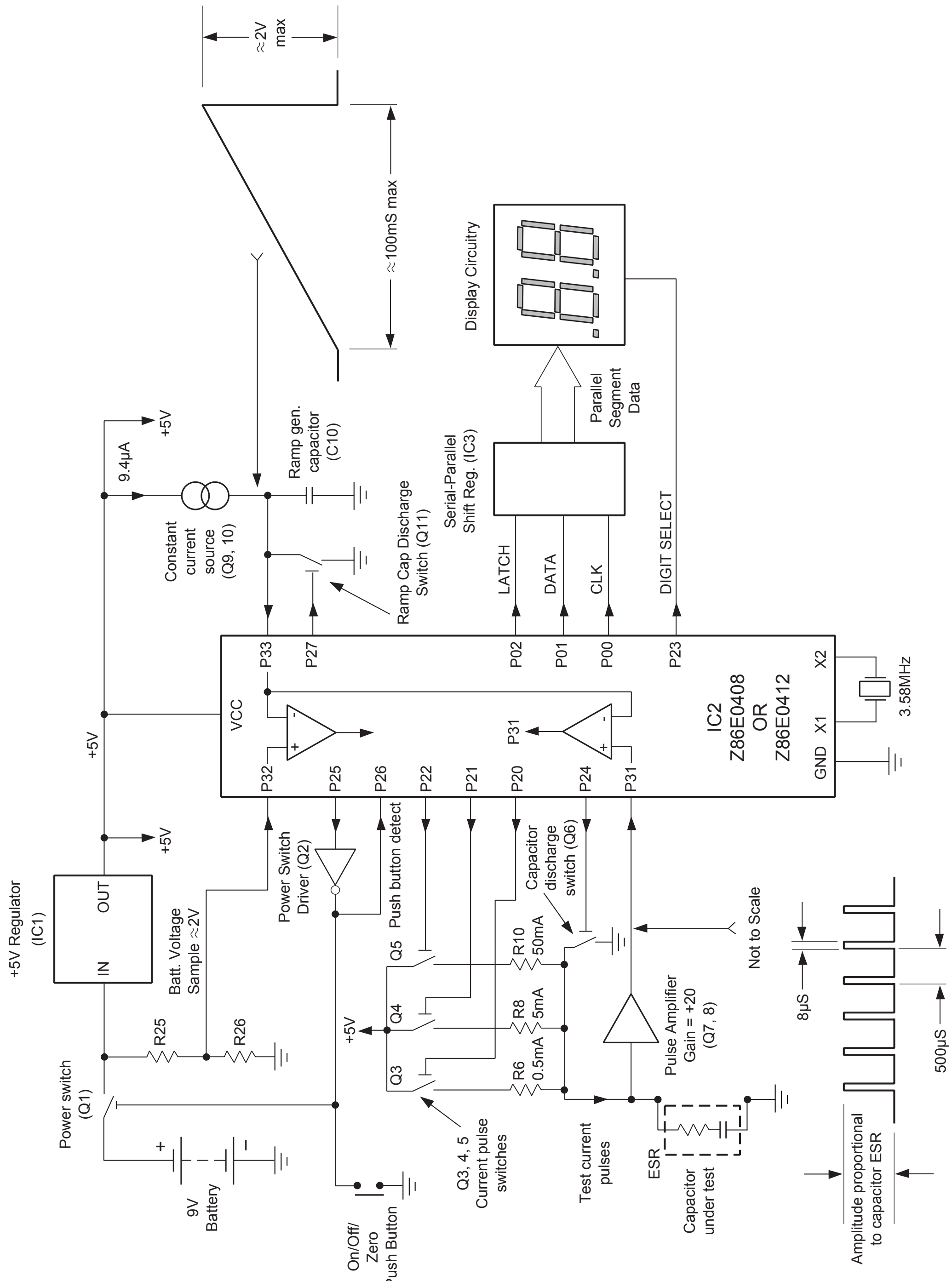
The voltage pulses across the test capacitor, proportional to its ESR, are amplified and applied to the microcontroller's P31 comparator. The firmware terminates this process when the voltage on C10 exceeds the amplified pulse amplitude. The total number of pulses is used to calculate and display the capacitor's ESR, after subtraction of the test lead resistance.

Between measurement cycles, the microcontroller allows C10 time to charge to 2 volts. If the battery voltage sample on its P32 comparator is below this 2 volts, the firmware periodically flashes a *b* on the display as a Low-Battery warning.

Display segment and decimal point data is sent serially from port 0 to a serial-to-parallel shift register (IC3), driving the LED displays that are multiplexed at a 100-Hz rate determined by the Z86E04's second timer. This timer additionally controls the automatic switch-off period and all other system timing.

This design takes advantage of all the Z86E04 analog comparators and timers to produce a simple but versatile capacitor ESR meter. The firmware occupies about 700 bytes of program memory, and runs effortlessly at a 3.58-MHz crystal frequency.

Figure 20. Electrolytic Capacitor ESR Meter Schematic Diagram



Electronic Door Control

Submitted by: Fernando Garcia Sedano

Abstract

Electronic door controls have been developed to control electrically-operated doors for railway toilets, especially for the handicapped.

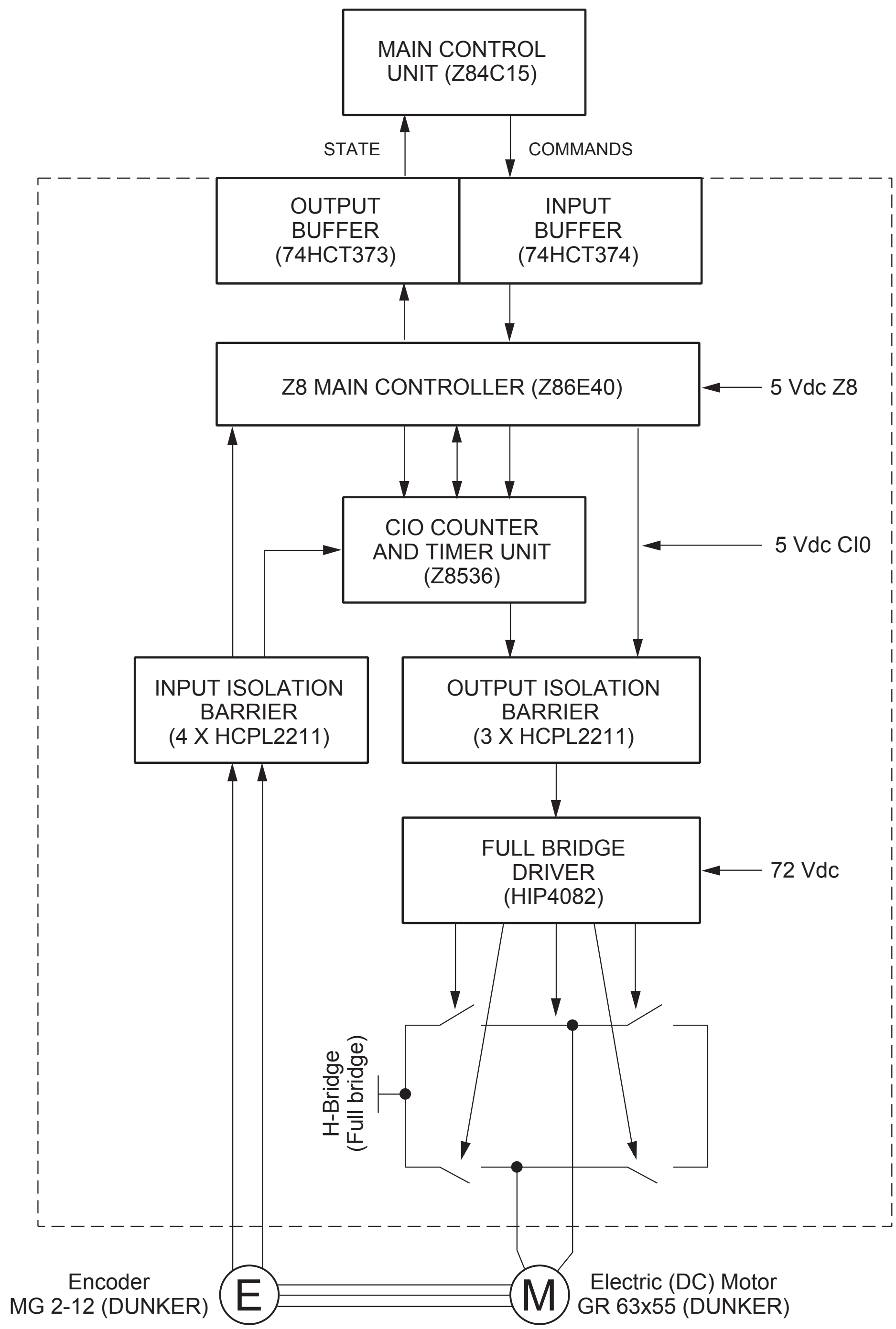
All commands received by the door control module are processed by the Z86E4016PEC microcontroller. The microcontroller also drives a ZiLOG Z853606VEC clock I/O (CIO). The CIO counts the encoder pulses and acts as a PWM generator. It uses two of three internal counter/timers. The Z86E40 software is used to modify the PWM-generated duty cycle and carrier frequency.

Commands to and from the main toilet unit are sent via the octal D-latch U15 and D-latch U14. D-latch U17 implements the logic to satisfy the requirements of the Z8 timing signals and the Z84C15 intelligent peripheral controller's (IPC) main control unit.

The Z8 microcontroller uses an MG2-12 encoder to control door displacements, direction, and the opening and closing speeds.

The electronic door control module has operated effectively on railway toilets in Spain since 1999.

Figure 21. Electronic Door Control Block Diagram



Firearm Locking System (FLS)

Submitted by: Phillip F. King

Abstract

The Firearm Locking System (FLS) is a firearm safety system designed to add an extra layer of protection to the keeping and use of guns. Using a Z8 microcontroller, the FLS can make a firearm available and ready to use quickly when required, while virtually eliminating the chances of an accidental or unauthorized discharge.

FLS can be manufactured into new firearms or added as an after-market option by a qualified gunsmith. It works with any existing mechanically-fired weapon, including handguns, rifles, and shotguns of any caliber. At the heart of the system is a Z86E83 Z8 microcontroller, the brain behind the FLS.

The controller gathers input from sensors on the firearm (See Table 3), and outputs a control signal to a mechanical solenoid that toggles the firearm's safety, typically by disengaging or blocking the firing pin or hammer. The software allows the user to define profiles of acceptable usage depending upon requirements. For example, a skeet-shooter might define an acceptable firing angle as anything above horizontal, while a handgun user who typically target shoots on an indoor range would allow a firing angle of only ±5 degrees off horizontal. Both users might also define a self-defense mode in which any firing angle is allowed.

Table 3. Firearm Sensor Input Functions

Input	Function
Rocker Switch Access Code Input	Four rocker-toggle switches provide an eight-number input, and provides 8^N possible access codes for an N-digit code.
Hand-Grip Sensor	Senses pressure on the grip of the weapon that indicates it is being handled. Prevents accidental discharge when a weapon is dropped or transported. In self-defense mode, can also be used to determine, when a user has lost control of a firearm, to disable the weapon and prevent use by an assailant.
Inclinometer	Measures the current angle of the barrel. Prevents accidental discharge of a weapon being held in a rest or nonfiring position.

Figure 22. Firearm Locking System Block Diagram

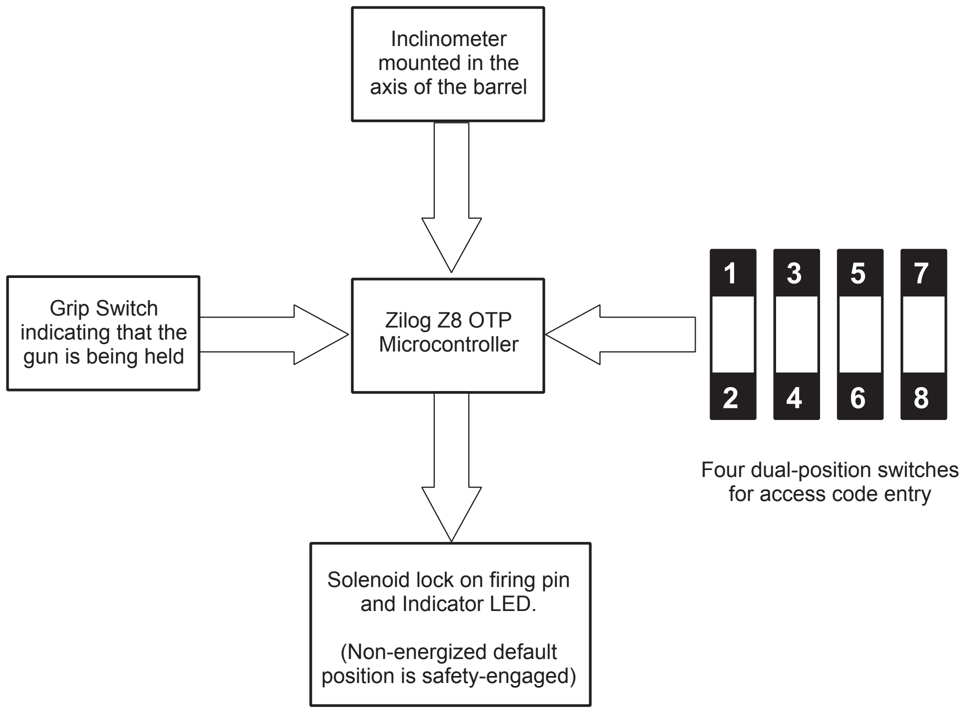
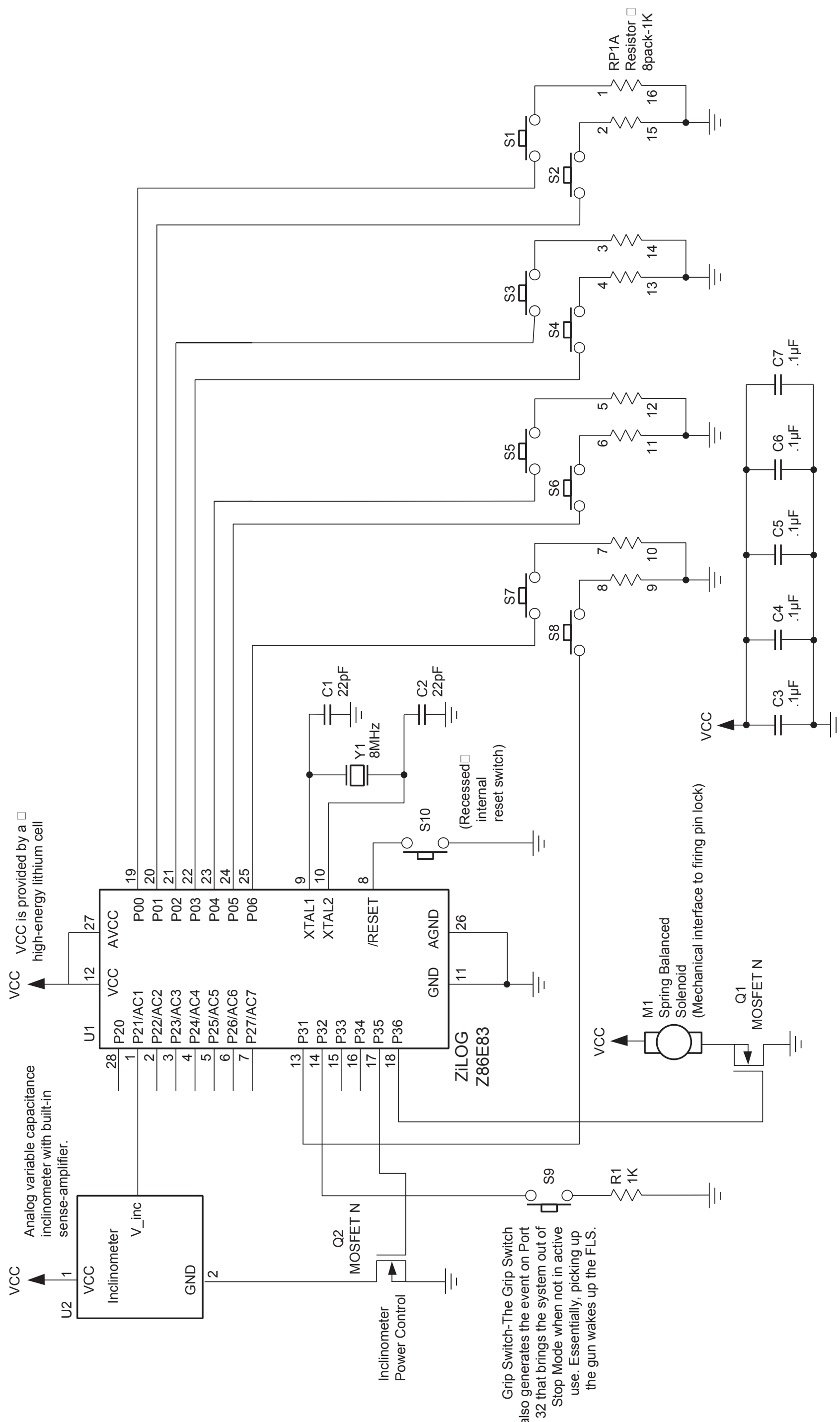


Figure 23. Firearm Locking System Schematic Diagram



Forecaster Intelligent Water Delivery Valve

Submitted by: James Martin

Abstract

The Forecaster Intelligent Water Delivery Valve measures soil moisture and changes in air temperature and barometric pressure to prevent unnecessary watering before, during, or after natural rainfall. Simple analysis of three sensor readings over time determines whether to postpone water delivery in expectation of natural rainfall, or to skip to the next programmed cycle.

The primary function of the Z8 microcontroller is timed actuation of an electric water valve. Timing may be relative or absolute—relative timing is described herein for simplicity.

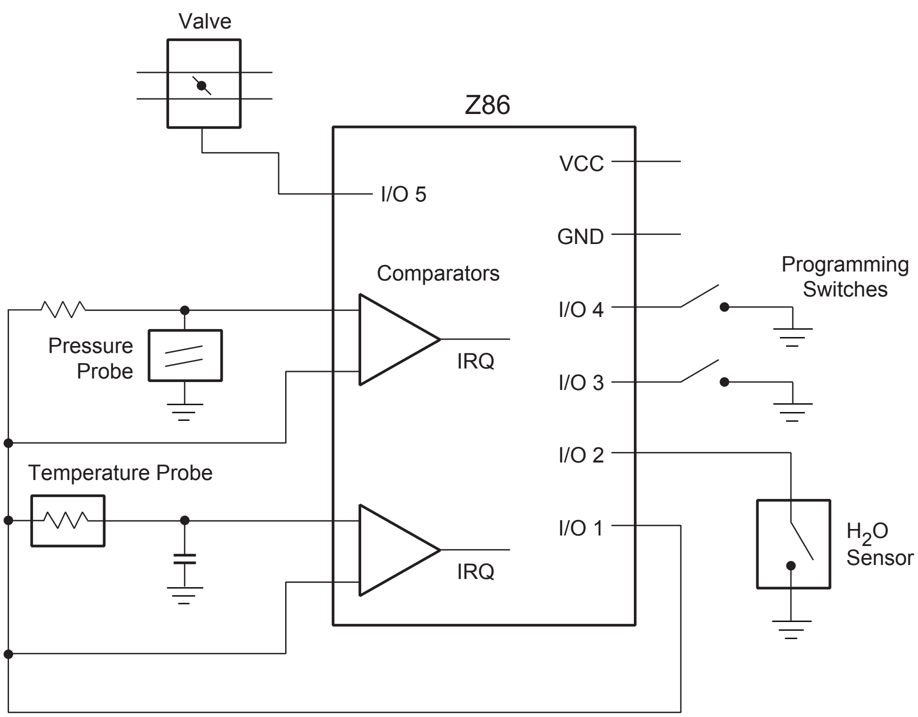
User selection of watering schedule and duration can be set in a routine as simple as a relative start time (for example, *hours from now*) and duration (in ten-minute increments), and can be implemented with only two push-buttons.

The sensors are used as follows:

- A simple moisture sensor reads true when water is present. This value effects a delay in valve actuation during or immediately after rainfall. Two other sensors utilize the available on-chip dual analog comparators. The first comparator is used to read the resistance of a temperature probe as part of a charging and discharging RC. An output pin is turned on, providing both a reference to the noninverting input to the comparator, and a charging voltage to the RC, which consists of a known capacitor and the resistance of the probe. An interrupt is generated when the RC is charged. The output pin can then be set Low. Another interrupt occurs when the RC is discharged (the time between interrupts can be used to calculate the resistance).
- The capacitance of the barometric pressure sensor can be determined in the same manner using the second comparator. A known resistance and the sensor capacitance together form the RC.
- The sensors can be polled in regular increments (for example, every 30 minutes). Absolute changes that exceed programmed limits trigger a delay if scheduled watering is about to occur.

This system allows regular watering to occur only in the absence of sufficient natural rainfall, and when rain is not expected to occur based on temperature and pressure changes.

Figure 24. Forecaster Intelligent Water Delivery Valve Schematic



Improved Linear Single-Slope ADC

Submitted by: Li Gang

Abstract

A highly accurate linear single-slope ADC is achieved by using a linear integrator and two comparison units on a Z8 microcontroller.

A MAX418 is a high-input-impedance, low-power-consuming and rail-rail operational amplifier. Combined with a resistor R4, a capacitor C1 and a diode 1N4148, it forms a linear integrator. At usual status, the P00 is set to one, and the output of the integrator is at a low level. To start the ADC conversion, set P00 to 0 to charge the integrator until its output increases. When the output of the integrator equals the voltage at P32, the comparison unit at P32 operates, allowing the timer to begin counting. The output of the integrator continues to increase. When it reaches the voltage level at P31, the comparison unit at P31 operates and the timer stops counting. As a result, the number in the timer displays the voltage difference between P31 and P32. This kind of single-slope ADC exhibits higher accuracy than either PWM Ramp ADC or RC Ramp ADC, due to a linear integrator, rather than an exponential one, and makes use of the middle range of its input-output characteristic curve.

A MAX619 is used to convert 3 volts to a stable 5 volts. The MAX418 features two operational amplifiers—one is used as a buffer, and the other is used to form a linear integrator as described above. The 2-point calibration is used instead of the conventional 1-point calibration. The calibration values are stored in an EEPROM (1C3, 24LC01), resulting in a great improvement in its measurement precision.

The calibration is performed automatically. Insert the probe into the standard acid or alkali liquid, and press the calibration key K1. The microcontroller automatically determines that the measured calibration liquid is acid or alkali liquid. After the measurement value becomes stable, the Z8 stores the calibration results into 1C3 (24LC01) and the buzzer rings, indicating the calibration finished. For measurement, insert the probe into the liquid to be measured and press K2 to begin the measurement. If the differences among five successive measurement values are within a certain range, then the stable-measurement state is determined and the result is displayed on the LCD. The buzzer sounds, indicating that the measurement is completed. The final results are provided by linear interpretation with the two calibration points.

Figure 25. Improved Linear Single Slope ADC Block Diagram

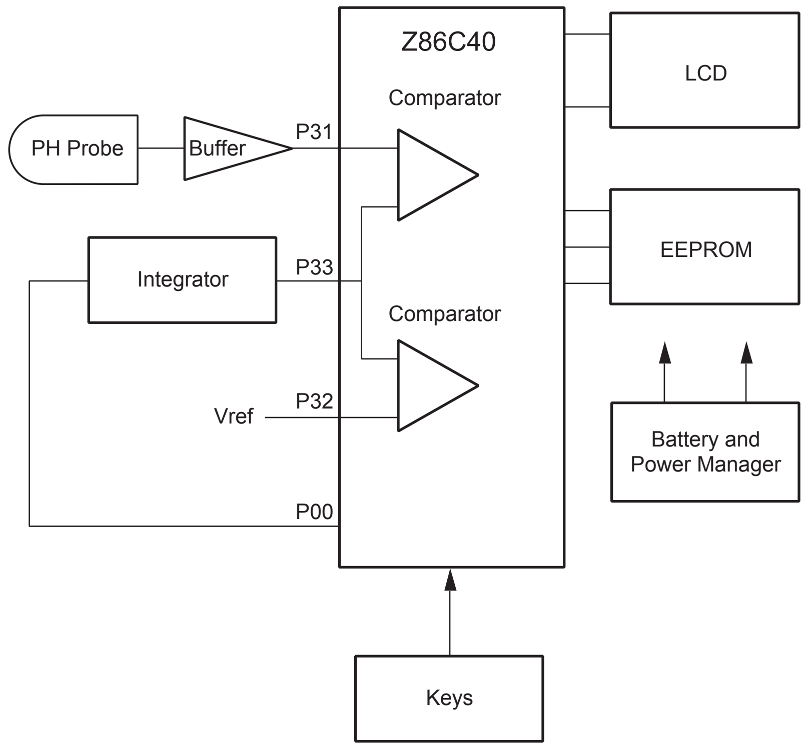
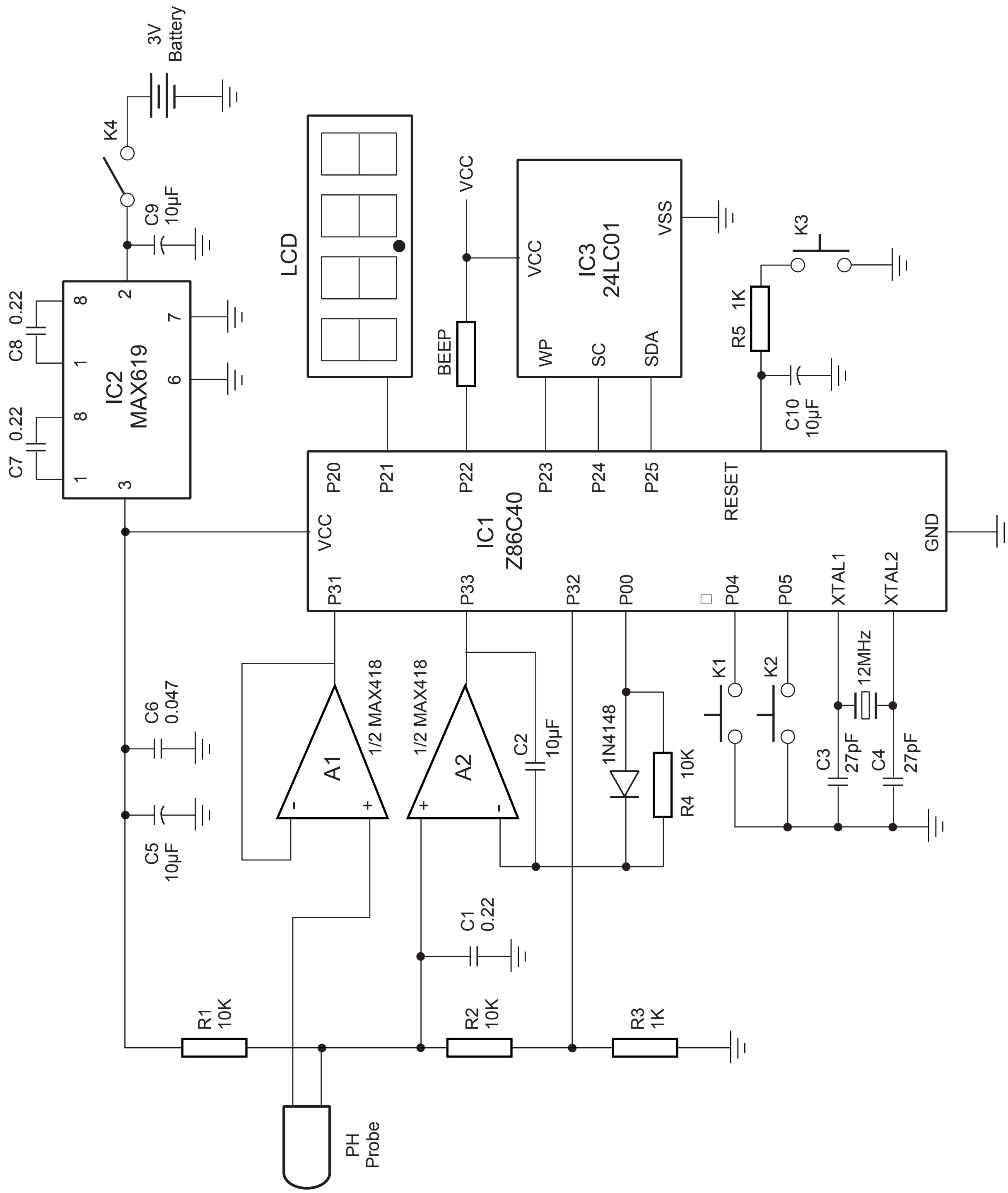


Figure 26. Improved Linear Single Slope ADC Schematic Diagram



Integrated Sailboat Electronic System

Submitted by: David R. Sneitzer

Abstract

The Integrated Sailboat Electronics System (ISES), by taking advantage of the price and feature set of the microcontroller, is able to provide a low-cost instrument with a level of integration never before seen in the sailing community at any price. It integrates the information in Table 4 onto a low-cost monochrome-graphics display.

Table 4. Graphics Display Features

Wind speed	Heal angle
Wind direction	Heading
Air temperature	Boat speed
Water temperature	Distance Total/Elapsed
Barometric pressure	Time Total/Elapsed
Depth	Power (Voltage/Current)

ISES utilizes a state-of-the-art micromachined silicon ultrasonic transducer with a Z8 at the core of the sensor. By using two pairs of ultrasonic transducers, the *x* and *y* components of the wind can be measured. In order to determine the *x* component of the wind, the sensor pair aligned with the centerline of the boat is utilized.

One of the transducers emits an ultrasonic pulse and Z8 reads the time delay until the pulse is received. For the same sensor pair, the roles are reversed. The time it takes for the sound to travel (propagate) through the air is dependent on air temperature and the speed the air is moving past the sensors. By computing the average of the two delays, the propagation time through still air is calculated by the Z8 and the virtual air temperature is calculated.

The air temperature is used to make corrections for the velocity calculation. This same procedure is used by the Z8 to calculate the component of the wind. A dual-axis accelerometer is placed in the *y,z* plane to acquire the angle that the boat is heeled at. The Z8 applies the heel angle to the *y* component of the wind to create wind speed and direction. The Z8 is also used as an I/O and display processor.

Figure 27. Integrated Sailboat Electronic System Block Diagram

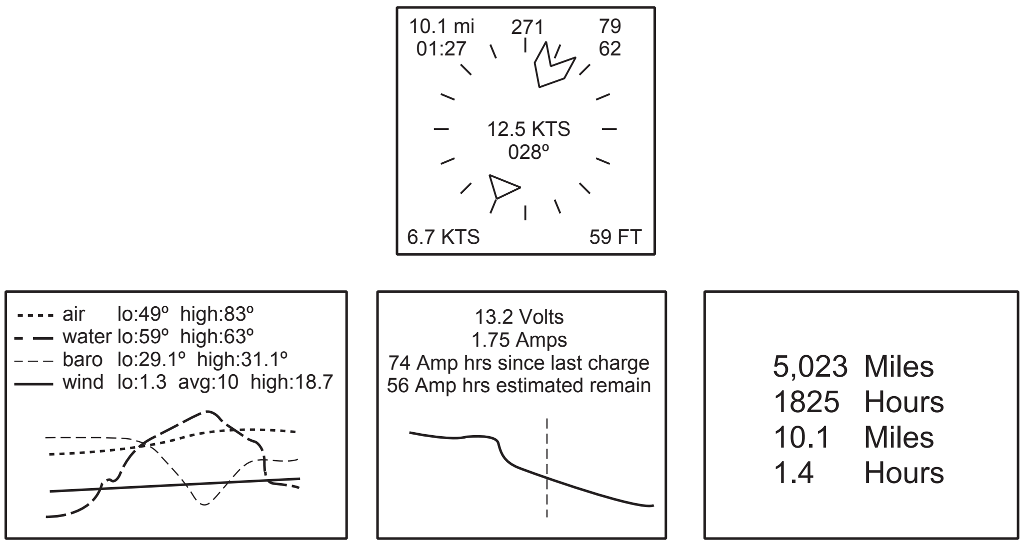
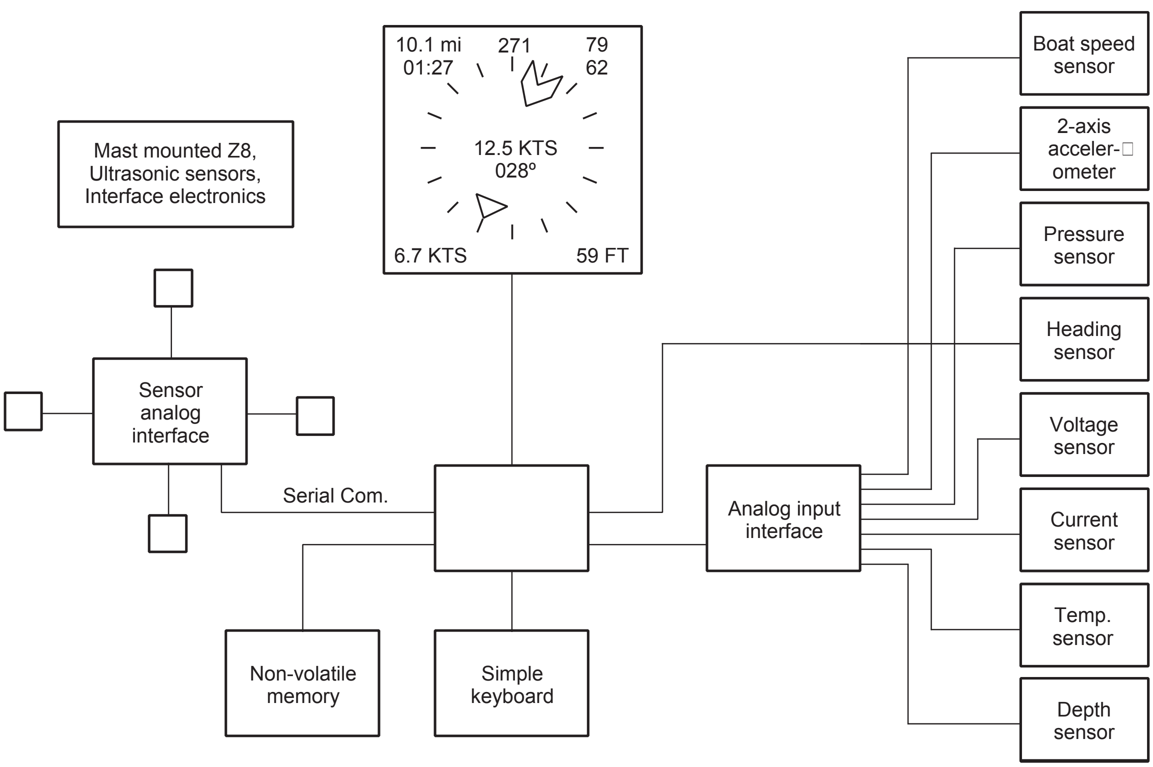


Figure 28. Integrated Sailboat Electronic System Schematic Diagram



Intelligent Guide for the Blind

Submitted by: R. Sharath Kumar

Abstract

This self-contained, self-propelled, intelligent guide incorporates the ZiLOG Z86E31 microcontroller. Using ultrasonic and infrared transducers, the surroundings are scanned for complete, intricate detail, including pavement-surface deformations, puddles, and pits apart from general traffic. The microcontroller analyzes this information, determines the safest path, and controls a propulsion motor to manipulate and lead the handicapped safely through these obstacles. The guide further interacts with the individual via audio messages, informing of the surroundings and distance traveled. A chosen direction of travel is commanded via push-button keys. The microcontroller immediately repositions the scanners toward this direction. An indicator lamp pulses on/off, together with a beeper, to alert a person of any slow-moving traffic or obstruction. The guide can also be programmed to remember the direction traveled automatically when commanded.

The direction commands include Straight Ahead, Turn Left, Turn Right, and Reverse Back, and are received from keys SW1–SW4. The stepper motor is controlled in half-steps for increased position control by the microcontroller. A ping-pulse wave is emitted and transmitted through the air by the microcontroller through a 40-kHz ultrasonic transmitting transducer. The wave, reflected off objects in its path, is detected by the receiving transducer. The received echo is amplified, centered, and compared against a fixed reference voltage by an LM6132, and fed to the microcontroller. The microcontroller measures the timing of the wave from the instant it leaves the transmitter to the instant an echo is received (taking the Doppler effect into account) and calculates the distance.

After the guide orients itself in the commanded direction, scanning continues in an oscillating mode. During this mode, the microcontroller continuously monitors the echo signals and maneuvers the movement accordingly.

An infrared sensor is activated at the same time as the ultrasonic transceiver. This sensor scans the pavement surface ahead. Infrared transmitter D1A is pulsed on/off at 1kHz, and the bounced signal is captured by D1B. The signal strength depends on the distance from the obstruction. This variable-strength signal is converted proportionally into pulses by the voltage-to-frequency converter, LM331.

All information is updated to the individual via prerecorded messages. The sound chip is configured to operate in MESSAGE CUEING mode.

Figure 29. Intelligent Guide for the Blind Block Diagram

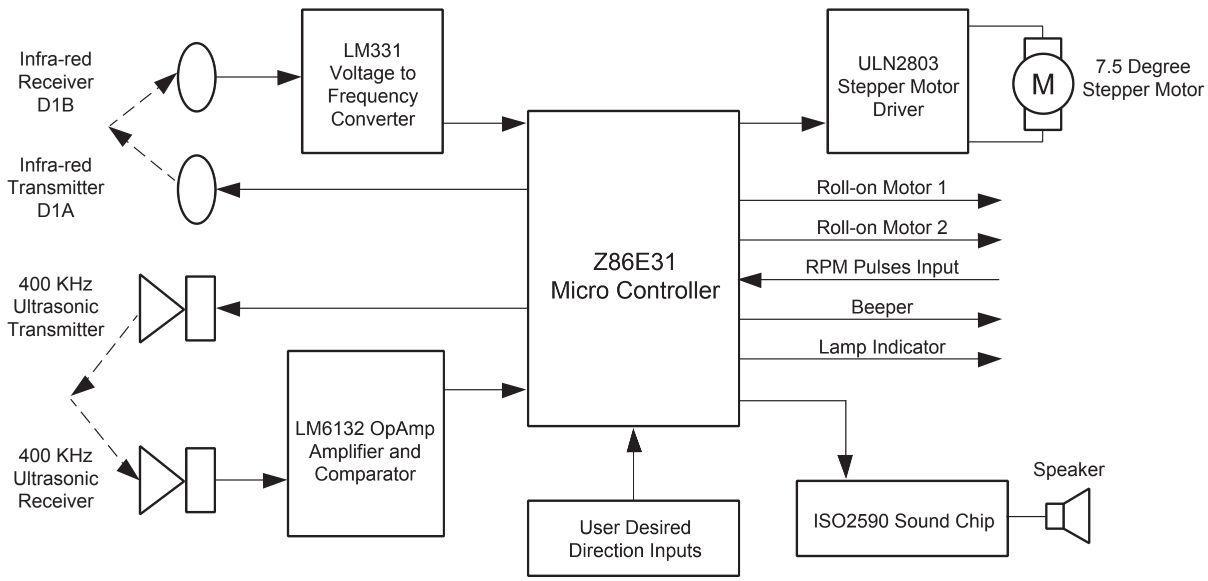
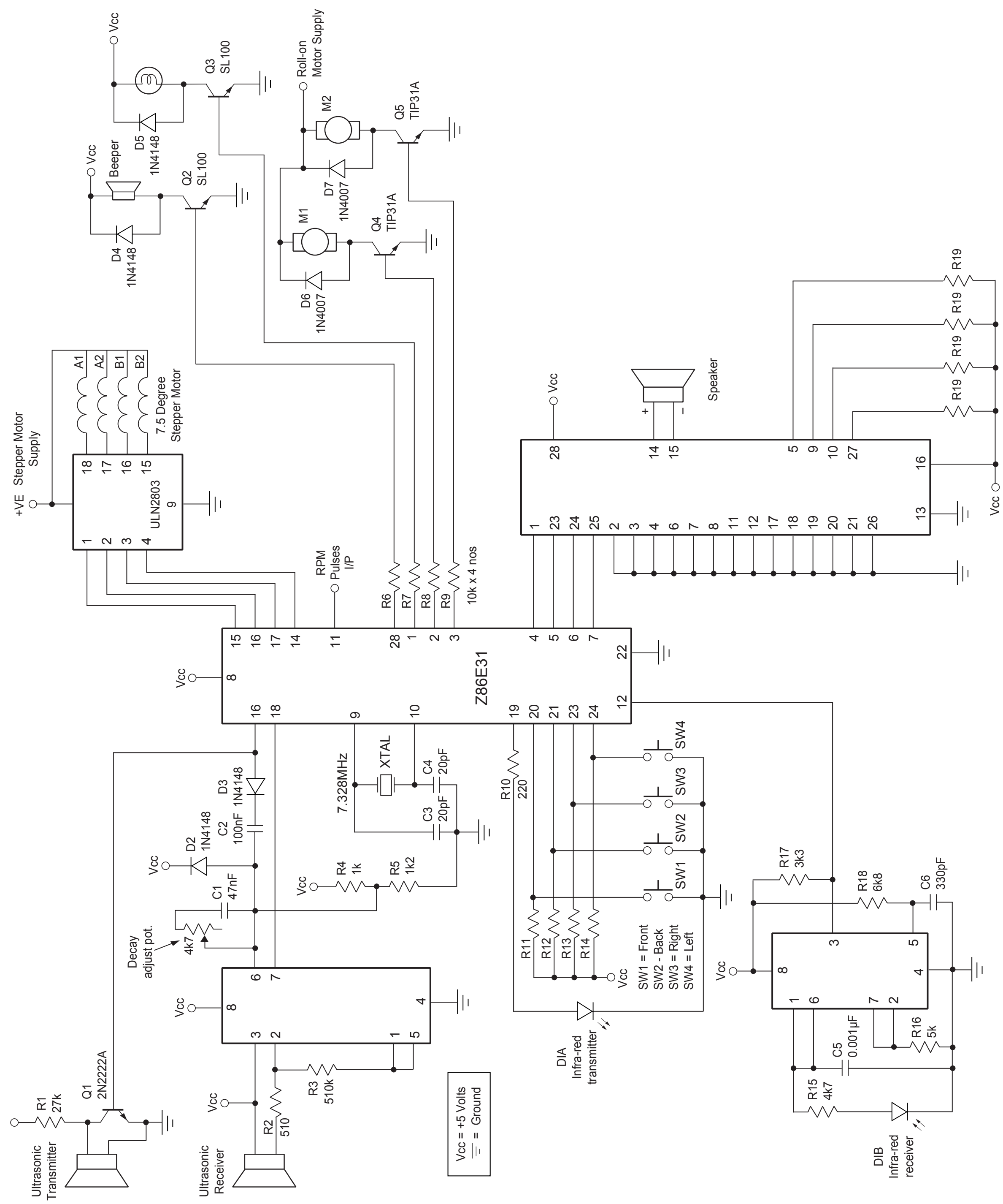


Figure 30. Intelligent Guide for the Blind Schematic Diagram



Internet Email Reporting Engine

Submitted by: Michael W. Johnson

Abstract

The Internet Email Reporting Engine is a design that can he embedded inside a device to connect via a dial-up function to an Internet Service Provider, and send email reports to anywhere on the Internet.

A ZiLOG Z02204 modem module provides the connection to the real world via a phone line.

The Seiko iChip (S7600A) provides PPP and PAP authentication, and the Internet protocols IP, UDP, TCP, and ICMP.

The ZiLOG Z8 controller receives commands from a serial connection and communicates to the Seiko iChip via an 8-bit parallel CPU interface to control the modem and the iChip's Internet functionality. The Z8 MCU also provides a higher-level command and Internet functionality via software

The software running on the ZiLOG Z8 CPU receives commands via a serial interface and processes them. Based on those commands, the Z8 performs dial-up and connects to the Internet, establishes an Internet connection to an ISP via the PPP protocol (authenticated with PAP), and opens a connection to a mail server. It then sends a message, and hangs up.

Commands are sent to the engine via a serial port that is implemented as a software UART running at 2400 bps on the Z8 controller. These commands are processed, the state of the email engine is updated, and a command status code is reported back through a software UART.

Table 5. Serial Commands

sn	Set phone number	sl	Set login name	sp	Set password
sd	Set DNS server IP	sr	Set recipient email address	ss	Set SRC email address
du	Dial-up and connect to ISP	cs	Connect to email server	ps	Print message to email body
ms	Message send	hu	Hang up		

Each command is a parameter string that terminates with a return and a line feed. The software responds to each command using a return code that terminates with a return and a line feed.

Once a connection is made to the Internet, sending email is as simple as configuring an email server to connect, choosing a recipient, and sending text as the body of the email.

Figure 31. Internet Email Reporting Engine Block Diagram

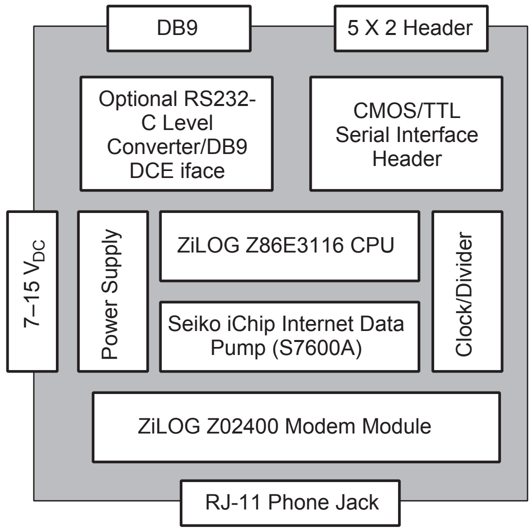


Figure 32. Internet Email Reporting Engine Software Block Diagram

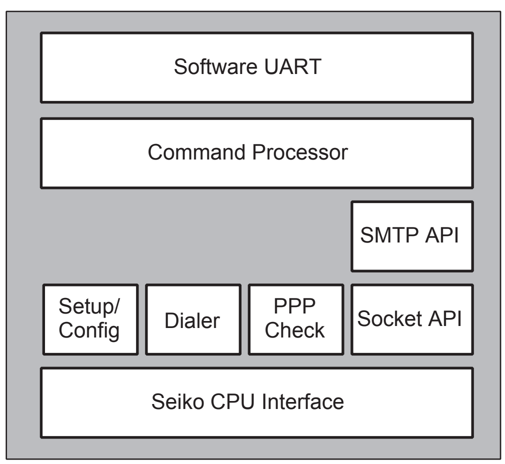
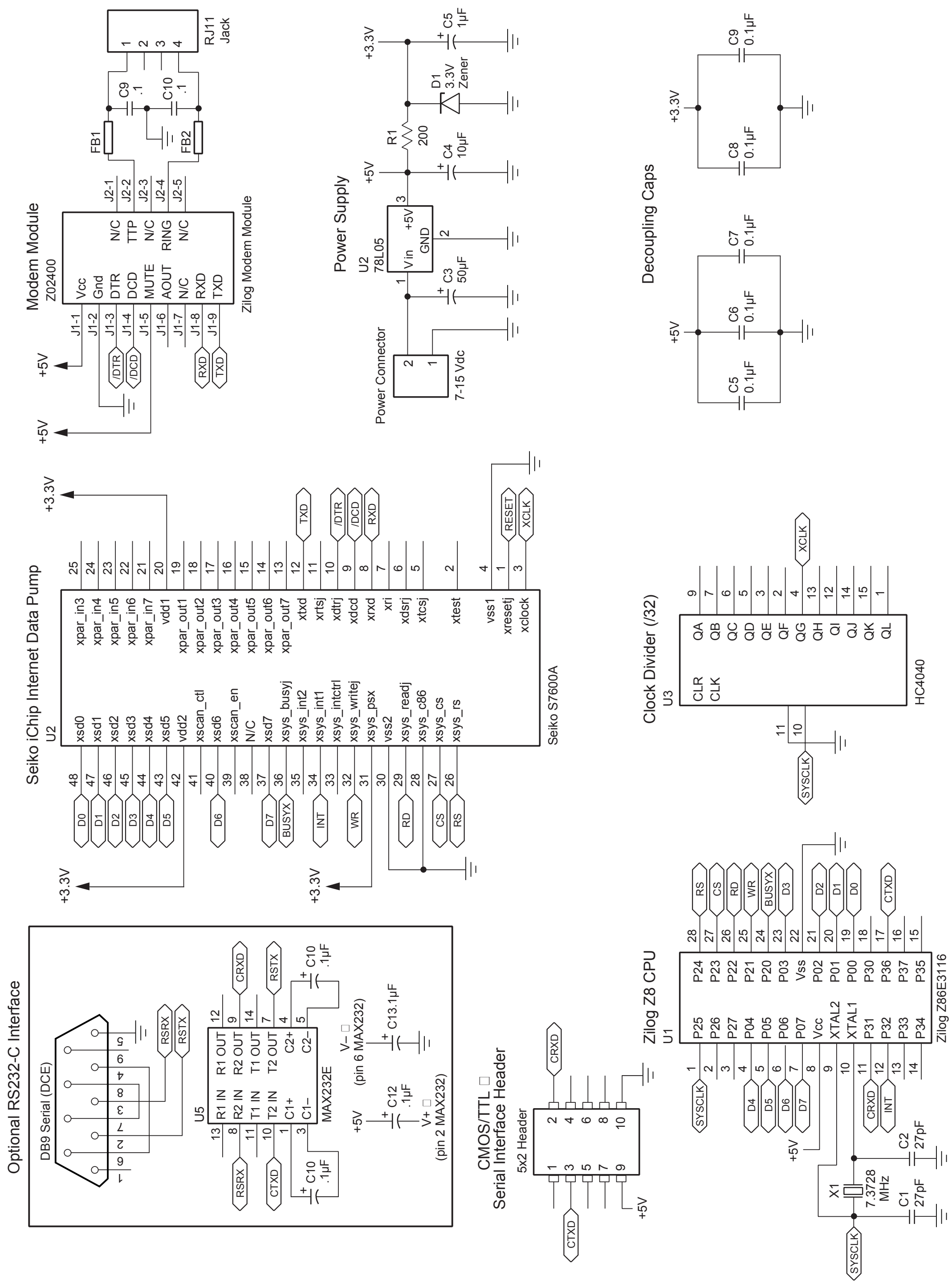


Figure 33. Internet Email Reporting Engine Schematic Diagram



Lunar Telemetry Beacon

Submitted by: Russell McMahon

Abstract

The Lunar Telemetry Beacon (LTB) is a small Z8 microcontroller-controlled telemetry system and radio transmitter. It is intended for deployment on the lunar surface to subsequently return temperature, seismic, and location information to Earth.

No receiver is incorporated in the LTB, due to severe design constraints. Consequently, all decisions must be made on a preprogrammed basis.

Key demands on the overall system include the ability to survive impact velocities of over 300 kph and decelerations of 1000 g, to return data to Earth using a self-contained aerial and transmitter, and to survive in an ambient temperature range of –180º to +130º Celsius (with the transmitter not operating at extreme temperatures).

Key demands on the Z8 microcontroller include:

- Control of initial deployment from the main payload
- Control of the physical orientation of the LTB after landing
- Control of a transmitter to return data to Earth
- Thermal management of the electronic core to maximize the prospect of surviving the lunar nights (2 weeks at –180º Celsius)

Because of severe mass, and therefore battery restrictions, the unit operates intermittently, with a decreasing duty cycle over time.

Mechanical survivability is enhanced by the use of surface-mount construction, housing in a custom-fitted mechanically-compliant pressure shroud, encapsulation of the whole system in a homogeneous medium, and subsequent mounting in an external matrix-medium that ensures controlled deceleration over the maximum available distance.

The LTB's initial objective is met if it transmits successfully from the lunar surface for a period of a few Earth days. Over this period, transmissions are relatively frequent. Long term operation (weeks to years) requires surviving the low temperatures of lunar nights. Lunar night survivability is targeted by use of a super-insulated core for the key electronics and the provision of very low levels of electrical heating under system control. Battery systems utilize two versions of lithium chemistry due to their potential tolerance of the extreme thermal conditions and high energy densities. Thionyl Chloride batteries (800 Watt-hr/kg) are used for core stay-awake electronics (due to their good energy density) and lithium-sulfur

dioxide batteries (300 Watt-hr/kg) for transmitter power (with a somewhat lower energy density but better high-current performance).

The key technical objectives are:

- Survive landing
- Deploy aerial system successfully
- Return at least one successfully-received message

The above three objectives are listed together because, while each is a separate goal, all must result before success is achieved. The device must additionally be able to:

- Send transmission bursts increasingly less frequently throughout one lunar day (2 Earth weeks)
- Survive one lunar night (2 weeks at –180º Celsius)
- Send transmissions at regular infrequent intervals throughout the lunar day, and as many possible subsequent lunar days

Message data includes temperature and seismological observations and sponsor dictated content (not necessarily advertising per se). A failure to return some or all data would still be a reasonable success, provided actual transmissions continued to be received.

All activities must be accomplished with a minimum of weight and power consumption.

The Lunar Telemetry Beacon is designed to be as independent of the main spacecraft and main payload as possible while communicating with it prior to deployment. Communication with the core spacecraft control system is by way of a single bidirectional data serial circuit which interfaces with a bus interface in the spacecraft. Power can be provided to a stay-alive input on the LTB prior to launch to avoid utilizing the internal inaccessible and nonrechargeable batteries. However, this connection is used when the final stage of the countdown commences. A failed LTB prior to launch is not repaired; it is replaced in its entirety.

After launch, the LTB does not function until lunar impact. It can communicate with the main spacecraft as required.

Under strictly predefined conditions, a mission failure mode exists whereby the LTB can self-deploy, if it is obvious that the main mission has failed. The prospects are good for an LTB to survive a catastrophic explosive failure of the main craft upon reaching orbit.

As lunar impact is imminent, the LTB arms itself.

A combination of advice from the main craft and/or loss of communication at the appropriate time determine the approach and occurrence of lunar impact.

On impact, the LTB is ejected horizontally from the main payload to prevent it from being trapped in the main debris. The small pyrotechnic charge for this activity is external to the LTB.

While the LTB can technically initiate this action if the main craft should fail, it is unlikely that its command would be accepted if the main controller fails to initiate the release.

Shortly after impact, and having come to rest, the LTB ascertains its survival, and attempts to determine its attitude using its onboard triple-axis accelerometer. In a preferred orientation, as encouraged by its weight distribution, the LTB deploys its main aerial using a pyrotechnic charge to trigger a release mechanism. The antenna is of spring construction with a deployed orientation normal to the body. It is a simple whip antenna that is mechanically wound around part of the outside body. A nonoptimum orientation of the LTB on the surface can be corrected by deploying a sequence of up to three other similar antennae, followed by the actual antenna. When the antenna is deployed (or if it cannot be), the LTB commences its transmission sequence. Transmissions are initially frequent, and decrease with time.

During two-Earth-week lunar nights, temperatures fall below battery and transmitter safe operating limits. Under such circumstances, the LTB shuts down all activities except core activities, and attempts to maintain its core temperature at a minimum but safe level.

With the return of lunar day, the LTB attempts to reestablish its transmissions.

It is intended that the core continue to function after the transmitter fails. If the LTB determines that the transmitter has failed, it ceases transmission, except for occasional short retries.

Magic Dice

Submitted by: Darren Ashby (www.chipcenter.com)

Abstract

The ZiLOG Z8PE001 microcontroller generates a display of six numbers, and the sound effects of rolling dice. The ZiLOG microcontroller also generates the random numbers rolled on the dice. The LEDs are multiplexed using only the ZiLOG microcontroller and the display components; no other ICs are required. The LEDs are positioned to represent the dots on a pair of dice.

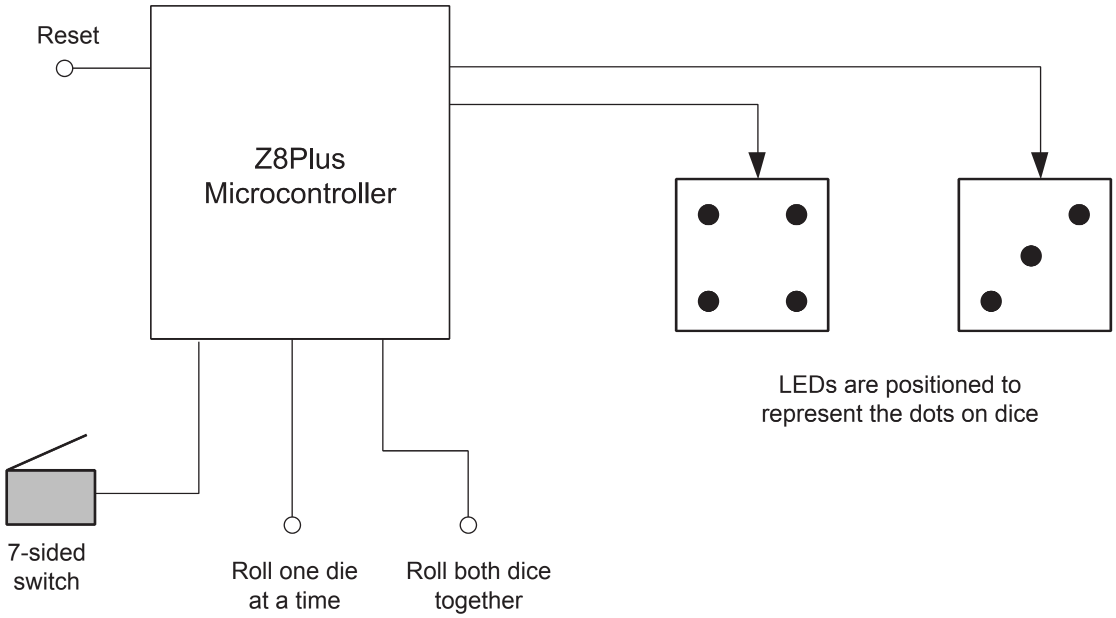
The dice displays are animated, rolling as real dice do. By controlling the brightness of each individual LED, (using the timer interrupt capabilities of the ZiLOG part), the user can achieve a visual effect to simulate rolling dice. The animation slowly comes to a stop at the final value of the dice. Each individual die may stop at different times, further enhancing the simulation.

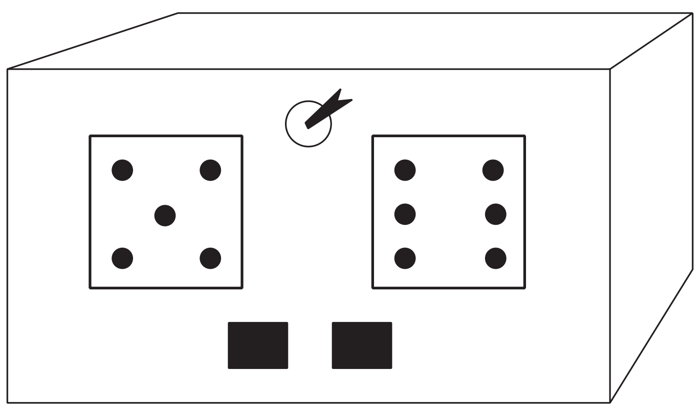
As the dice roll, sound effects simulate the bouncing action of a real die. At the end of the roll, additional sound effects are added as required for various final values. For example, a short victory song can play when a player has rolled double sixes. Such a scenario is fairly simple to create using the T_{OUT} mode on the Z8PE001 to drive the piezoelectric buzzer.

Four controls are provided to the user. Switch 1 causes only one of the dice to be rolled at a time. The first press rolls the first die, leaving the second die blank. The second press rolls the second die (the first roll is still displayed). The process then repeats. Switch 2 rolls both dice at once. Switch 3 is a reset button in case of problems.

Switch 4 is a special toggle feature that causes the dice to be seven-sided, where numbers 1 though 7 are possible. Geometry makes it impossible to create an actual die with seven sides that offers an equal chance of any number occurring. Such is not the case with the Magic Dice board.

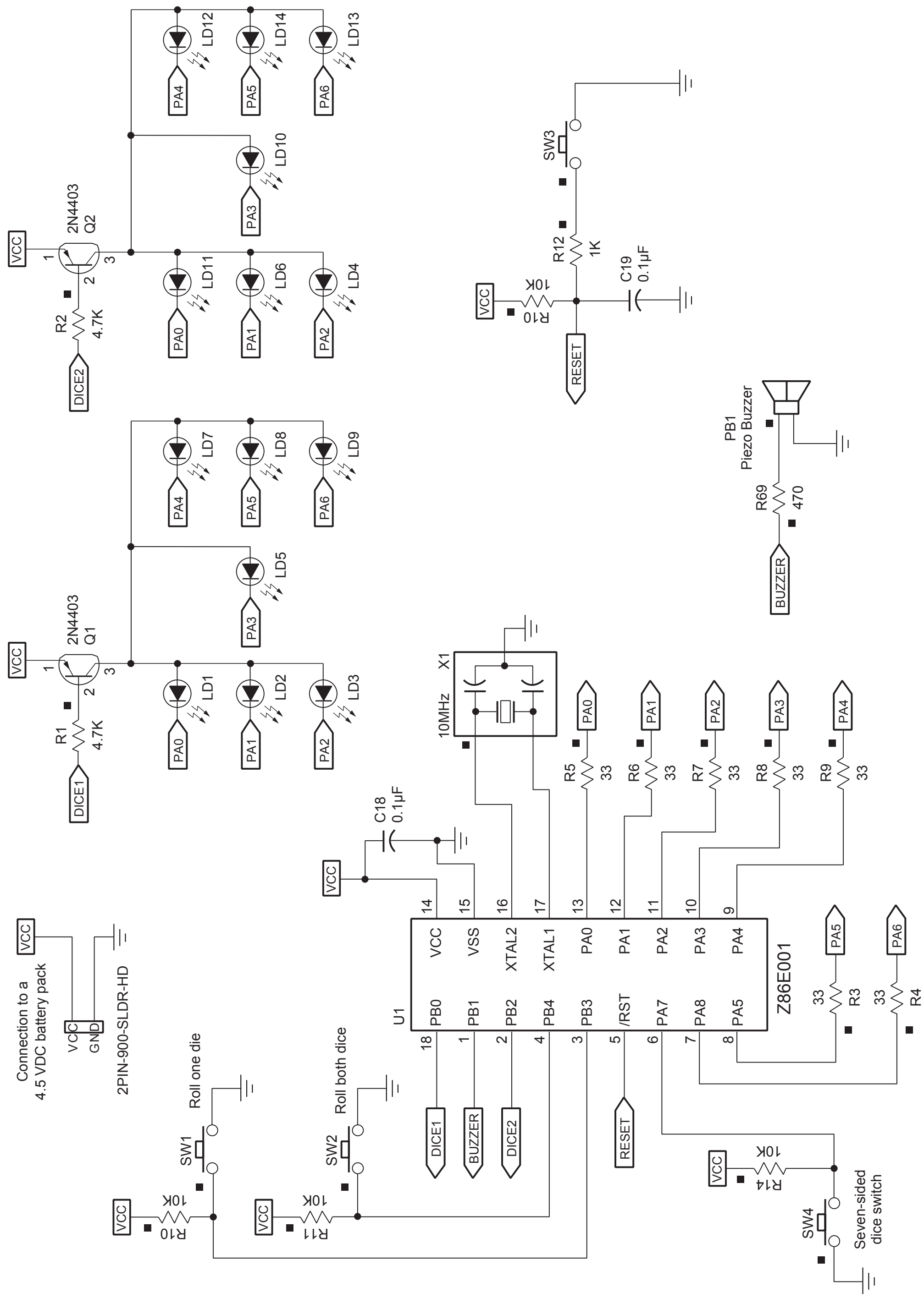
Figure 34. Magic Dice Block Diagram





Simple packaging design

Figure 35. Magic Dice Schematic Diagram



Modular Light Display Panel

Submitted by: Phillip King

Abstract

Each Modular Light Display Panel is made up of an 8x8 array of pixels. Each pixel contains 3 LEDs (red, green, and blue), which are controlled by a Z8 microcontroller. Panels provide a modular building block for expandable full-color LED displays. A single panel, running alone, can serve as electronic art, providing algorithmically-generated patterns of light and color. A linear array of panels becomes a full-color scrolling text and graphic display, such as a marquee, or an attractive enunciator panel. By connecting together a two-dimensional array of panels, users can construct large color displays. As a result, users can buy a small number of panels to start their display, and add panels as required.

Every 8x8 panel contains a Z86E21 OTP microcontroller. 192 bytes of the Z8 on-chip RAM form the image buffer containing the current state of the display. Three 64-byte arrays make up each color plane. The intensity of every LED is controlled using pulse-width modulation. At any given instant, an LED is either fully on or fully off, but by varying the duty cycle of on-time to off-time, the Z8 can vary the perceived intensity of every LED. The array can be built to allow strobing of one row of the panel at a time, or allow additional discrete latches to be used for a fully-static display (at slightly higher cost). In either case, the fully-digital control system can provide a seemingly analog variation in the color intensity of each pixel.

The software control is offered by two pads. A periodic interrupt routine updates the state of the currently-driven row of the LED array, providing the appearance of varied intensity of every pixel. The mainline code modifies the image buffer as directed by serial communication with the control computer and those panels around it. Because every panel communicates with those around it, the array itself can perform simple image manipulations such as wipes and simple animations. The total bandwidth required is reduced within the array, because not every panel must receive a fully-updated state during every frame.

When multiple panels are assembled to form larger displays, each panel communicates serially with the four around it. At power-on, each panel queries the four compass directions, and the top left panel becomes position (0,0). Every other panel determines its position successively from those above and to the left of it. When running, an external PC controlling the array can address every panel independently. The control PC coordinates the array, handling tasks such as scaling images to the available number of panels.

Figure 36. Modular Light Display Panel Module Block Diagram

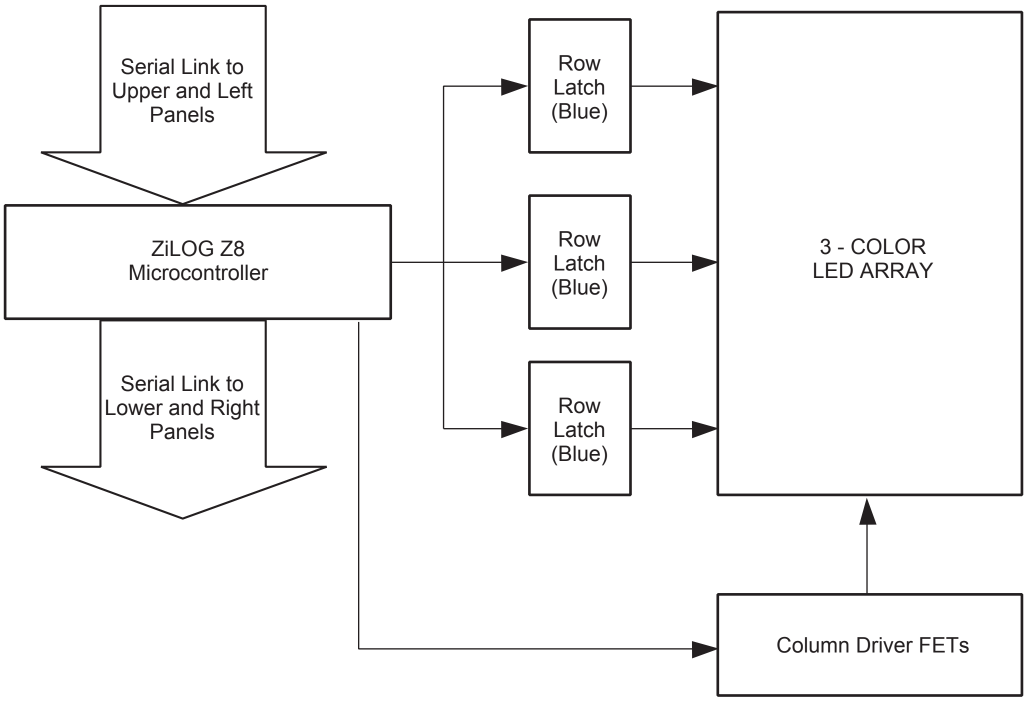
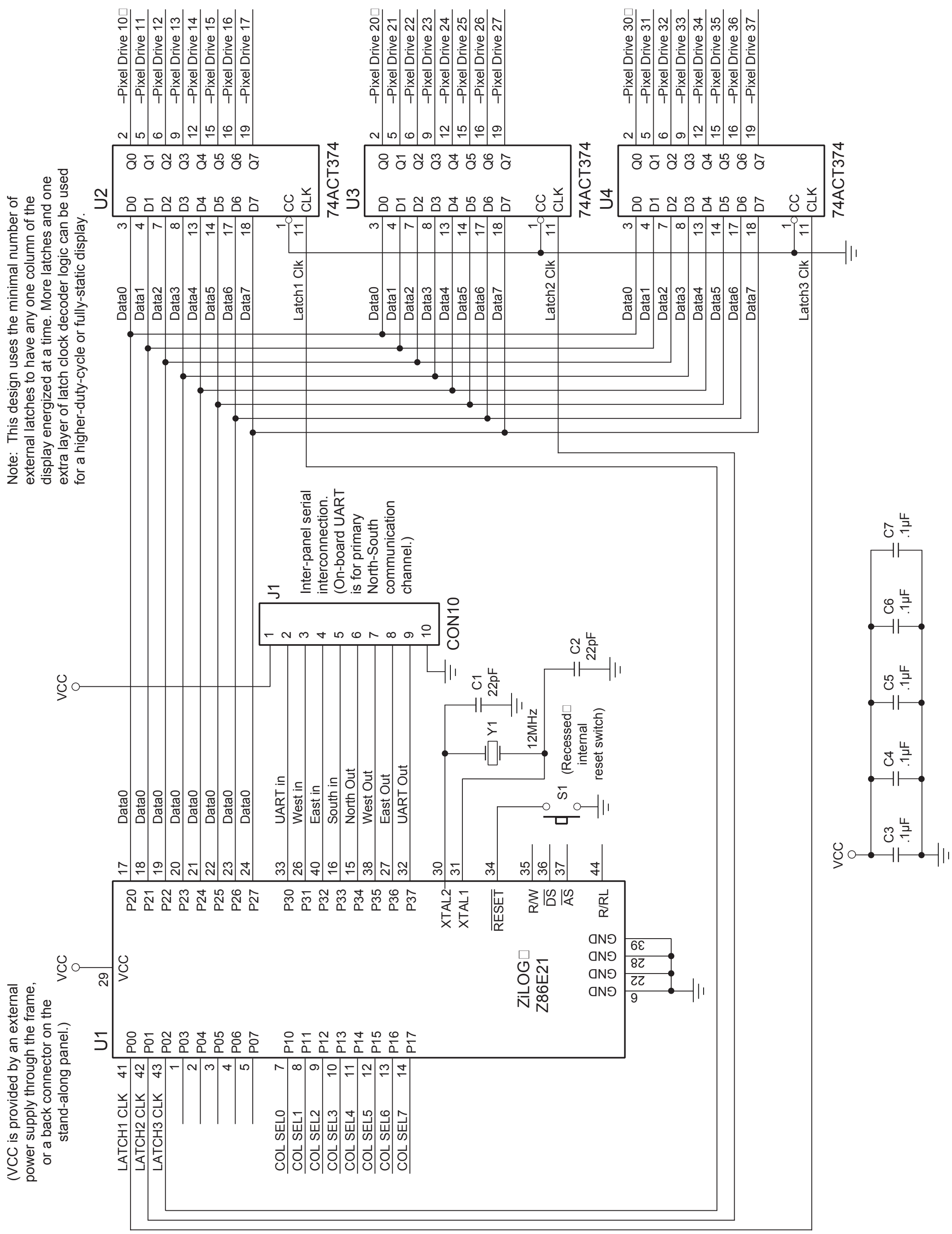


Figure 37. Modular Light Display Panel Module Schematic Diagram



Nasal Oscillatory Transducer

Submitted by: Sarah Brandenberger and Doug Keithley

Abstract

The Nasal Oscillatory Transducer (N.O.T.) is an electronic device that does not use drugs or chemicals. It acts as a nasal decongestant and uses a piezoelectric speaker, hooked up to the speaker of a frequency generator.

Press the N.O.T. to the offending sinus area and press the start button. The N.O.T. immediately starts alleviating sinus congestion. For greater effectiveness, set the switch to HIGH-POWER mode and an LED illuminates. In five minutes, the N.O.T. stops making sounds, and turns itself off.

By exciting the sinus' resonance frequencies, mucus becomes more fluid and is easily expelled. Various sinus cavities tend to resonate at frequencies within the audio range. Variances in individuals and even variances in sinus size within the same person dictate the requirement for exciting the sinus cavities at multiple frequencies. The N.O.T. sweeps through a range of frequencies. Through microphone feedback, the N.O.T. determines the specific resonant frequencies that are excited for a short duration. Because the resonant frequencies are dynamic (due to changing volumes), the sweep and excite process is repeated every 30 seconds for 5 minutes.

Circuit Description:

- Power Supply—LM2937 was chosen because of low voltage drop-out. The unregulated 9 volts is supplied by a battery and powers the output the output driver directly.
- Output Driver—simple single transistor drives a 45-ohm speaker. Fidelity is not necessary.
- Reset circuit—simple RC time constant as specified by data sheet
- Variable Output Voltage—the Z8 timer is configured as PWM per data sheet and output on PB1. The signal is passed through an active 2nd order low-pass filter and is used as the reference on the analog comparator inside the Z8.
- Microphone feedback—an electric condenser microphone is AC-coupled to an active 2nd-order low-pass filter and peak detector. The output of the peak detector is fed into the analog comparator of the Z8.
- Z8—direct drive of the LED indicator and the watch-dog timer prevents excessive on-time, a ceramic resonator provides acceptable timing, and a security bit protects firmware features from competitors.
- Firmware—provides all timing using a 16-bit internal timer, algorithms for modulating the output driver pin to generate sounds out of speakers, and

monitoring resonance by comparing the peak microphone signal to the PWM-generated reference.

Figure 38. Nasal Oscillatory Transducer Block Diagram

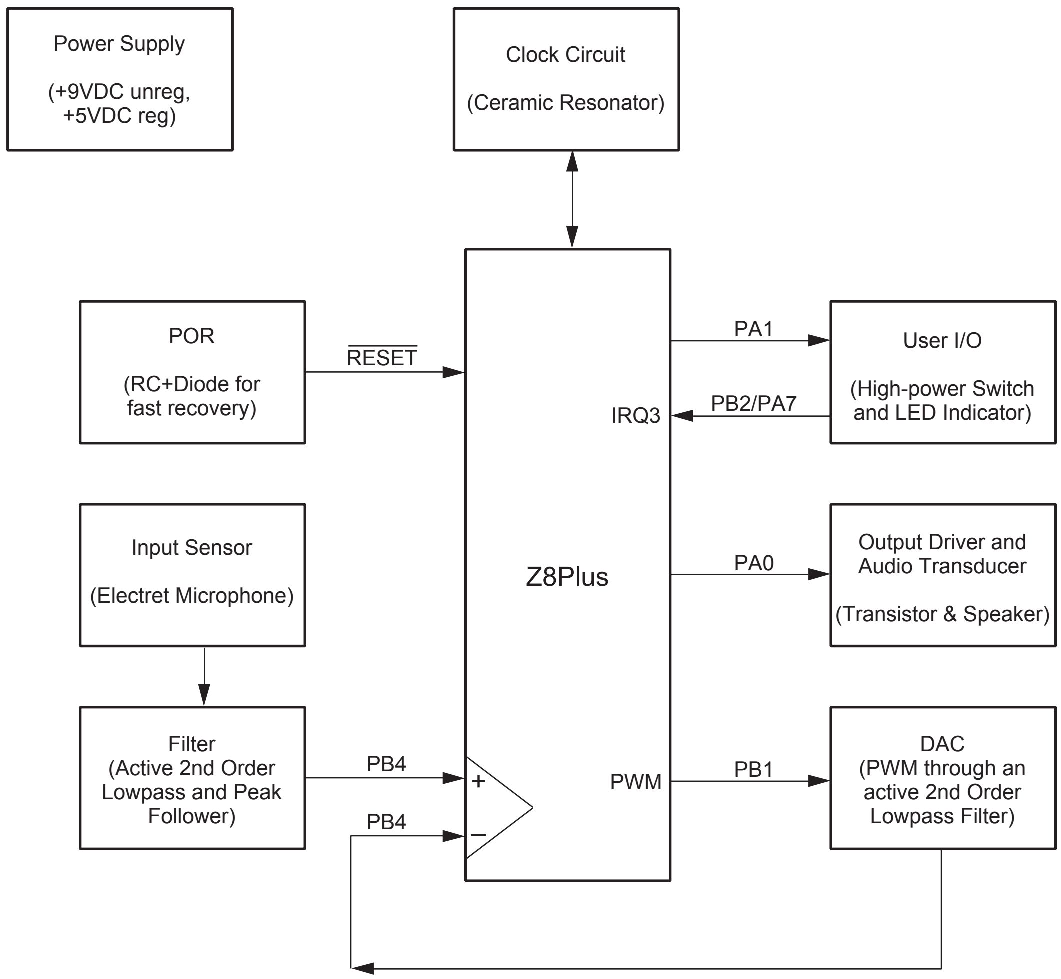
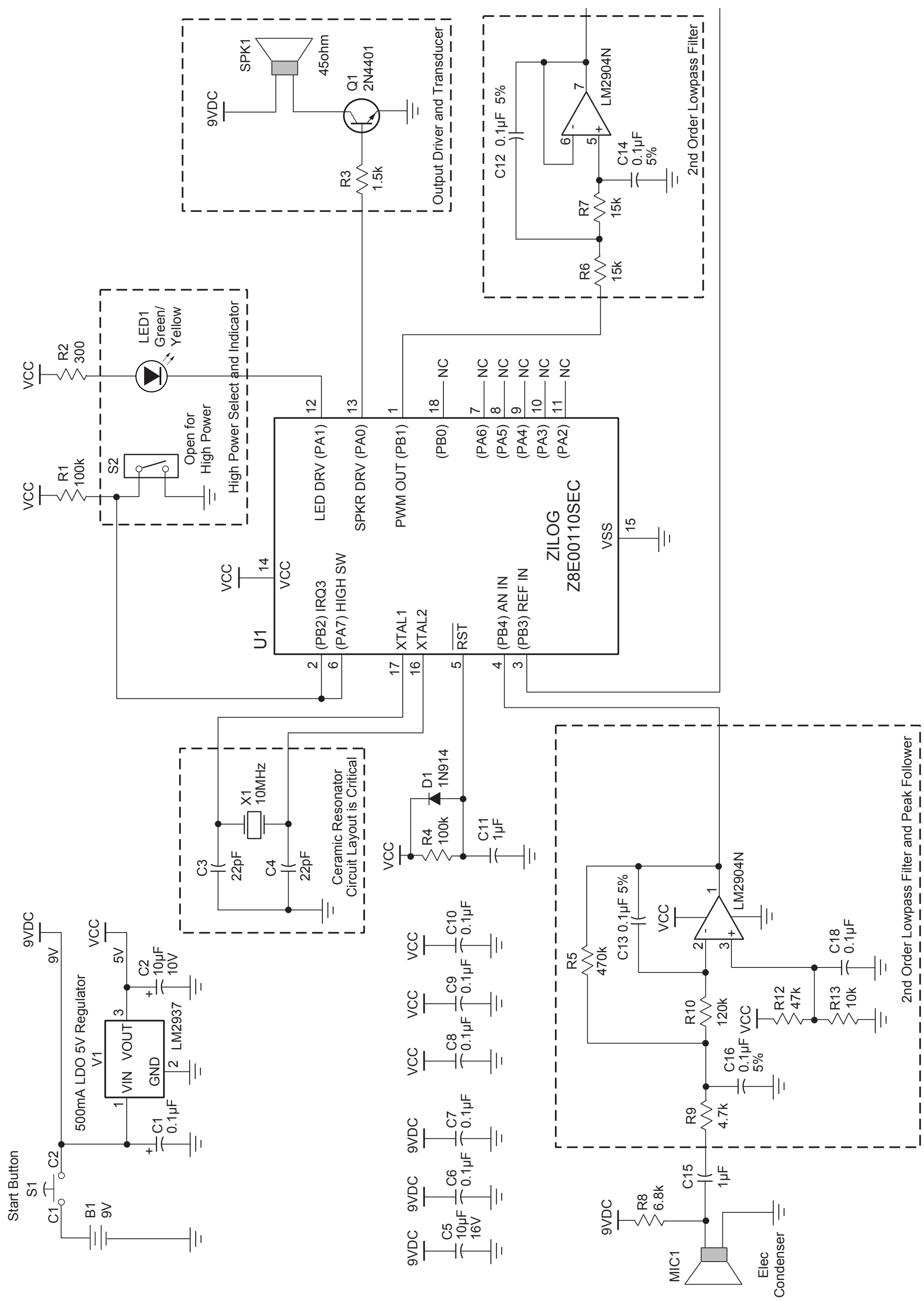


Figure 39. Nasal Oscillatory Transducer Schematic Diagram



New Sensor Technologies

Submitted by: James Champion

Abstract

The ZiLOG Z8 is ideal for use in applications where a small, minimal I/O processor is required. Incorporating different levels of capability in the same pin-out footprint makes the Z8 family an excellent choice where a series of increasingly feature-rich products are made with the same basic high-volume circuit design.

Micropower Impulse Radar (MIR) is an emerging technology that has recently attracted attention. The technology can be licensed from Lawrence Livermore Laboratories (LLNL) to develop a new series of products aimed at in-tankfluid-level sensing, and fuel-level applications. However, unlike the cover of Popular Science, a full *Radar on a Chip* is a few years away. As with any emerging technology, the first products must be flexible (programmable), avoid the development-risk ASIC or custom chip (because the technology is still emerging), and yet be cost-effective.

A ZiLOG OTP processor can perform some of the functions performed by discrete components in basic MIR Circuits, provide the required flexibility, and keep cost low on product design.

The technology employs a method of Equivalent-Time Sampling, where many thousands of pulses are sent out, and the reflected response is built-up by adding up a single time-delayed sample from each reflected pulse to form a response signal at a lower frequency than the original.

The outgoing pulses are sent at a Pulse Rate Frequency (PRF) of 4 MHz (the oscillator frequency used for the Z8). A simple reset pulse from the Z8 to start the sample time base initializes a sample delay circuit. The recovered sample signal for the fluid measuring probe features a maximum length of typically 20 msec, determined by the rate the reset pulse is sent by the Z8. Given a PRF of 4 MHz and a sample time base of 20 msec, 80,000 pulses are sampled to create the equivalent-time waveform.

An example of a reset pulse and recovered waveform are shown as the top and bottom waveforms in Figure 40. This waveform is applied to the comparator circuit of the Z8. The Z8 timer measures the time from the reset pulse to the reflection to determine the fluid level.

By using an OTP Z8, fuel tanks with unusual shapes can exhibit a level indication, compensated for the nonlinear volume response with a look-up table. Additionally, by using techniques outlined in US patent 5898308, contaminated fuel can be detected by measuring both the return pulse from the fluid level, and the return pulse from the probe end.

A 100-Hz PWM signal generated by the Z8 is used to drive an indicator. The low power of the MIR circuits and the Z8 result in easy vehicle load-dump protection.

Figure 40. New Sensor Technology Waveform

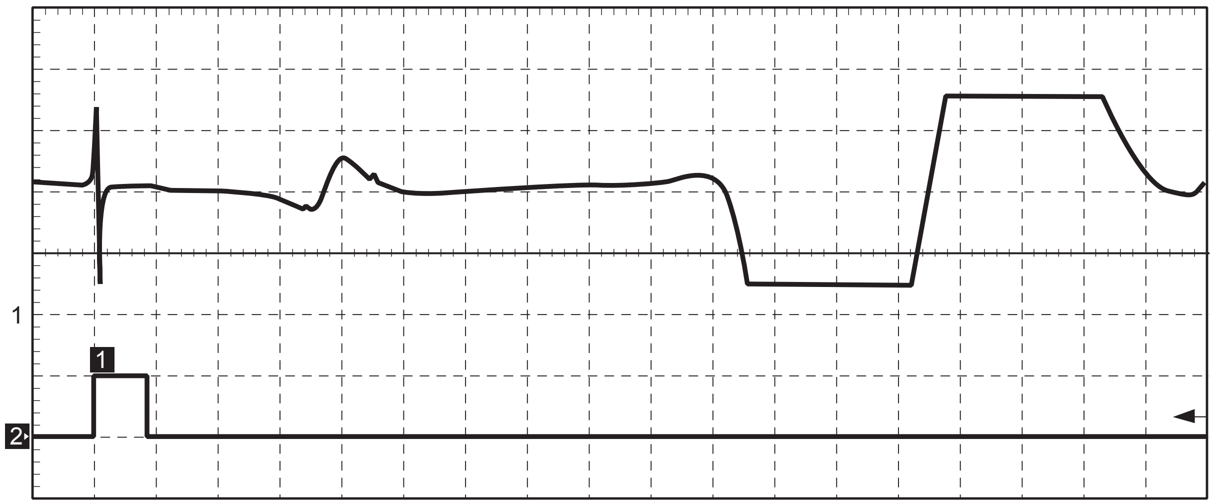
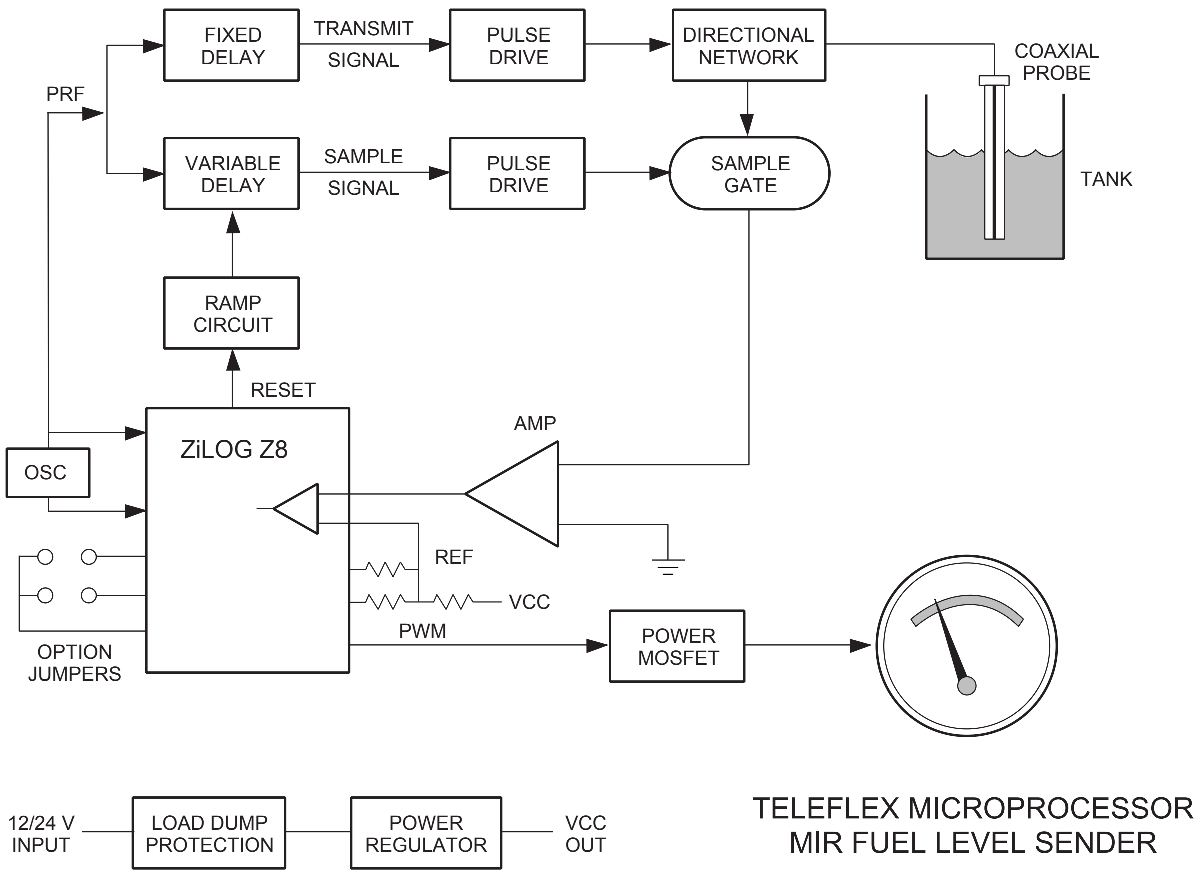


Figure 41. New Sensor Technology Block Diagram



Phone Dialer

Submitted by: Daniel Dina

Abstract

The Phone Dialer is a device that attaches to a telephone and monitors all activity from either the line or the phone. The line activity being monitored involves detecting several phone line conditions such as on-hook, off-hook, and ringing. The analog portion of the circuit detects these conditions and provides logic levels and wake-from-sleep-mode interrupts to the microcontroller.

The phone activity being monitored starts when the Phone Dialer device either detects the handset being picked up, or if programmed accordingly, answers the phone. Should a customer pick up the phone and start dialing, the Phone Dialer receives all key presses and, based on the phone number dialed by the user, generates a new string that ultimately dials out on the line. This new string contains all the prefixes and codes necessary to utilize the lowest-cost carrier available to the user. Through proper filtering, all phone numbers entered by the user are blocked from reaching the line, thus preventing the an outgoing call.

The Phone Dialer device ultimately dials the numbers, along with the proper prefixes and suffixes. The Phone Dialer device can also be programmed through the phone (by turning on the answer feature), or by picking up the phone and entering the program mode (by the use of a password).

A simple example of operation for the device is as follows:

1. A user picks up the phone.
2. The circuit detects an off-hook condition and wakes up the Z8 microcontroller, enables the filter, and starts listening for a tone generated by the phone.
3. The user dials a number.
4. The firmware begins decoding the phone number being dialed, and makes decisions based on the area code and the prefixes, using programmed routing numbers.
5. Based on all programmed variables, the device forms the complete string and dials the number.

The Z86E08 device additionally helps to reduce part count by incorporating a built-in reset circuit. Its low sleep-mode current drain enables the shut-down operation of the circuit. The device analog circuitry (D4–D7) allows the Phone Dialer to be connected to any phone line regardless of polarity.

Figure 42. Phone Dialer Block Diagram

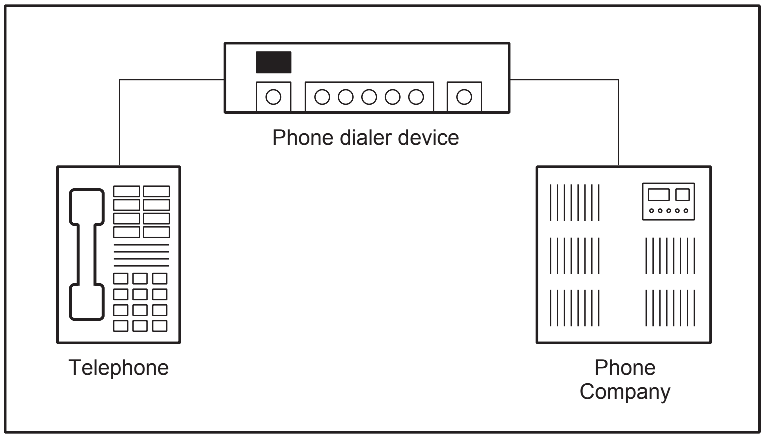
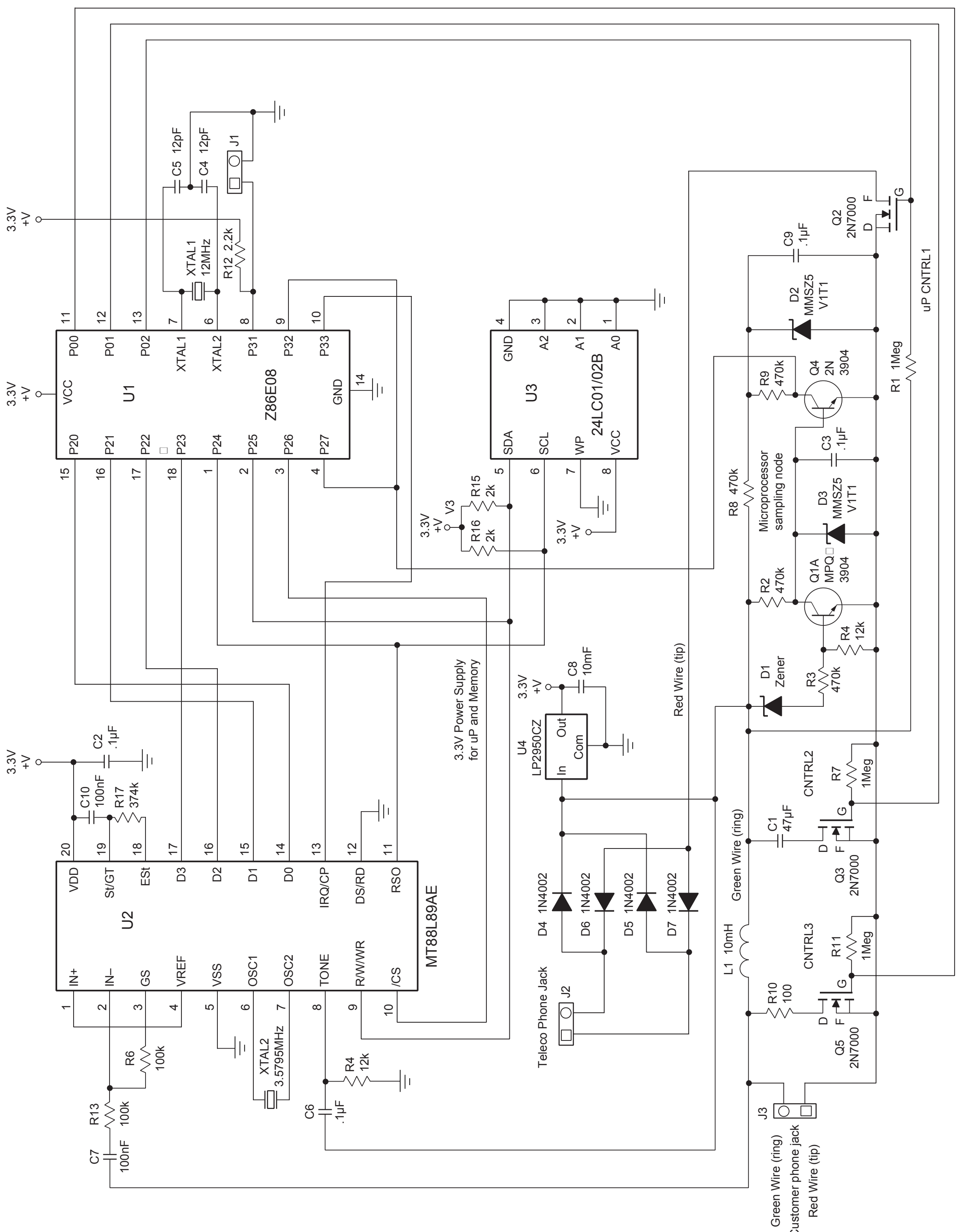


Figure 43. Phone Dialer Schematic Diagram



Pocket Music Synthesizer

Submitted by: Stan Sasaki

Abstract

The pocket music synthesizer is an instructional aid and motivational tool for elementary and middle school band and orchestra students and teachers. The synthesizer is loaded with a variety of scores, and the student can play back selected pieces and parts of any score. For example, the cello track can be removed, or just the flute track can be played. Tempo can be adjusted without affecting pitch, so that students can practice at home at their own pace. The student can jump to any location in a composition to repeatedly listen to and play along with challenging passages. This jump location corresponds to the sheet music measure number and call loop between measures. Other features include a metronome, instrument tuner, and scale transposer. Sound is output via an RF modulator played over any FM radio. The unit is similar in appearance and size to a TV remote with an LCD display. It can stand on-end on a music stand. For durability, the only connector is for battery charging.

A Z86C96 microcontroller interprets the score and the various instrument wavetables stored in a single 1-Mbyte Flash memory chip. The Flash chip contains both program and data memory. The Z86C96 features a 64-KB external memory interface. An additional four I/O lines extend the data space range to 1 Mbyte. A small complex programmable logic device (CPLD) manages the program/data memory segmentation; the CPLD also performs other I/O signal management. Each instrument track is stored in digital notation (for example, MIDI) where a note is encoded as instrument type, pitch, duration, and volume. For each note, the microcontroller reads the template note for that instrument out of the wavetable. The wavetable memory contains sound chunks of the actual instrument at selected points in its pitch range and with a prototype *attack-sustain-decay* envelope. The microcontroller adjusts for intermediate pitches by sample rate adjustment. The playback code is straightforward, because the wavetables are not compressed—the microcontroller simply reads and sums data arrays from memory.

The composite digital audio signal is written to a D/A converter, and the analog signal drives an FM broadcast band modulator. The carrier is phase-locked to allow exact tuning, because receivers are now also synthesized.

The Z86C96 scans the keypad for user commands and displays operating status in the LCD display. For example, the LCD displays the real-time measure number during playback. The microcontroller requires a crystal oscillator for pitch and modulator tuning accuracy.

The score and wavetable flash memory is downloaded from a PC by the instructor at the beginning of a school year. For grade school, the entire year's orchestration can be stored, while middle-school applications require periodic updates due to the complexity and length of scores. The memory is loaded via an infrared link directly decoded by the Z86C96's UART port. The UART interface allows any PC serial port driving an infrared diode pod to load the memory. The synthesizers for an entire class can be loaded in parallel by pointing them all at the emitter; each unit's LCD display verifies download integrity.

Figure 44. Pocket Music Synthesizer Block Diagram

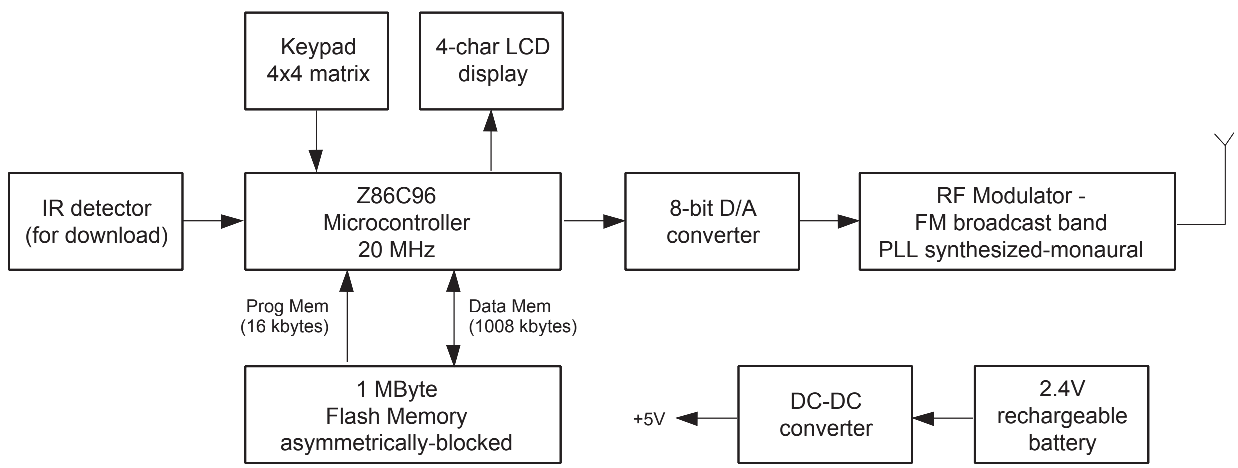
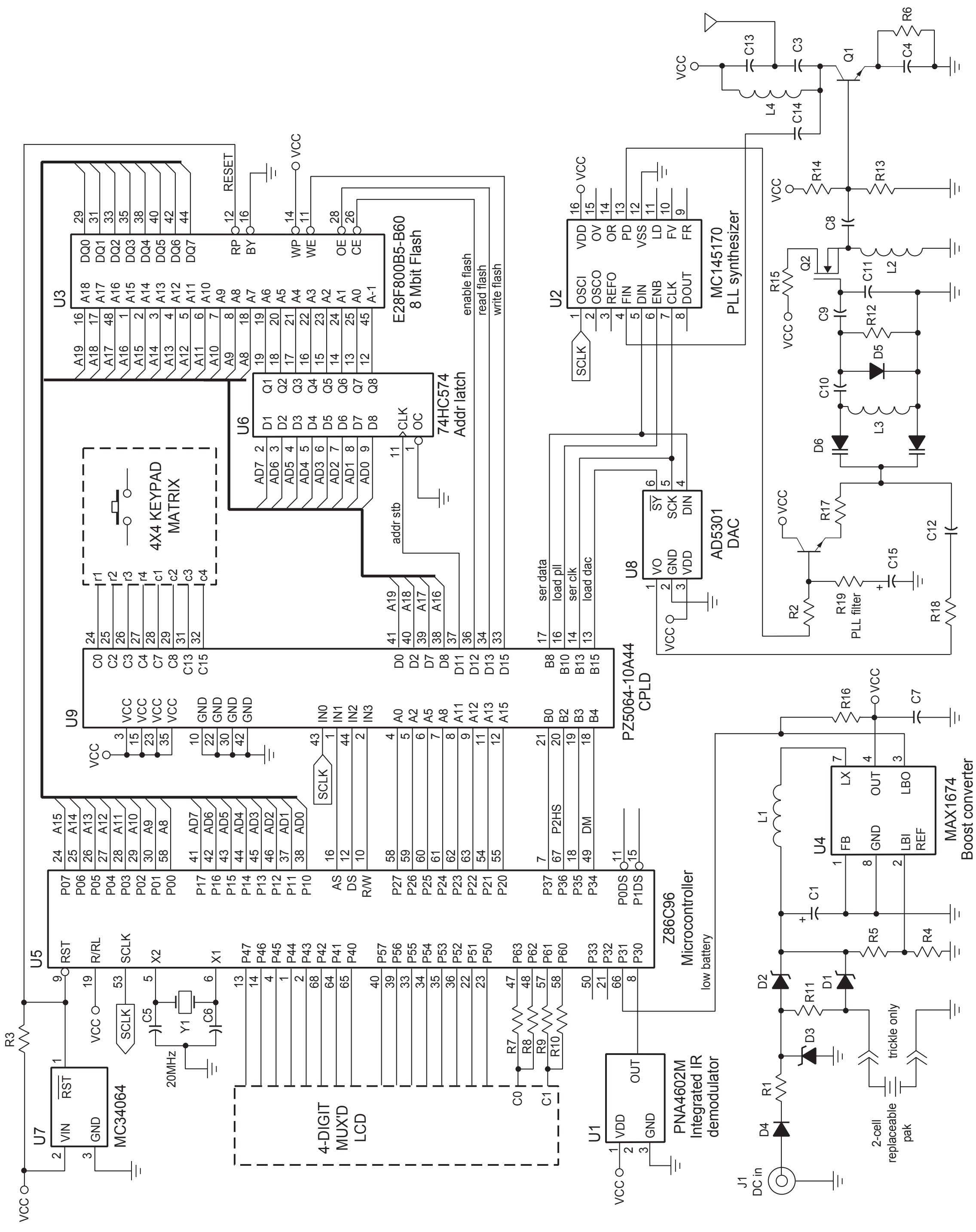


Figure 45. Pocket Music Synthesizer Schematic Diagram



Portable Individual Navigator (PIN)

Submitted by: Leonard Lee

Abstract

A ZiLOG 16-MHz Z86E83 microcontroller serves as the controller for a small, self-contained, belt-carried device that provides an individual with bearing and distance traveled on foot from an initial location. It can be used for individual navigation both indoors and outdoors. The device combines data from a solid-state magnetic compass sensor and an accelerometer-based stride sensor. The accelerometer is also used to compensate for mounting tilt. Iterative algorithms are used to compute the accumulated bearing/distance vector on the fixed-point microcontroller in an efficient way.

A typical application might be an individual who is hiking. The portable navigator can also be used indoors to track the location of people wearing the device in a certain area. When the device is initialized, the wearer can wander freely on foot, both indoors and outdoors. When it is time to return home, the device displays the required compass bearing and distance in meters to the starting point or most recent waypoint.

The design requires the sensing of voltage from several sensors. It also provides user input and display control; therefore, a microcontroller with a large number of I/O pins is required. It is possible to sense analog voltages using Z8 devices without analog-to-digital (A/D) converters (for example, measuring the charge time of an RC circuit connected to a comparator input). However, these methods require external circuitry and can be considered somewhat ad hoc measures. Consequently, the ZiLOG Z86E83 (OTP version) was chosen because it features an 8-channel A/D converter and a relatively large number of I/O pins. These features permit the PIN to include minimal glue logic and external analog circuitry. Z86E83 software is the heart of the system and performs all functions, such as reading the sensors, converting the data into distance and bearing, and managing the user interface.

The Z86E83 is configured to use a crystal oscillator clocked at 16 MHz to offer maximum code flexibility for the prototype software. To keep power supply design simple, an LM2930T-5.0 low drop-out linear voltage regulator is used to regulate the 6-V battery voltage (from two 3-volt lithium CR3032 coin batteries) down to 5 volts. The efficiency of the linear regulator in this case is 5V ÷ 6V = 83%, which is comparable to a switching supply, because the input-output differential is only 1V.

Figure 46. Portable Individual Navigator A/D Ratio Over Time

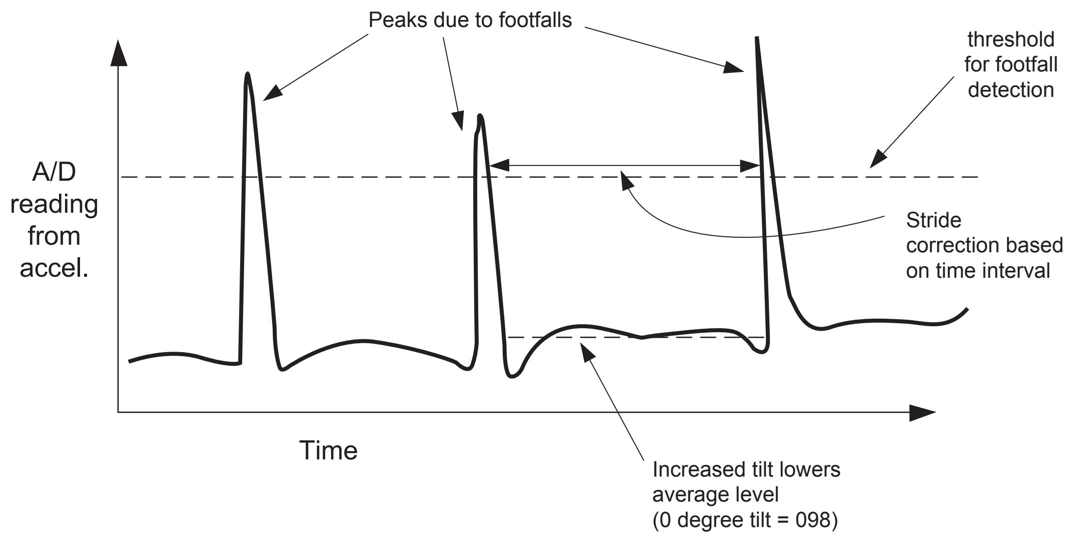
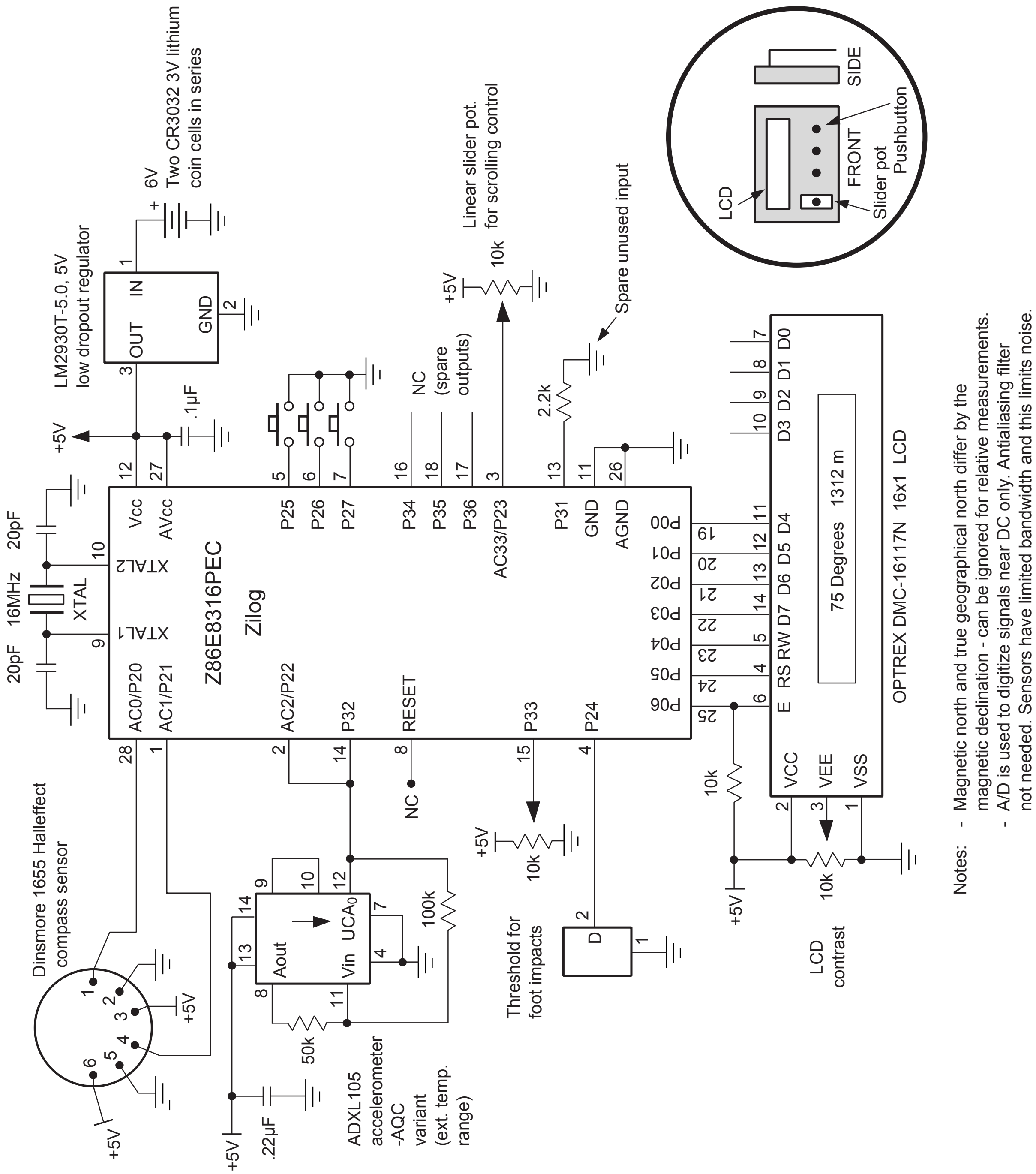


Figure 47. Portable Individual Navigator Schematic Diagram



Postal Shock Recorder

Submitted by Bryon Eckert

Abstract

The increased competition between shipping companies has brought lower costs for business and the consumer. Demand from these sectors has caused the speed with which packages are handled to become more important than care in their handling. The result has been increased breakage of fragile items.

An inexpensive shock recorder can be very helpful in pinpointing the probable time of breakage by recording the amplitude of each shock, along with a time stamp in serial EEPROM. Low cost is the most important requirement. Light weight and small volume is also important, as it relates to cost of use.

The heart of the shock recorder is the sensing element. Three sensors are used (one for each axis), each consisting of a ceramic magnet epoxied to the end of a metal strip. A shock causes the metal strip to vibrate and produce a time-varying magnetic field proportional to the amplitude of the shock.

The magnetic field variation produces a voltage across a sensing coil. Balanced amplifiers minimize interference pick-up. AC coupling to the subsequent amplifier stages eliminates the requirement for DC offset adjustment. U3C provides low-impedance virtual Ground, allowing single-supply operation while adding minimal additional power consumption. Each sensing amplifier feeds an inverting peak detector. The diodes are inside feedback loops to minimize temperature drift. All three amplifier outputs are connected across a single tantalum capacitor for charge storage.

The Z86E04 usually runs in STANDBY mode, minimizing power consumption. When a shock is detected, the peak detector voltage rises above the level preset by R27 and R28, triggering IRQ3 (rising edge). The CPU wakes and starts the A/D conversion routine. Voltage readings are taken for several seconds, with the highest reading stored in EEPROM (8-bit value), together with a time stamp (24-bit value). A second comparator is used to monitor battery voltage. A low drop-out regulator provides a stable reference voltage and makes efficient use of a low-cost carbon-zinc 9-V battery. With LM324A operational amplifiers, the overall current consumption is about 5 mA, allowing up to 100 hours of operation.

A 93LC66 EEPROM contains 512 bytes of memory, allowing up to 125 events to be stored (leaving room for the base date and time and a tracking number in BCD format). The user interface consists of a serial port and an alarm LED. The serial port is implemented in firmware, and can run at up to 38.4K baud for a 4-MHz crystal in low-EMI mode. The serial cable must be kept short (less than 6 feet), because the interface is not a RS-232-level interface. The base date and time is set through the serial port, and the EEPROM is read and erased through the

serial port. The alarm LED indicates that a shock threshold is exceeded, and/or the battery is low. PC-based software allows a user-friendly interface when the postal shock recorder is connected to a personal computer.

Figure 48. Postal Shock Recorder Block Diagram

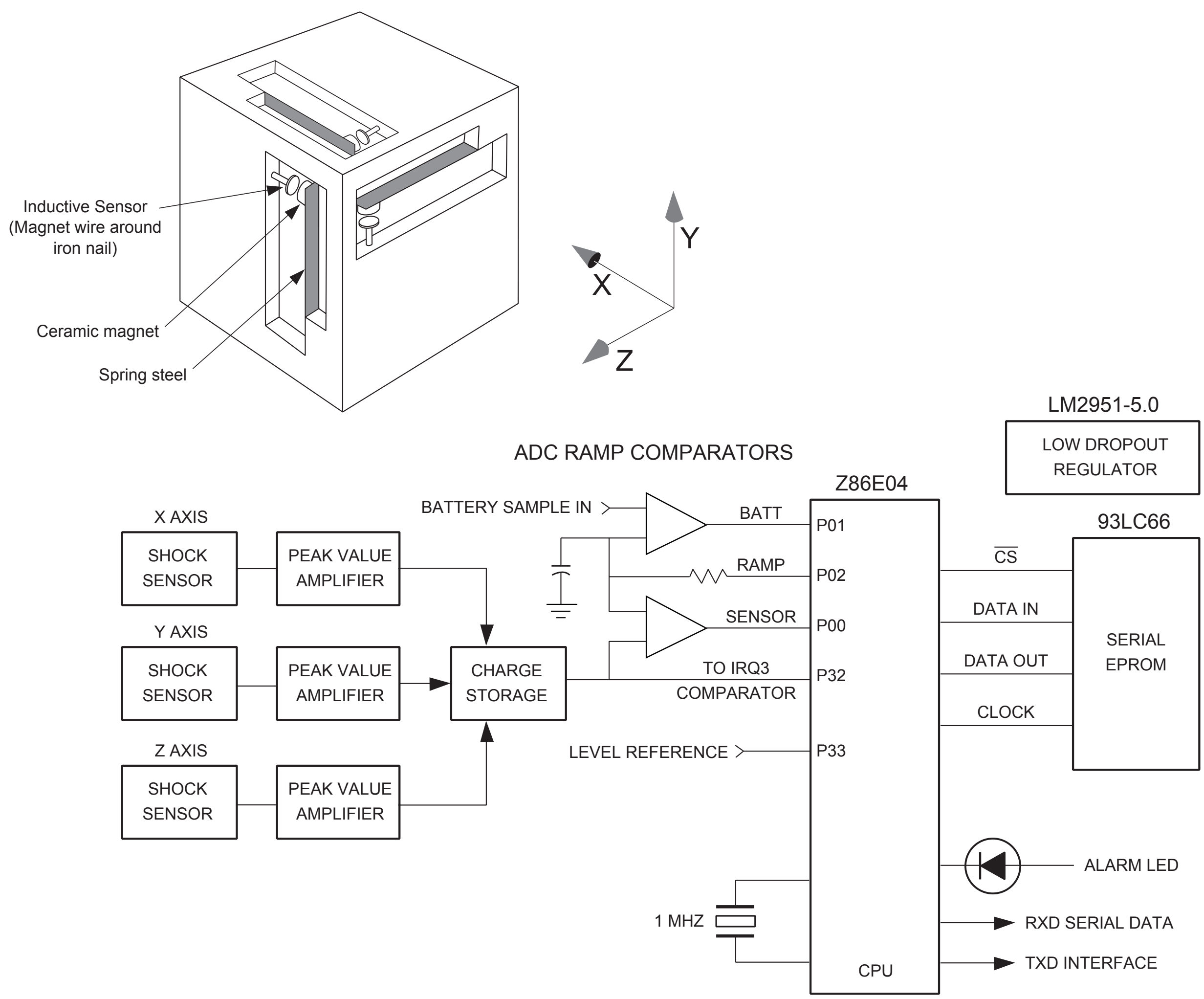
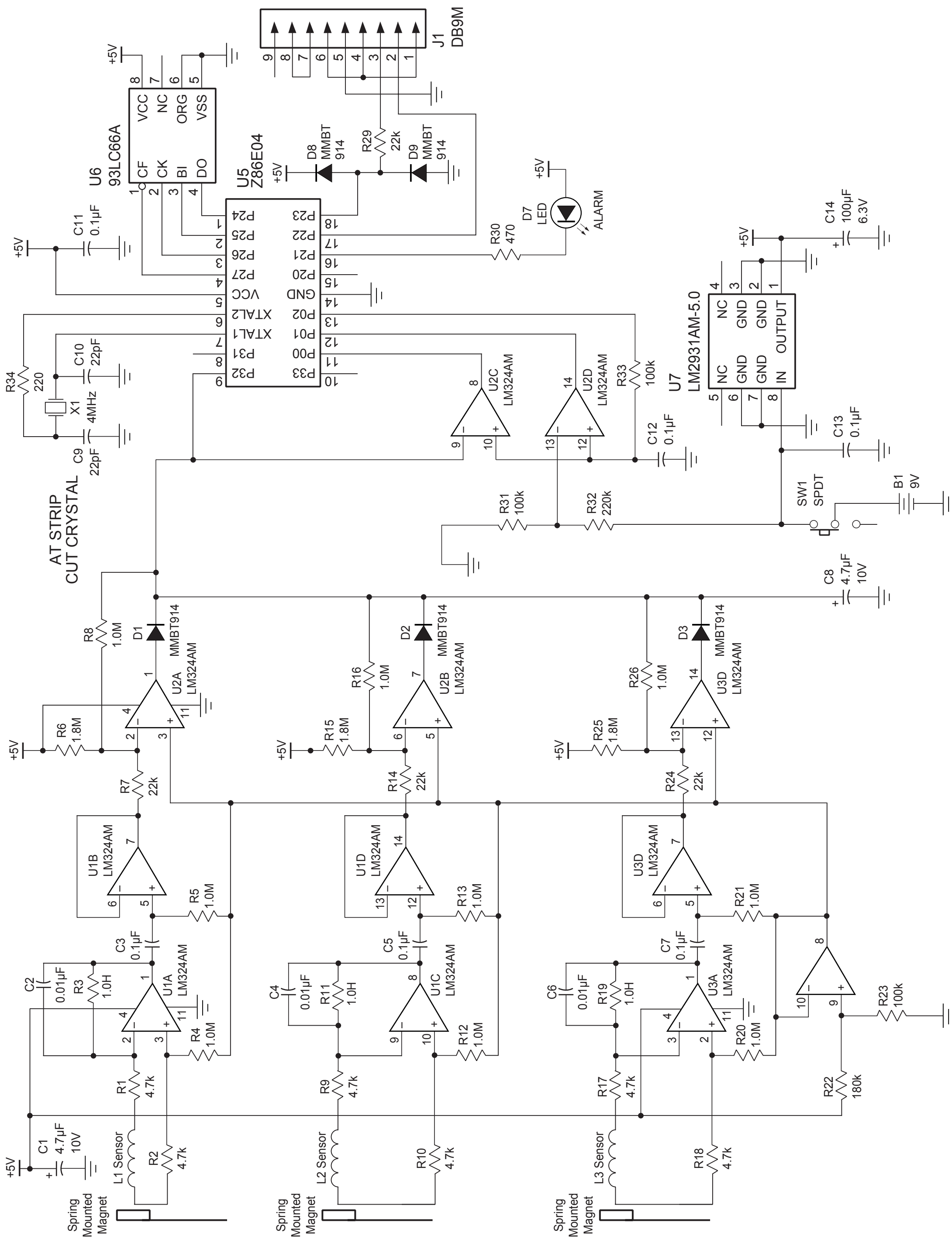


Figure 49. Postal Shock Recorder Schematic Diagram



PWM Input/Output Interface Module

Submitted by: Fernando Garcia Sedano

Abstract

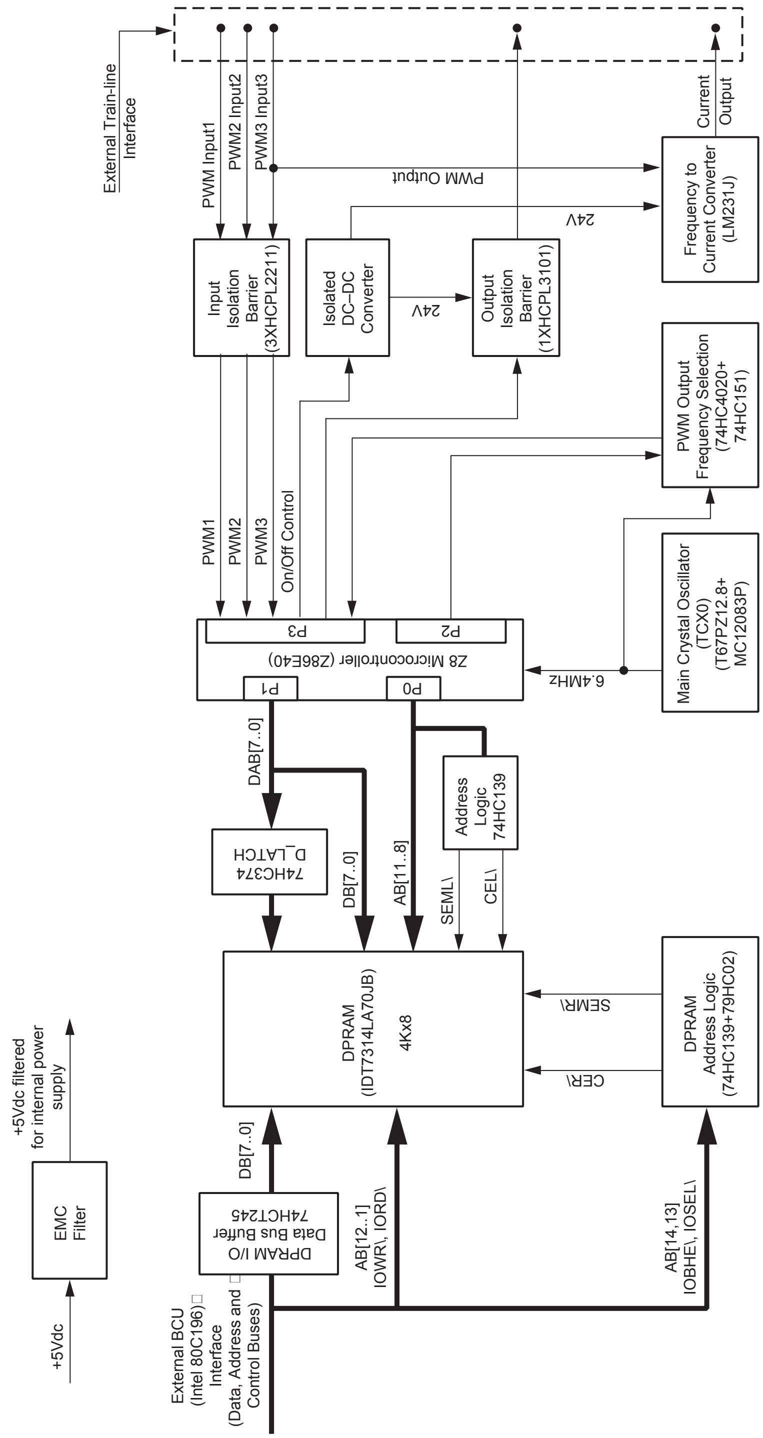
The PWM I/O interface module is designed to process pulse-width monitor (PWM) input and output signals, very often used on railroad vehicles to transport analog information on train lines (for example, brake demand). With a PWM signal, analog information is a function of duty-cycle index modulation. Usage of PWM signals to transport analog information is due to the very high electrical noise immunity. It is also easy to isolate a PWM signal from other voltages, due to the pseudodigital appearance, making these signals suitable to be demodulated using only digital circuits.

The circuit receives three different PWM input signals with galvanic isolation at two different voltage levels (depending on R10 and R11 value). There are three input stages (U2, U3, and U4) with their corresponding overload protection (T6, R12, T7, R7, T8, and R8), and with EMC protection (D1, D2). The third PWM input channel (U4) feeds back the PWM output signal ($24V_{PP}$ maximum).

The Z8 microcontroller is programmed to demodulate PWM input signals, to count the times where PWM input is at high and low levels, and to perform the corresponding division. Obtained values are loaded in the DPRAM. The Z8 is programmed to address external memory using Port 0 and Port 1 to send address and data lines.

DPRAM works as a data buffer between the Z8 microcontroller and any other external microprocessor or microcontroller.

Figure 50. PWM Input Output/Interface Module Block Diagram



Reaction Tester

Submitted by: Martin Bass

Abstract

The Reaction Tester measures the reaction time of an automobile driver using repeated cycles of signaling, time measurement, data display, data transmission via serial interface (to a PC that performs evaluation over the entire runtime), and waiting randomly for the next signal. Power-on also performs a system check (display, lamps, buzzer, and serial interface) at this time.

All system functionality is performed by software:

- LED-multiplex for 7-segment display and lamps
- Sound via buzzer
- Reading status of the contact switches
- Serial output

This device is built into a car simulator (a box containing seat, steering wheel, and two pedals) and uses contact switches to check for steering left, steering right, gas, and brake.

A Z86E0812-1866 is the heart of this device, which is optimized for maximum integration and minimum parts count. The power supply is an AC/DC wall adapter that delivers an unregulated 9volts to 12volts at a 500-mA load. A capacitor and standard linear voltage regulator uses a diode in series to protect against a wrong connection and a ZORB diode for overvoltage protection. The multiplexed display consists of 3-digit drivers and the 74AC164 shift register; these components perform I/O expansion and power-sink driving for segment currents.

Multiplexing drives three of the four LED lamps. The buzzer is driven by the controller port pin via a small electrolyte capacitor in series, and is controlled by software. The serial interface yields real RS-232 voltages (approximately +4V, +8V, and –9V under load) to be operable even on problematic PCs (for example, some laptops do not interpret 0V for the more negative voltage). If there is an immense cost problem, it can be easily downgraded to +5V/0V.

To read the status of the contact switches, the Reaction Tester includes an interface consisting of pull-up resistors, capacitors for noise clamping, and input protection for the controller port. The oscillator is run by an 8-MHz quartz crystal.

Figure 51. Reaction Tester Block Diagram

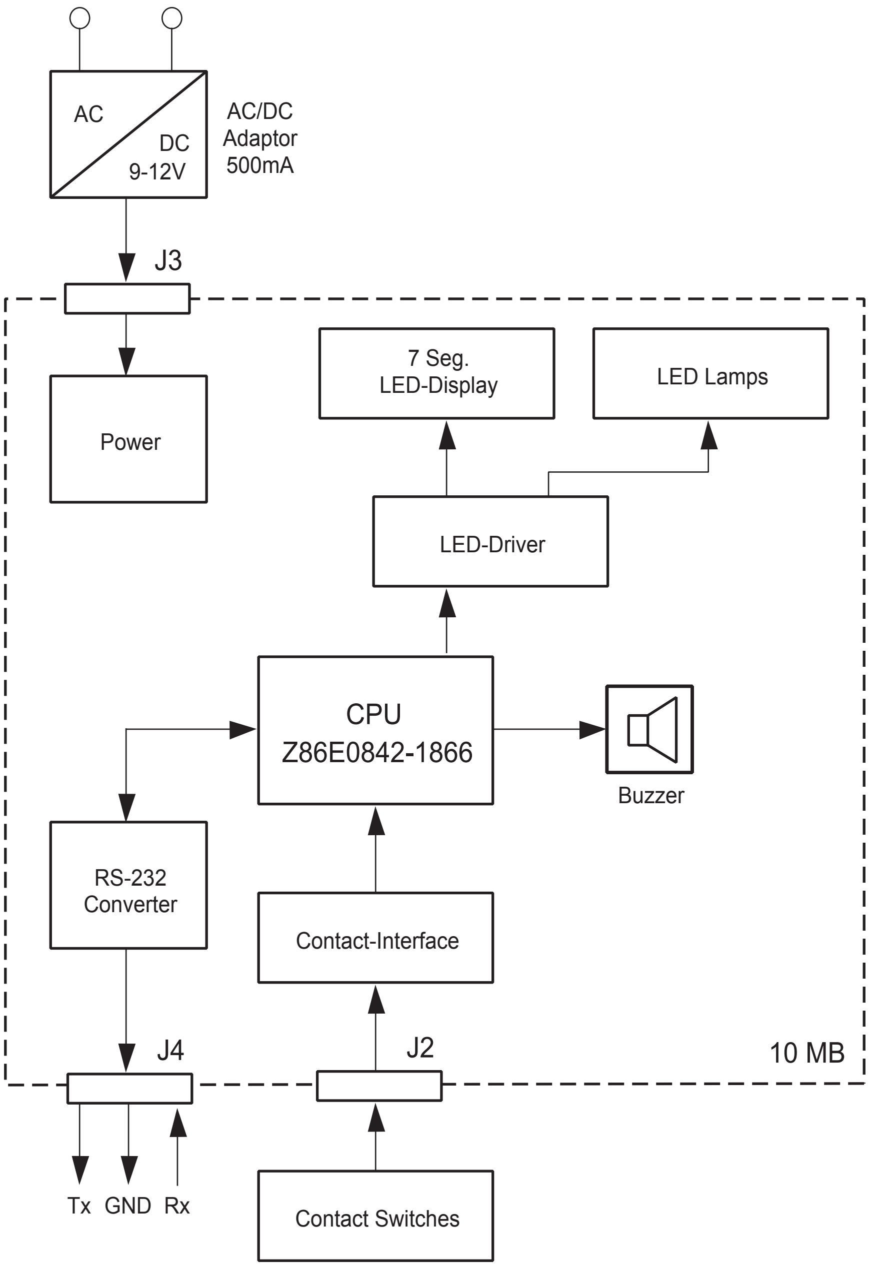
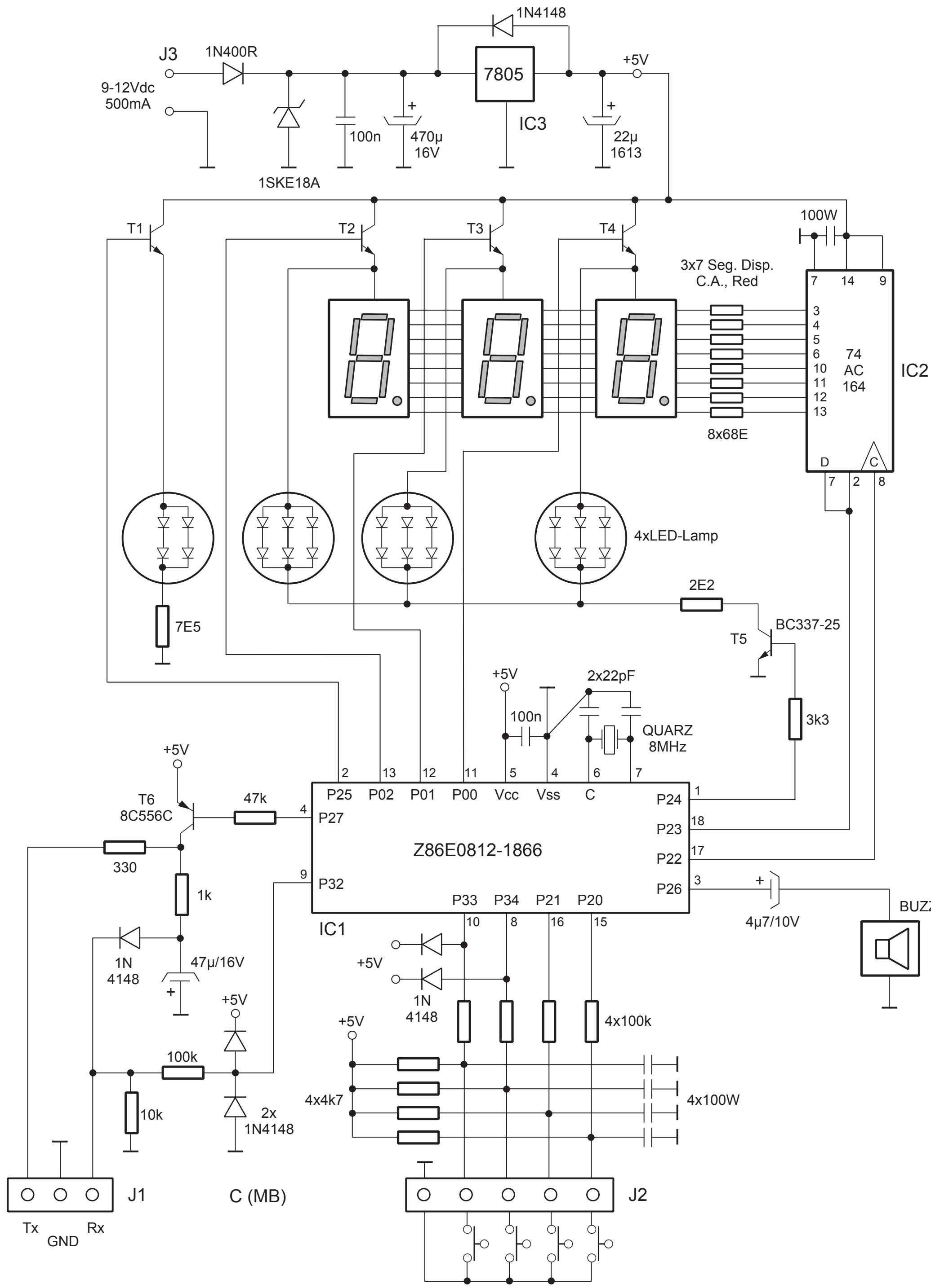


Figure 52. Reaction Tester Schematic Diagram



Remote-Controlled Air Conditioner

Submitted by: Shailendra S. Vengutlekar

Abstract

The Z86E30 controls an electronic air conditioner. Remote-controlled operations are available together with manual key operations. The remote range is 10 meters.

There are two different sensing points for temperature control. A/D conversion uses two analog comparators. The A/D channels work simultaneously with PWM reference P33. Previous settings are restored when the unit is powered on.

The electronic air conditioner uses two timers. INTR4 tracks the time of the On/Off timer control mode, stepper motor control pulses, SLEEP mode, day-mode time track, remote-control pulse count, and display refresh pulses. PWM generation for A/D conversion uses INTR5.

The Remote-Controlled Air Conditioner features the following items:

- Fuzzy temperature control
- Four modes of operation
- Three fan speeds
- Automatic fan speed
- Stepper motor control for split air conditioner
- 12-hour On/Off timer
- Selectable room temperature
- Air-swing On/Off control
- ZiLOG Z86E30 microcontroller

Figure 53. Remote-Control Air Conditioner Block Diagram

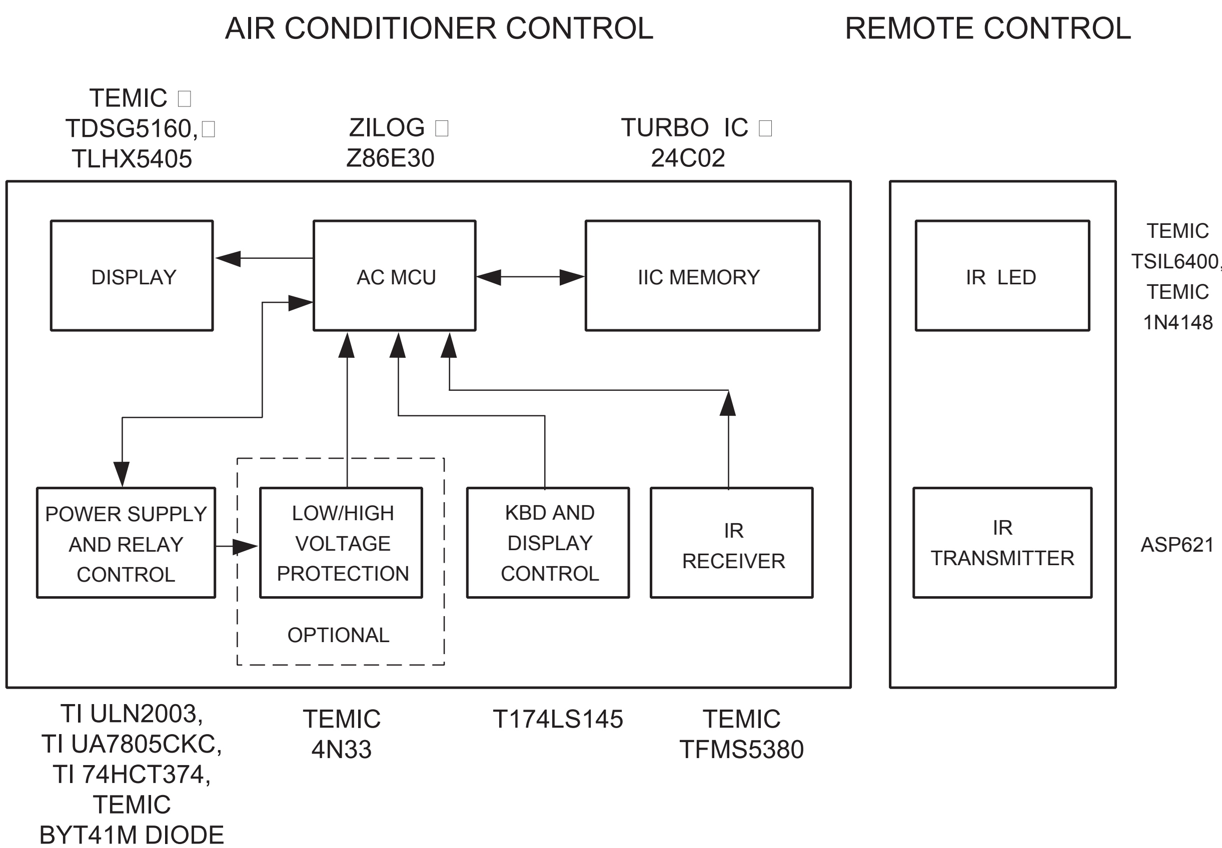
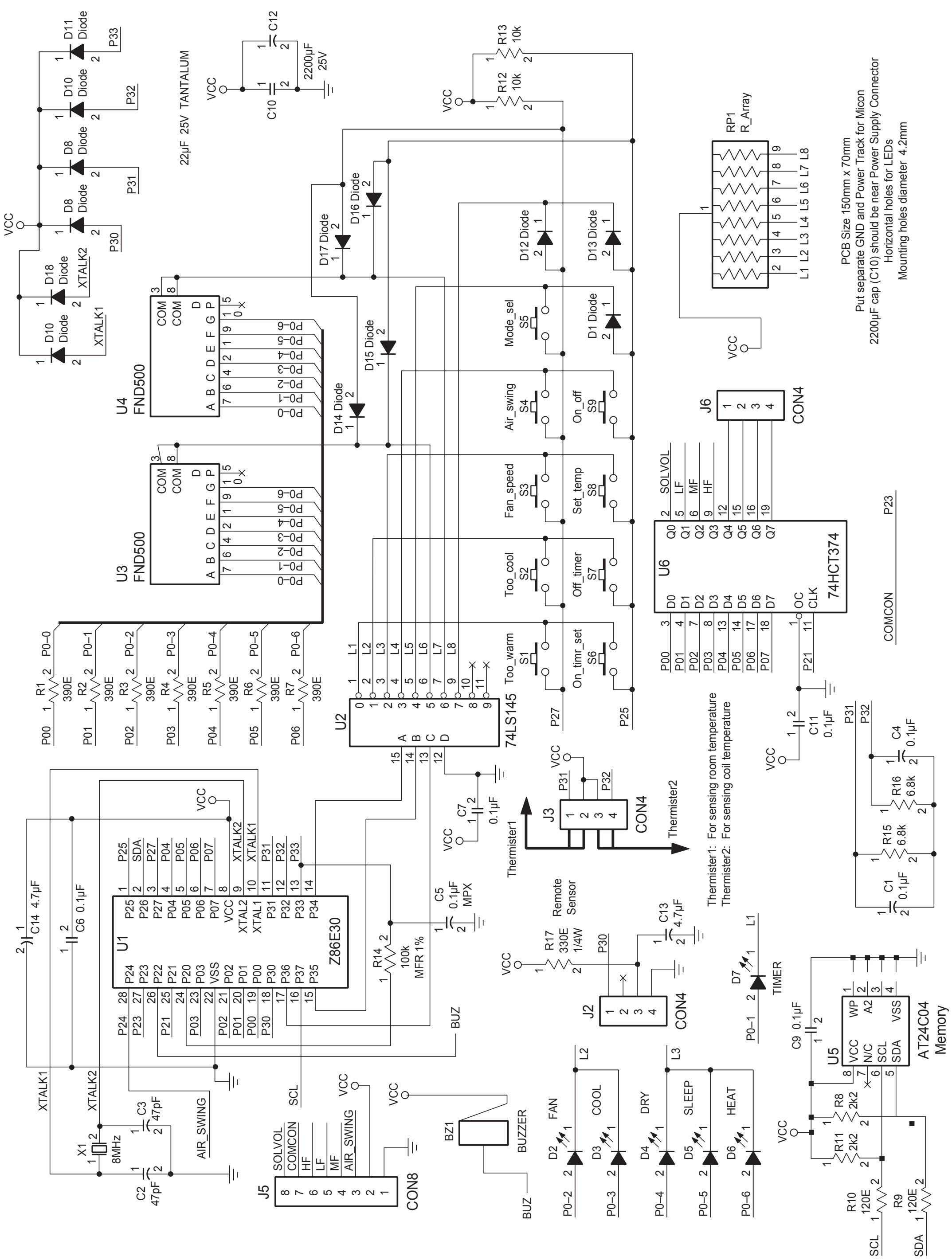


Figure 54. Remote-Control Air Conditioner Schematic Diagram



Remote-Control Antenna Positioner

Submitted by: R. Sharath Kumar

Abstract

Antennae, parabolic dishes, and other types of wireless signal-receiving devices are today a common essential necessity in almost every home, office, and military application. Owing to the present number of communication satellites, it is often necessary to precisely reorient an antenna to different positions. Generally, this procedure involves laborious cranking of mechanical gears while observing a calibration scale.

A microcontrolled antenna-positioning device allows a user to align an antenna to the required elevation/azimuth precisely to the nearest degree by pushing a button on an infrared hand-held remote.

The device consists of two modules: a controller and a hand-held infrared transmitter. The controller module based on the Z86E31 manages reception of coded commands from the hand-held remote. The Z86E31 decodes a command and drives the two motors to align the elevation/azimuth. The LCD display is updated to indicate the exact aligned position. Up to 20 positions can be preset on the system memory and recalled for alignment. Positive feedback is incorporated to ensure precision up to the nearest degree. Fault tolerance is embedded to avoid an erroneous command value from overdriving and damaging the antenna or the mast. The motion circuitry is biased-off and a beeper sounds along with the message `Error: Out Of Range` flashed on the LCD of each module.

Encoded commands from the hand-held remote are received on the infrared receiver D1A and processed by the microcontroller. The beeper is pulsed On/Off to indicate a successful decode. The power transistors T5–T8 and T13–T16 are biased-on to drive the elevation and azimuth motors M1 and M2, respectively.

Figure 55. Remote Controlled Antenna Positioner Block Diagram

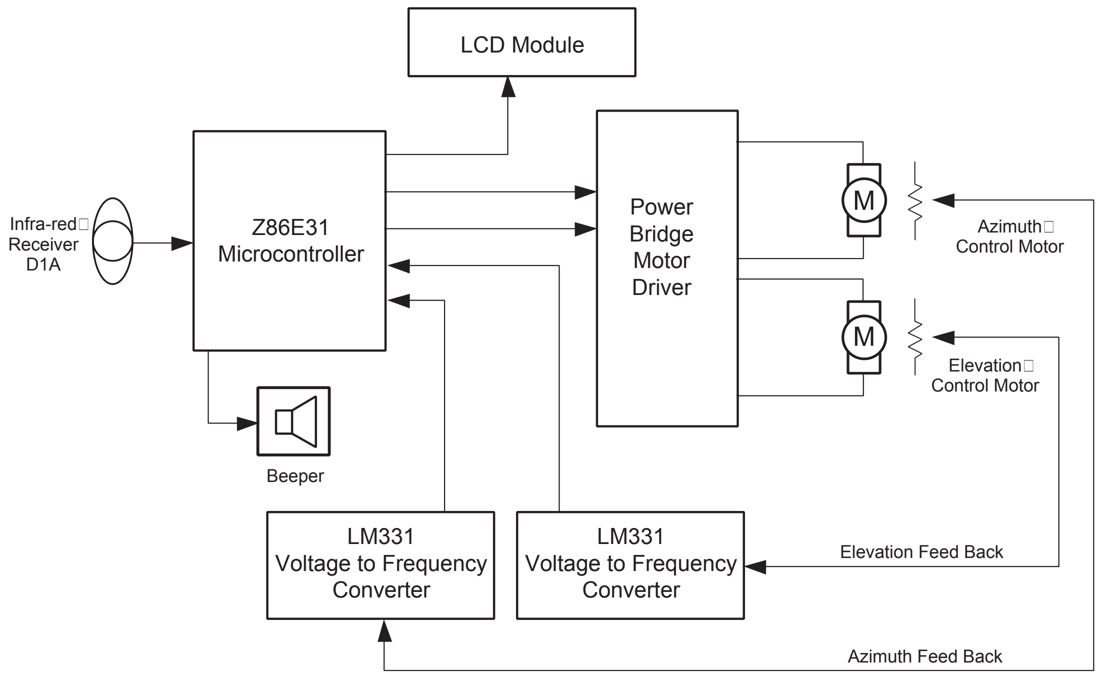


Figure 56. Hand-Held Remote Block Diagram

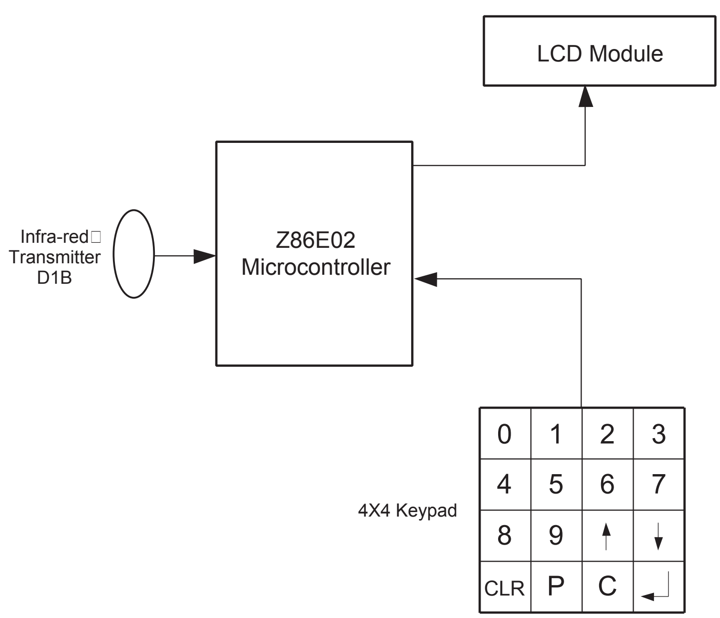
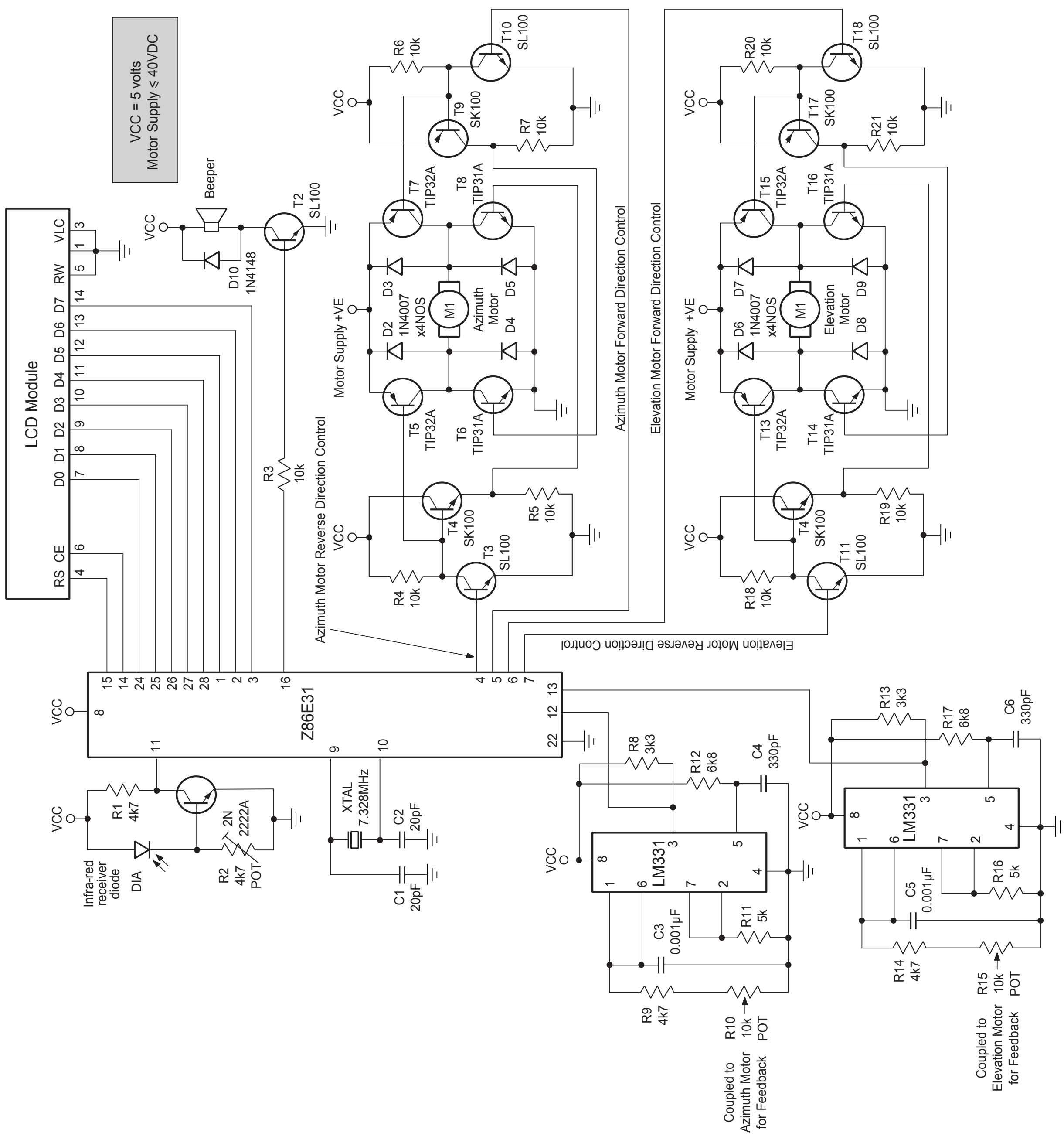


Figure 57. Remote Controlled Antenna Positioner Schematic Diagram



RF Dog Collar

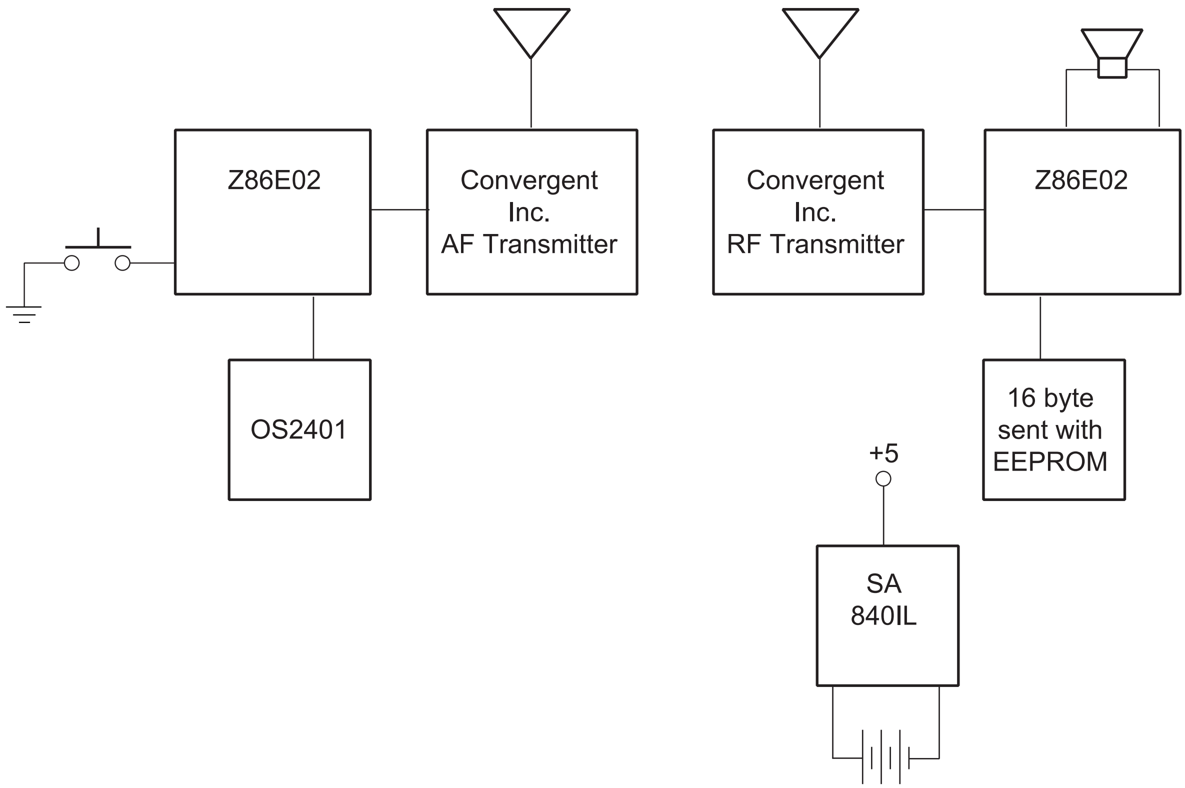
Submitted by: John Kocurck

Abstract

Current electronic fencing relies on a wire that is buried around the perimeter of the area to be fenced. A signal is sent through the wire that activates a dog collar should a dog stray too close to the barrier. If the dog decides to chase a varmint, it triggers a beep (or shock) when it enters the area around the buried wire, and nothing more.

Using the ZiLOG Z86E02 on both the transmitter and the receiver, a better system can be designed. This system addresses the weak points of the electronic fencing systems currently on the market. Each transmitter features a unique 64-bit number supplied by a Dallas Semiconductor DS-2401. That number, along with a control byte, is transmitted via a Convergent Inc. radio transmitter at approximately 2 Kbps. Each transmission lasts for less than 50 ms and is repeated every 250 ms. The dog collar receives the packet and checks if the serial number is stored in its 128-bit serial EEPROM. If it checks out, the processor in the collar resets. If the collar does not receive a valid packet within 800 ms, it enters ALARM mode and sounds the buzzer. As a result, the dog returns to the house. When the dog is back in range, the collar resets and turns off the buzzer. New transmitters can be added by bringing the collar into range and pressing the button on the transmitter. The transmitter then sends out a special control packet and serial number that the collar recognizes, and stores it into the EEPROM for future reference. This method allows the building of short-range jammers to deny certain areas and also small hand-held units for RF leashes. Because of the unique 64-bit serial number, neighbors using the same dog-control system do not extend the dog's range because of overlapping areas.

Figure 58. RF Dog Collar Block Diagram



Signature Recognition and Authentication

Submitted by: James Doscher and Harvey Weinberg

Abstract

As more transactions are completed electronically, concerns about threats to data security increase. In particular, a user is required to be able to ensure that no one else can forge a signature or a password. There are new products on the market that attempt to solve this problem. For example, there are mouse devices that claim to be able to read fingerprints, and much development is occurring in the area of digital signature analysis.

An alternative solution is a pen device that recognizes the unique characteristics of a signature to authenticate the user. Typical applications could be encryption, secure web transactions, receiving (signing for a UPS package), and controlled access to secure data.

Existing systems, such as pen tablets, record the shape of a signature, but not necessarily the speed or emphasis (pen pressure) of the signature. By using a micromachined accelerometer to sense pen movement, an individual's distinctive signature motions can be recorded and compared against a stored copy. Recognition algorithms from speech processing are used to compare and correlate a person's signature. Prototype systems have already shown greater than 90% accuracy in recognition.

At the heart of the system is a ZiLOG Z8 for recognition algorithms, and the Analog Devices ADXL202 dual-axis accelerometer. The Z8 fans the recognition algorithms, decodes the accelerometer signal, and administers power management for the accelerometer. The accelerometer measures pen movements in the X and Y-axis in the plan of the paper.

Figure 59. Signature Recognition and Authentication Module Block Diagram

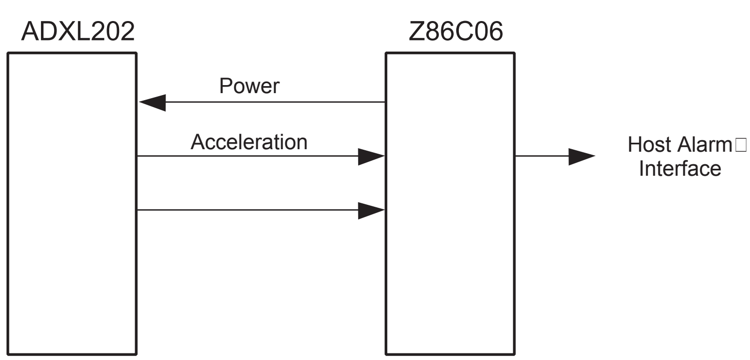
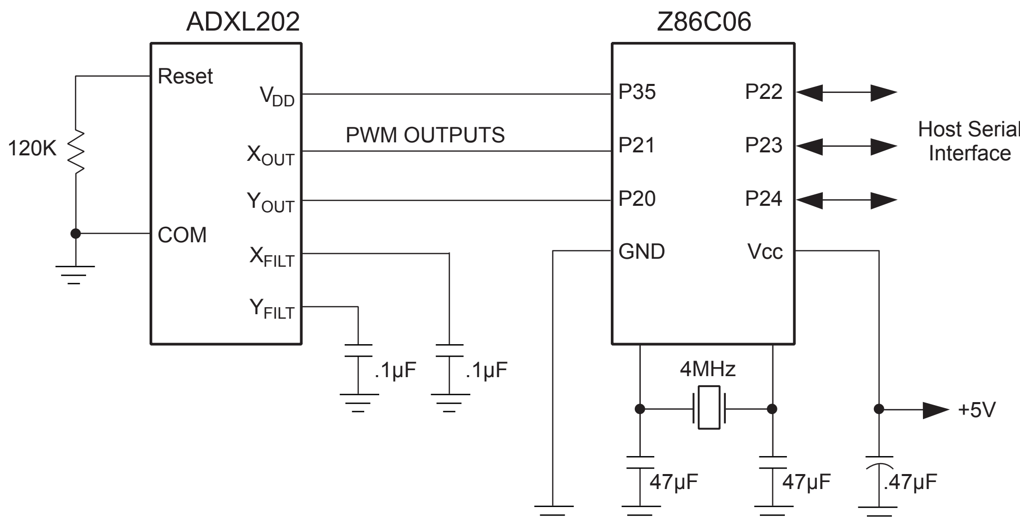


Figure 60. Signature Recognition and Authentication Module Schematic Diagram



Smart Phone Accessory

Submitted by: Syed Naqvi

Abstract

The Smart Phone Accessory eliminates the hassle of dialing long strings of telephone numbers by employing predefined user-programmed keysets. The Z8 microcontroller offers many advantages toward this solution, by providing the required power, RAM, and ROM to perform the application. The Z8 features scalable software compatibility and a configurable I/O that offers great flexibility in the design. The Z8 is also relatively inexpensive.

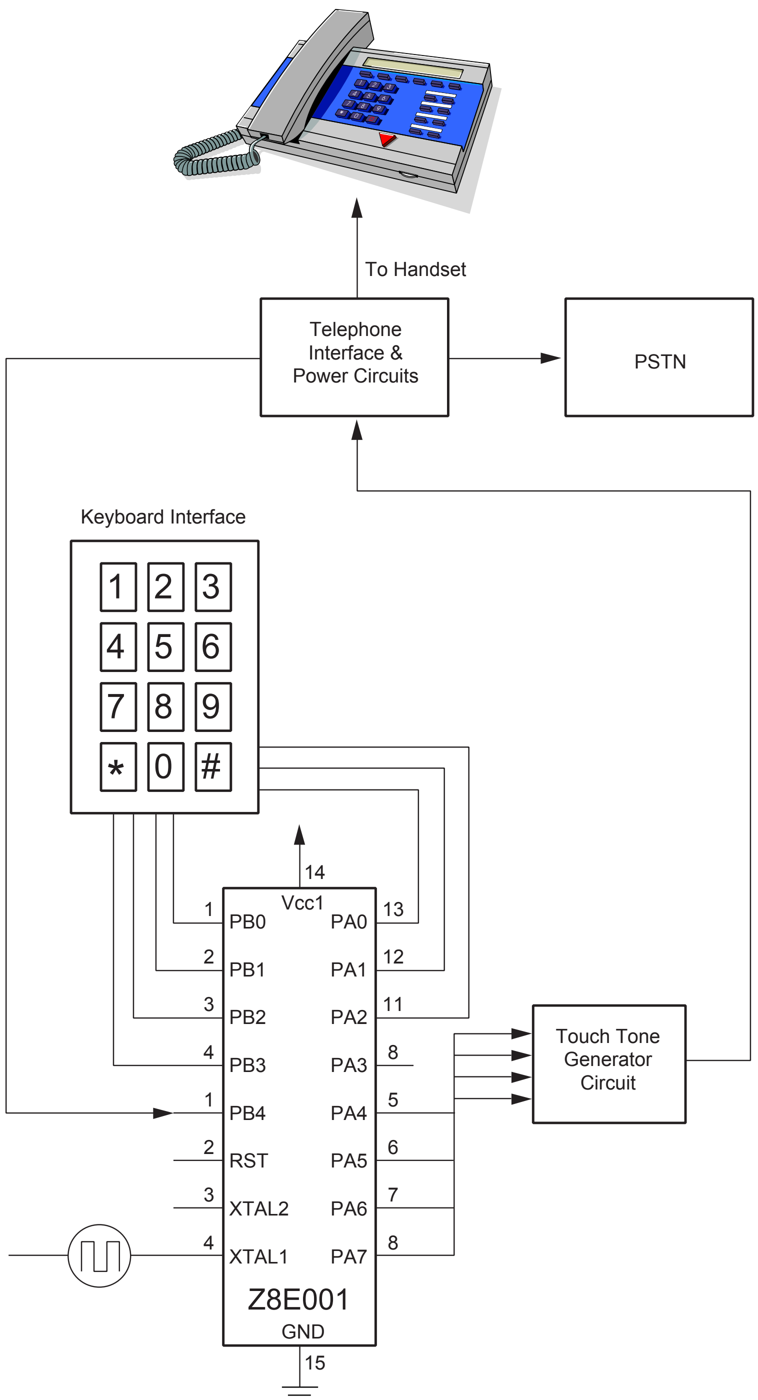
Caller ID offers unique usability to the party receiving the phone call. In most cases (depending on the service provider), the name and telephone number of the calling party is displayed. The receiving party can then keep a log of received calls for future use, or accept a choice of not answering the telephone call. On the other hand, most telephone companies offer the choice of an unlisted (unpublished) telephone number. However, if a person with an unlisted phone number makes a call, there is a possibility that his/her phone number will be displayed to other parties. The Caller ID feature can be disabled by dialing a predefined key sequence prior to calling. This step can be cumbersome and hard to remember on a regular basis.

Another very popular and fast-growing telephone service is the 10-10 calling service. Customers can secure very competitive long distance rates by predialing 7 more digits plus the phone number. The Smart Phone Accessory automatically dials the numbers prior to each call.

The Smart Phone Accessory is designed to work in series with the telephone handset. The product can use the telephone handset number pad, or it can display its own number pad. The predefined keys (for caller ID and long distance) are programmed into the product. The Smart Phone Accessory can be reprogrammed or removed from the phone line very easily, thus offering customers complete flexibility. The power for the complete circuit is derived from the telephone line.

Figure 61. Smart Phone Accessory Block Diagram

Figure 62. Smart Phone Accessory Schematic Diagram



Smart Solar Water Heating System

Submitted by: Eduardo Jose Manzini

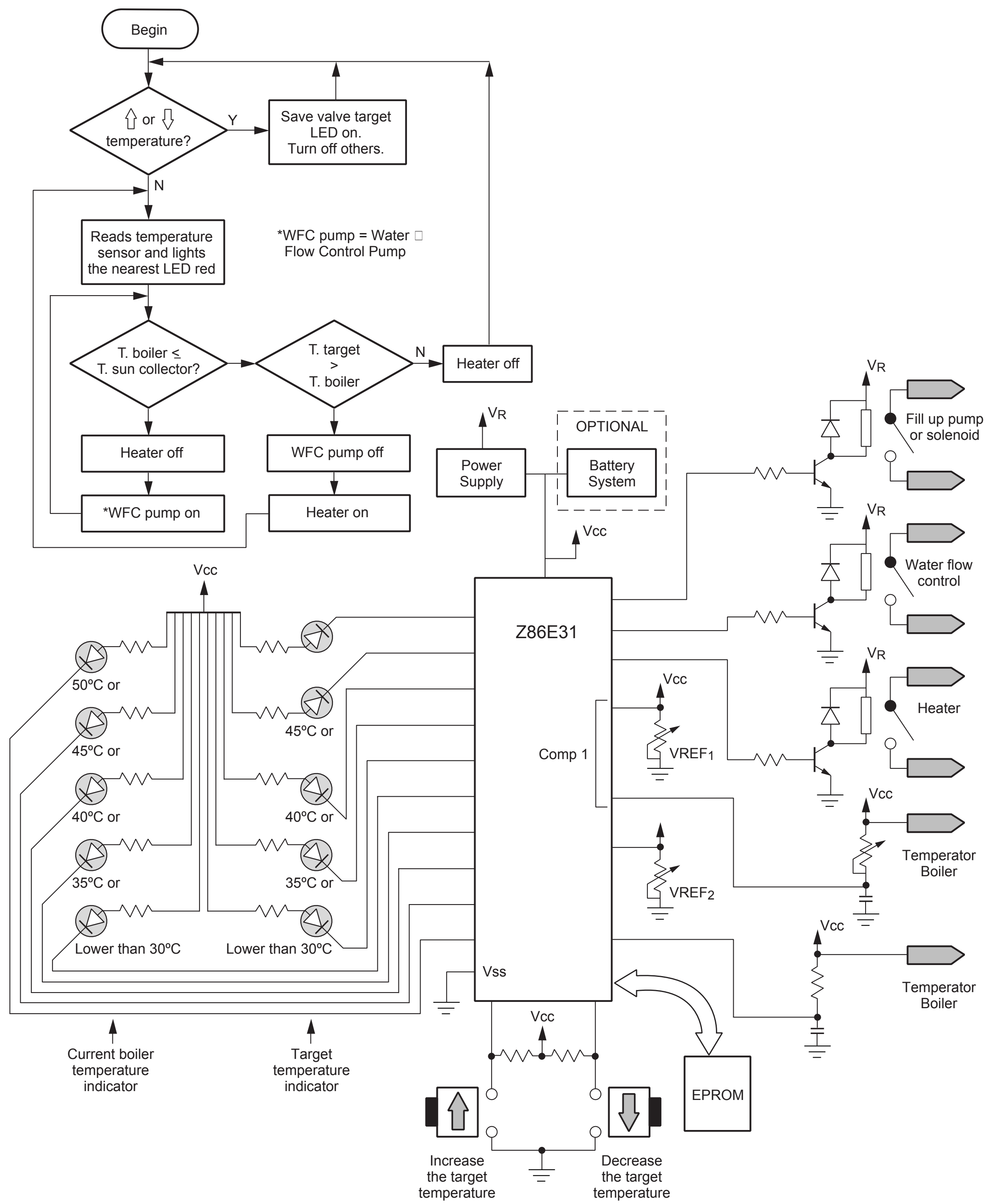
Abstract

The goal of the Smart Solar Water Heating System is to control the heating of the water supply for a home. After power-up, the microcontroller checks the value in EEPROM of the target value for temperature, and turns the LED on. The microcontroller reads the boiler temperature sensor (BTS), the sun collector temperature sensor (SCTS), and turns on a corresponding LED.

If the value of SCTS is higher than BTS, the water flow pump (WFP) is powered up to increase/speed the heating of the water by the sun until BTS becomes equal to SCTS. If both are lower than the target temperature, the microcontroller turns off the WFP and turns the electrical heater on and up to the required temperature.

There are two control keys and five LEDs used for the required temperature. Each time a target temperature is selected, the microcontroller saves it in EEPROM. The required temperature is kept in case VAC is missing (110 ~227 failure). The other five LEDs (10 total) reflect the current temperature of the boiler.

Figure 63. Smart Solar Water Heating System Block Diagram



Smart Window with Fuzzy Control

Submitted by: Tan Boon Lee

Abstract

Many homes in Southeast Asia contain sliding windows because of their lower cost. Most people open the windows when they are at home and close them during rains or when nobody is at home.

The Smart Window with Fuzzy Control design features an automatic window controller using the Z8. The Z8 uses a formula implemented in fuzzy logic to control the opening of a single sliding window that is proportional to the temperature, force of wind, and intensity of rain.

Port 2, pin 20 and pin 21 drive a 12-V DC motor via two relays. The motor features a current sense resistor (5R) connected to a comparator circuit to detect motor stall. The comparator circuit consists of a 100-ohm and 10-µF low-pass filter and a threshold detector implemented using LM339.

The wind and rain detector features a similar circuit. Both charge a 10-µF capacitor until a certain voltage is exceeded to trigger the Z8. The trigger voltage can be adjusted via a 20-ohm variable resistor.

The innovative feature of this design is the use of a single-slope ADC to read three switches and the temperature. The arrangement of the switches—open, close, and auto—present different voltages to P32. Different temperatures indicate different voltage outputs from the LM358 operational amplifier. The Z8 reads the temperature or the switch using the 74HC4006 analog switch.

The single-slope ADC yields consistent readings. A timer measures the charging of the capacitor (pin 33). When pin 33 reaches the input voltage of either the switch or the temperature, an interrupt is issued. The timer values are inversely proportional to the input voltage, because the timer is a downcounter. The range of the timer can be divided into 50 divisions very accurately but only 5 are required for 10ºC above the minimum set by the 20-ohm variable resistor.

Upon power-on reset, the Z8 reads the switches to check for AUTO mode. In AUTO mode, the position of the window away from the closed position is based on a weighted average of the temperature and wind. When rainy weather begins, the window shuts to a closed position. Manual positioning is possible in MANUAL mode. An LED indicates AUTO mode, and a buzzer sounds should the motor stall or the window is open during a rain.

Figure 64. Smart Window with Fuzzy Control

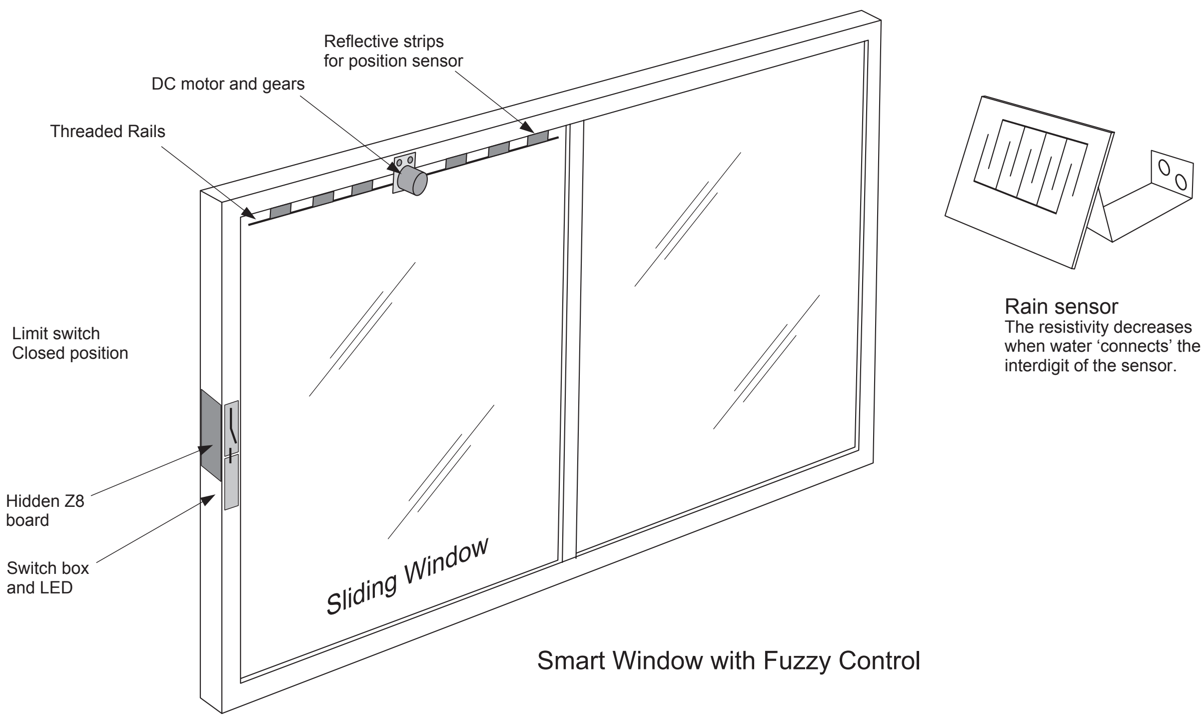
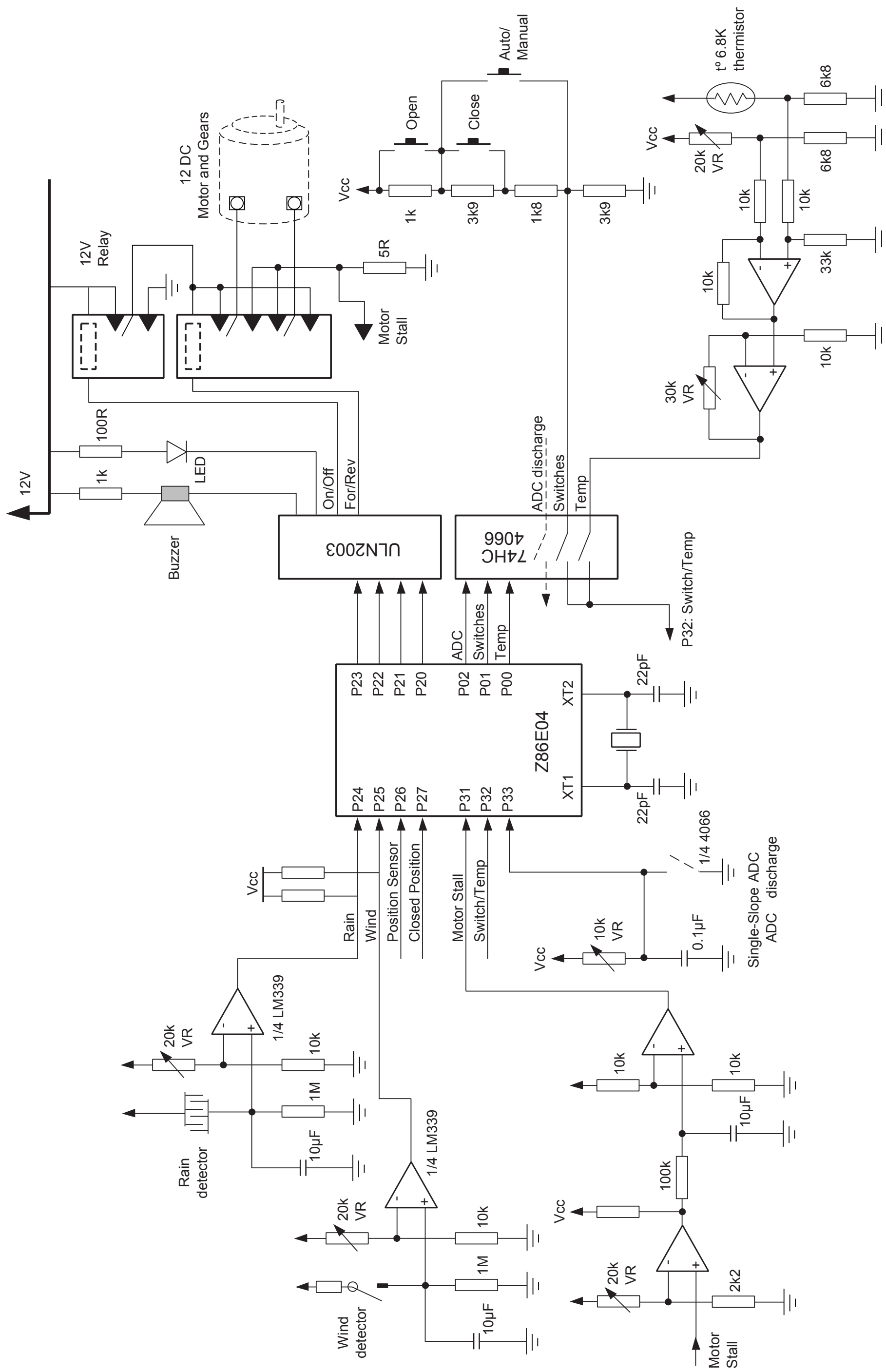


Figure 65. Smart Window with Fuzzy Control Schematic Diagram



Solar Tracker

Submitted by: David Ellis

Abstract

To achieve maximum efficiency from a solar device, the greatest possible amount of solar radiation must be collected. With a fixed angle, only a small portion of the available energy can be collected. The purpose of the solar tracker is to lock on to the location of the sun and to continually position the device to follow the path of the sun. The addition of a solar tracking device produces a smaller, more efficient photovoltaic system, allowing it to collect the greatest amount of energy over a longer period of time.

The solar tracker uses four CdS (Cadmium Sulfide 0 photoconductive) cells, wired in series and mounted on opposite sides of a vertical blind. When these cells are pointed directly at a light source, typically the sun, they exhibit approximately the same resistance. The output of the amplifier is half the supply voltage. This voltage is converted by the Z8 microcontroller into digital data, and set equal to 128, or half of an 8-bit conversion. By comparing this digital value to 128, the direction of the light source can be determined. If the value is larger than 128, move the tracker to the left. If lower than 128, move the tracker to the right. Using two sensor setups allows the unit to control two axes and position itself directly at the brightest light source. At the same time, using relays or MOSFETs to drive a larger unit, the solar tracker can keep one or more devices pointing at the brightest source.

U1A provides a virtual Ground. U1B and U1C provide a buffer for the sensors. R5 and R6 form the primary sensor. RV2 allows for adjustments for difference in the CdS cells. RV1 allows for adjustments to the overall gain of the amplifier, forming the X position sensor. R9, R10, RV3, and RV4 form the Y position sensor. The outputs of the sensors are fed to a 2-to-1 analog multiplexer made from a dual-switch ADG273 device. The output is fed to the comparator input of the Z8E001, which is set up as an A/D converter. Connectors P1 and P2 provide the control signals for the positioning motors, and are connected to a set of relays or H-bridge drivers.

Figure 66. Solar Tracker Block Diagram

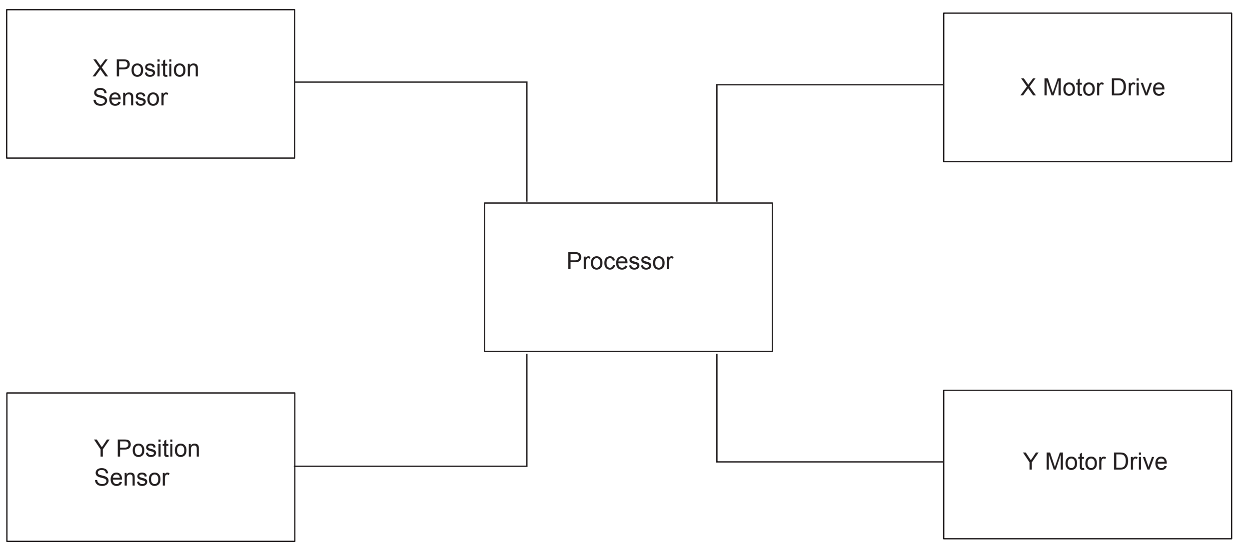
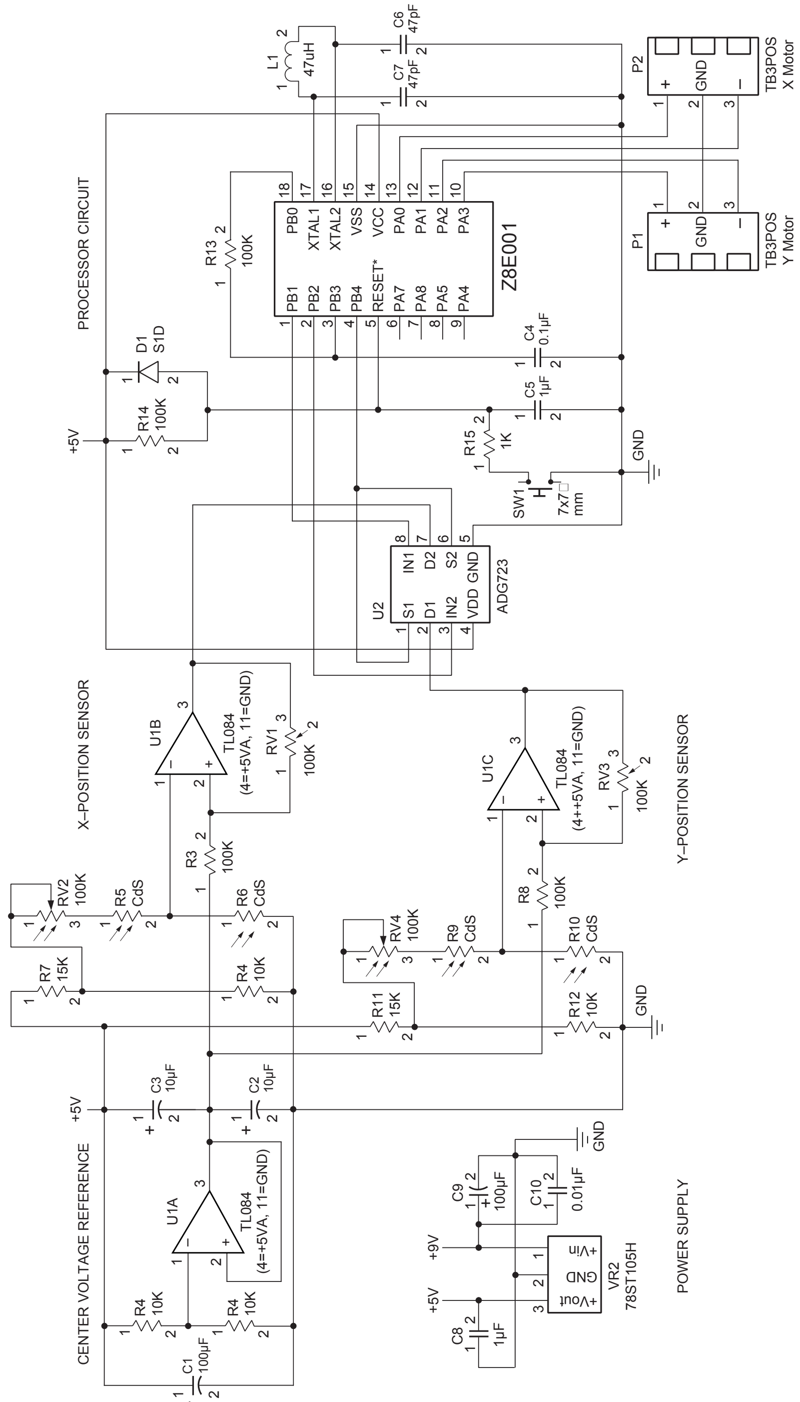


Figure 67. Solar Tracker Schematic Diagram



Speedometer

Submitted by: Mylnikov Pavel

Abstract

This speedometer design is intended for measuring the speed of a walking pedestrian. It can be worn on a waist-belt. The design uses a Z86C06 microcontroller because of its small size (18 pins) and speed (12 MHz).

The speedometer measures the difference in travel time of an ultrasonic signal from the speedometer to the ground and back. The signal consists of two short impulses with a short interval.

When turning on the speedometer, the user must remain motionless for a few seconds so that the speedometer can define its height over ground. The height is defined using the following formula:

$$h = t \times V \div 2$$

where:

h = height

t = passage time of impulse

v = velocity of sound in air (331 ms)

The speedometer is ready after the height is defined and the indicator light illuminates. During movement, the height changes are fixed automatically. The speedometer indicates horizontal speed only. Vertical movement can be approximated by linear functions.

The speedometer indicates average speed over a period of a few seconds. The speedometer can indicate an individual's speed and travel distance. Indication of speed or length is switched using a button. A reset button clears the displayed travel distance.

Figure 68. Speedometer Flow Diagram

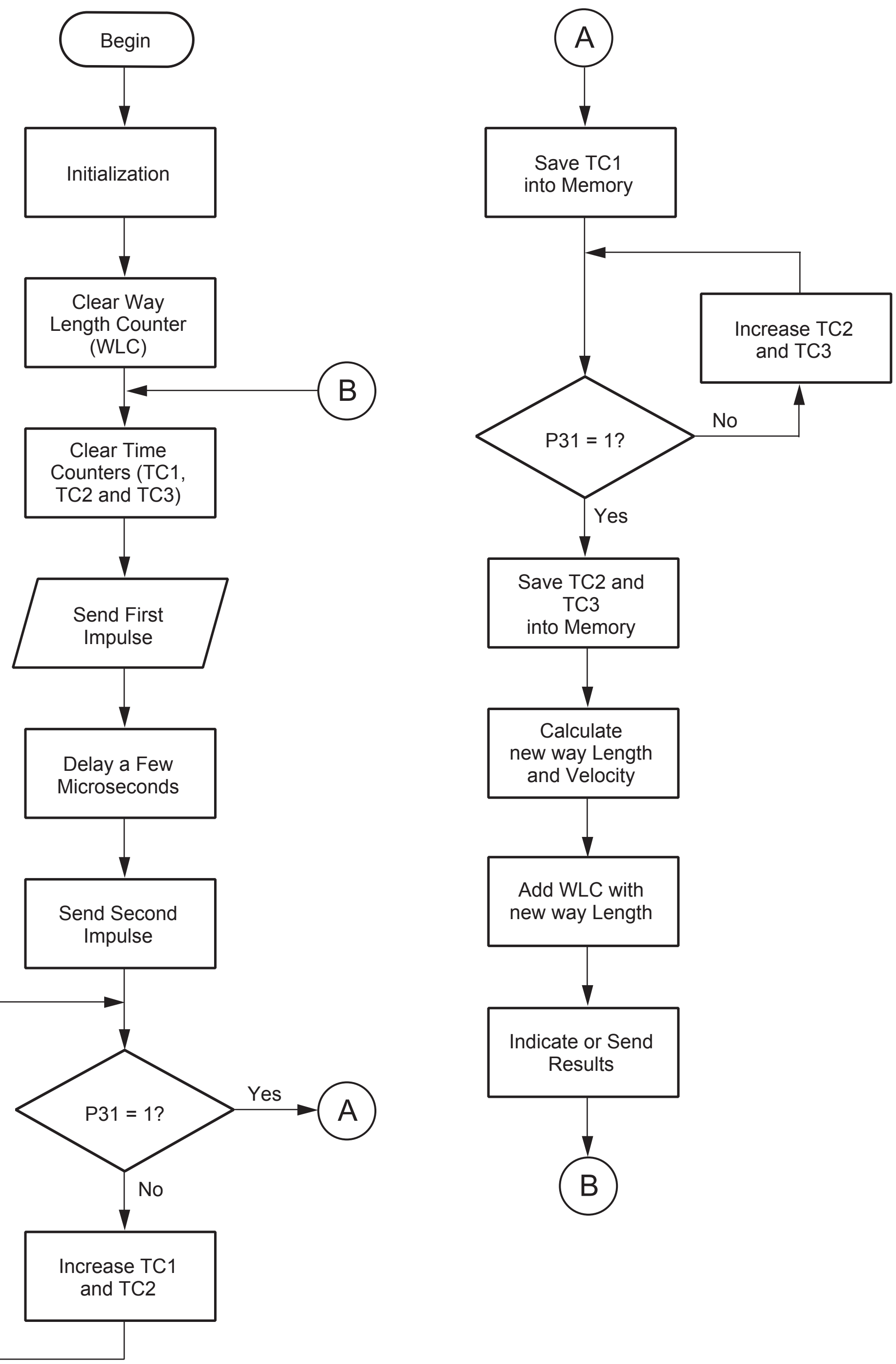
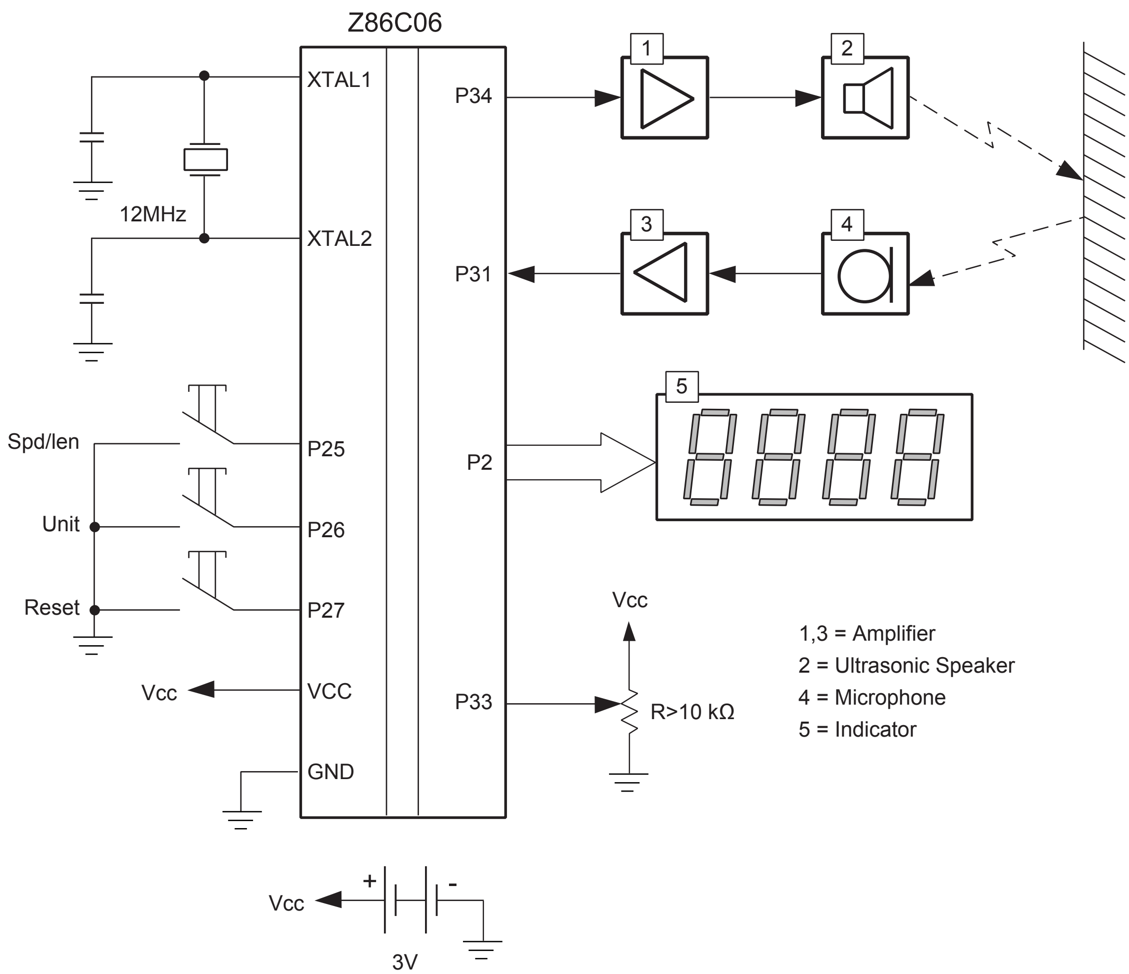


Figure 69. Speedometer Block Diagram



Stages Baby Monitor

Submitted by: Joe Peck

Abstract

There are a wealth of baby monitors on the market today, all with one purpose in mind: to alert the parents of the slightest noise, regardless of the necessity of doing so. The Stages baby monitor empowers the parents to balance between parents' necessity to hear their baby's every move and their necessity to get a good night's sleep.

The monitor can act as a traditional baby monitor, and broadcasts every little noise. Typically, parents only want to respond if the baby is awake or requires help, not if it rolls over and bumps a toy. The Stages monitor can be set to turn on for a fixed period of time if there is a particularly loud noise, or if a medium volume is sustained for a longer period. The sensitivity can be set by the parents to match their particular comfort level and environment. The monitor can also be set to help soothe the baby prior to actually turning the transmitter on. The monitor, upon detecting noise, can be set to play a short recording made by the parents if the noise exceeds the set level. If the noise continues or becomes significantly louder, the playback is stopped and the transmitter is turned on.

A ZiLOG Z86E83 Z8 OTP is the core of the Stages baby monitor.

Circuit Overview

- The On/Off Switch connects the 5-volt external power supply to the monitor.
- The mode switch is connected to digital input lines on the Z8. These lines are periodically sampled to set the operating mode appropriately.
- The Record switch is connected to another digital input. Holding the Record button causes the Z8 to record the audio from the microphone and write it to Flash memory.
- The sensitivity setting is controlled by a linear potentiometer and is connected to an ADC channel.
- The playback volume is controlled by a linear potentiometer and is connected to another ADC channel.
- The microphone is connected through a basic audio amplifier to another ADC channel. The Z8 uses this data differently depending upon the mode of operation.
- There are many transmitter circuits to choose from, depending upon required performance levels. This product uses a general transmitter black box.

- An audio amplifier connected to a PWM output drives the speaker. The PWM output is RC-filtered to create he audio output signal.
- The flash ROM uses a latched address scheme to reduce the number of pins required from the Z8.

Figure 70. Stages Baby Monitor Block Diagram

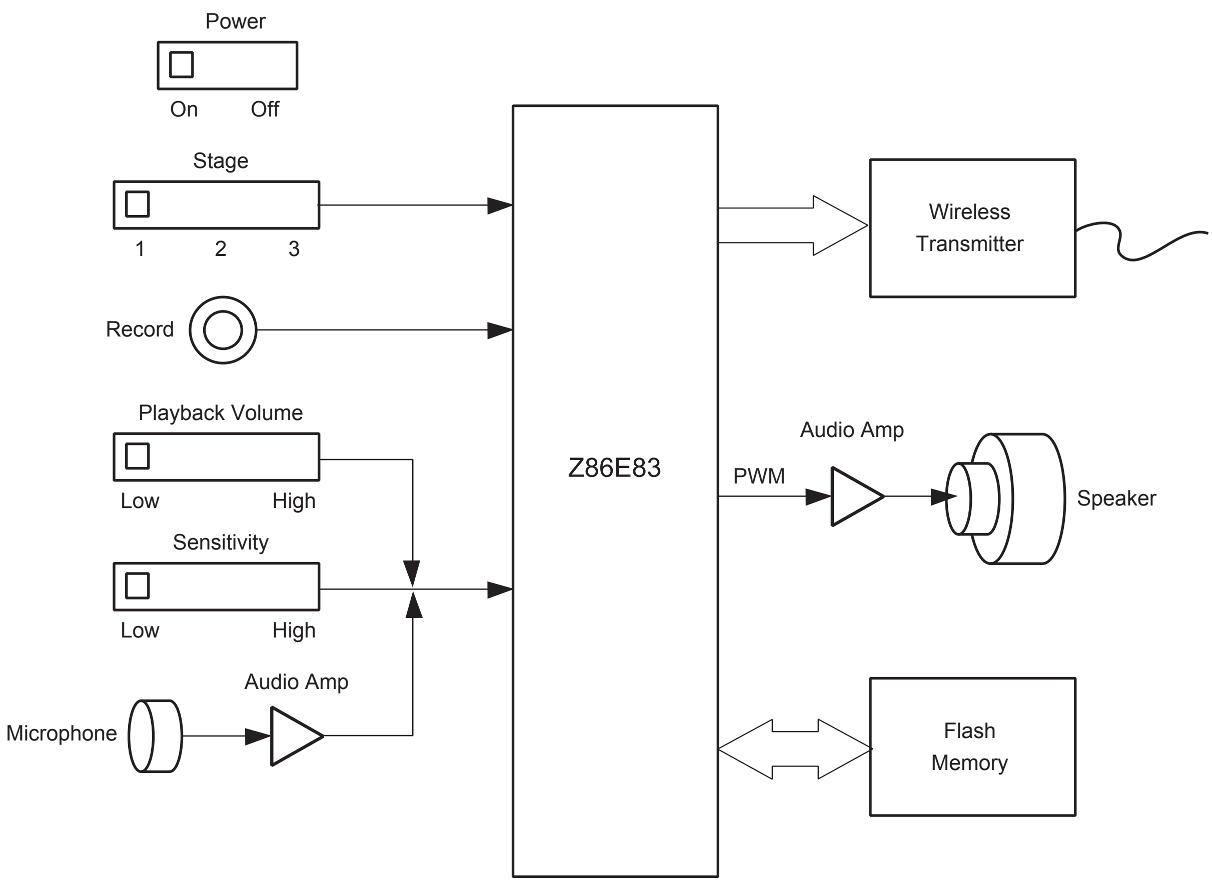
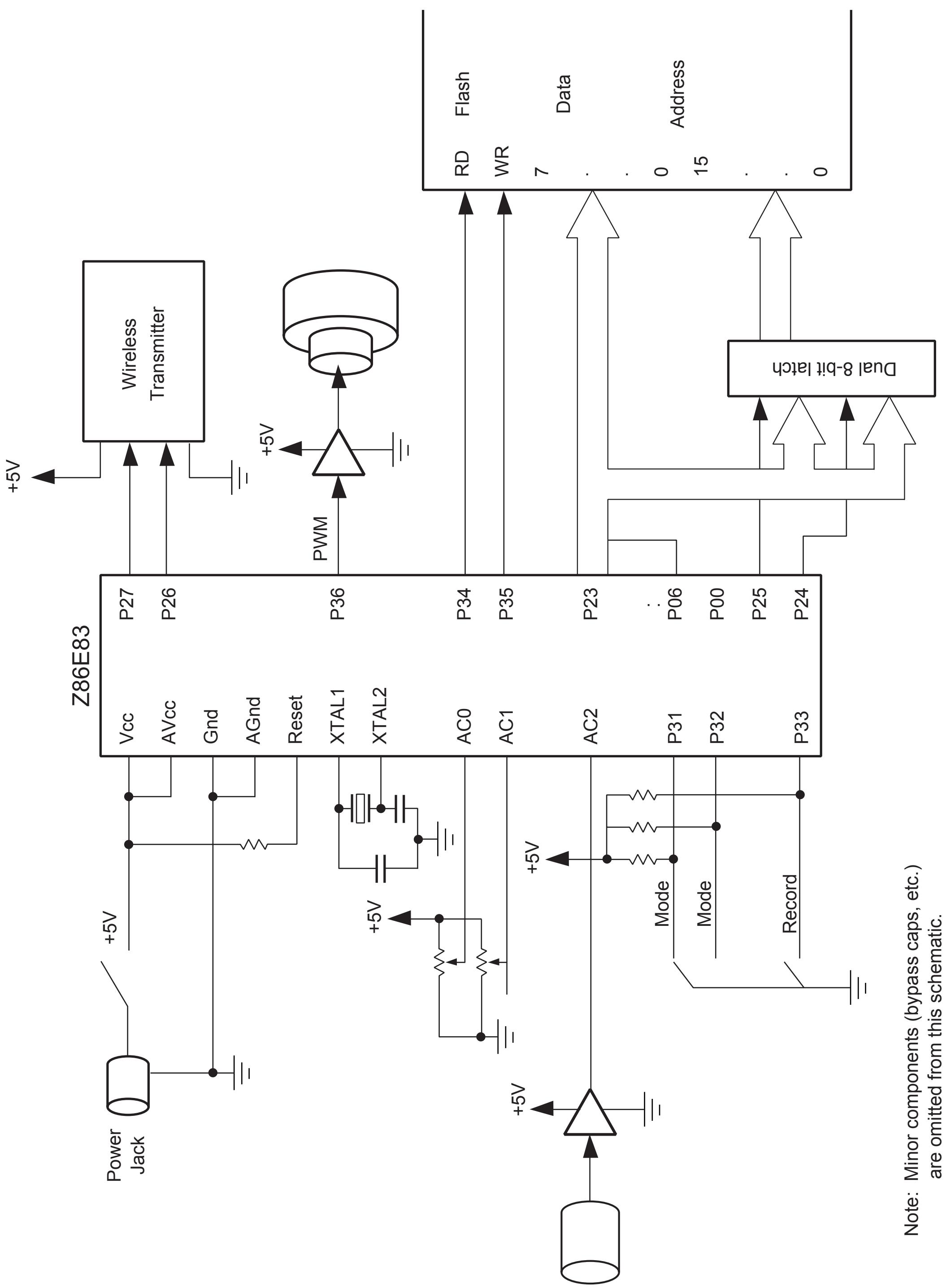


Figure 71. Stages Baby Monitor Schematic Diagram



Sun Tracking to Optimize Solar Power Generation

Submitted by: Willy Tjanaka

Abstract

To gain optimal efficiency, and hence maximum solar power generation, solar cells must be positioned directly toward the sun. This project, incorporating a ZiLOG Z8E001 processor, offers a solution for tracking the location of the sun and moving the solar cell panel correspondingly. The solar panel attaches to a mechanical fixture that allows the solar panel to rotate vertically and horizontally.

The 13 photosensors are arranged with equal spacing on top of a hemispherically-shaped housing. Each sensor is equipped with an optical filter to prevent the sensor from signal saturation. An A/D converter with a multiplexer samples the sensor signal and sends it to the Z8E001. The Z8E001 controls the vertical and horizontal rotational movement of the solar cell panel using the DC motors. Vertical and horizontal absolute encoders provide location feedback to the Z8.

The Z8E00110PSC is the controller chosen for this application. The PWM output on port PB1 provides a control signal for the motors (M1 and M2). Because only one PWM output is available, glue logic is required to control M1 and M2 one at a time. A Low on PB0 selects the horizontal motor (M2). A High on PB0 selects the vertical motor (M1).

B1 is an H-bridge-style motor driver that translates the PWM signal and direction signal to drive a DC motor.

M1 and M2 are the DC motors used to rotate the solar cell panel vertically and horizontally, respectively. B2 and B3 are absolute position encoders to track the position of the solar panel. The outputs of B2 and B3 are connected to the controller through serial interfaces (ENC_CLK, ENC_HDATA, and ENC_VDATA).

B5 controls the 13 photosensors arranged on a hemispherical housing. Optical filters are used to reduce the light intensity from the sun and prevent the sensors from saturating. The signal from each sensor is sampled sequentially by the A/D converter (B4). The ADC_SEL0 to ADC_SEL3 signals determine which A/D converter channel to sample. Data is transferred to the controller through a serial interface (ADC_CLK and ADC_DATA).

The program scans the signals of all the photosensors (B5) using the A/D converter (B4). By knowing the location of each photosensor and comparing all the intensity values to each other, the program determines the location of the sun. The program computes the horizontal and vertical rotations required to move the solar panel. Next, the program selects the horizontal motor (M2) and generates the PWM signal to move the solar panel with the signal from B3 as feedback. Similarly, the solar panel is rotated vertically by driving the vertical motor (M1) and using B2 as position feedback.

Figure 72. Sun Tracking Block Diagram

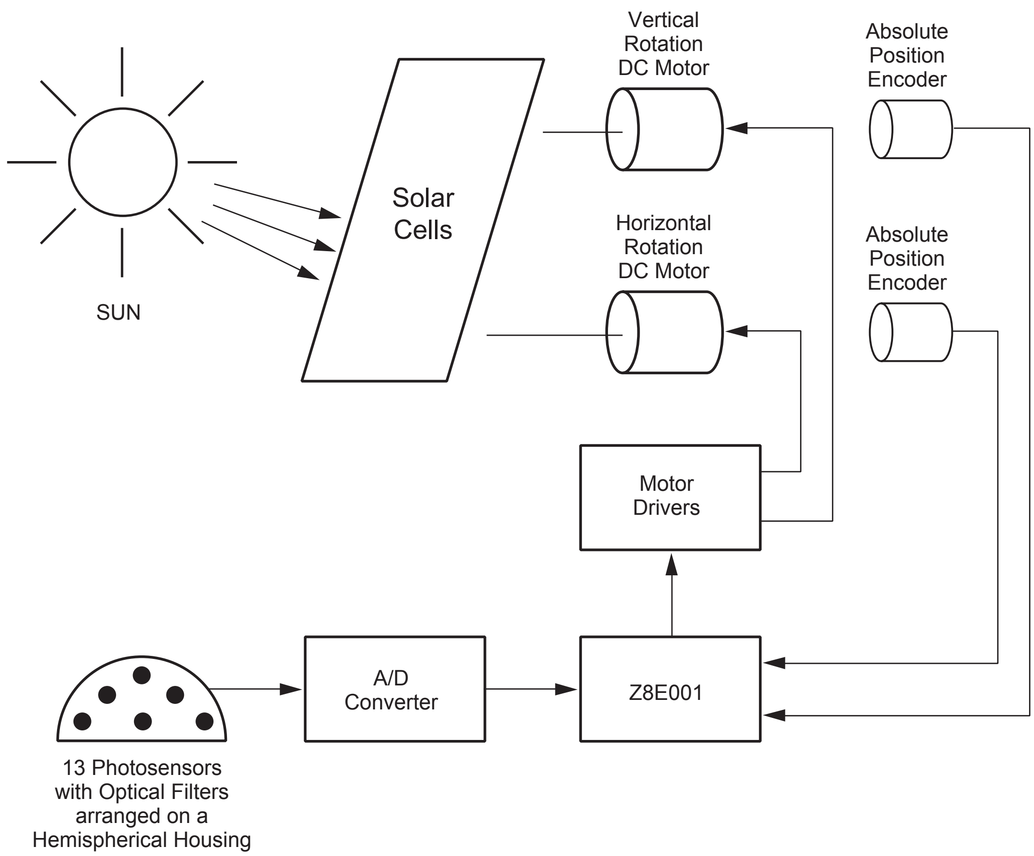
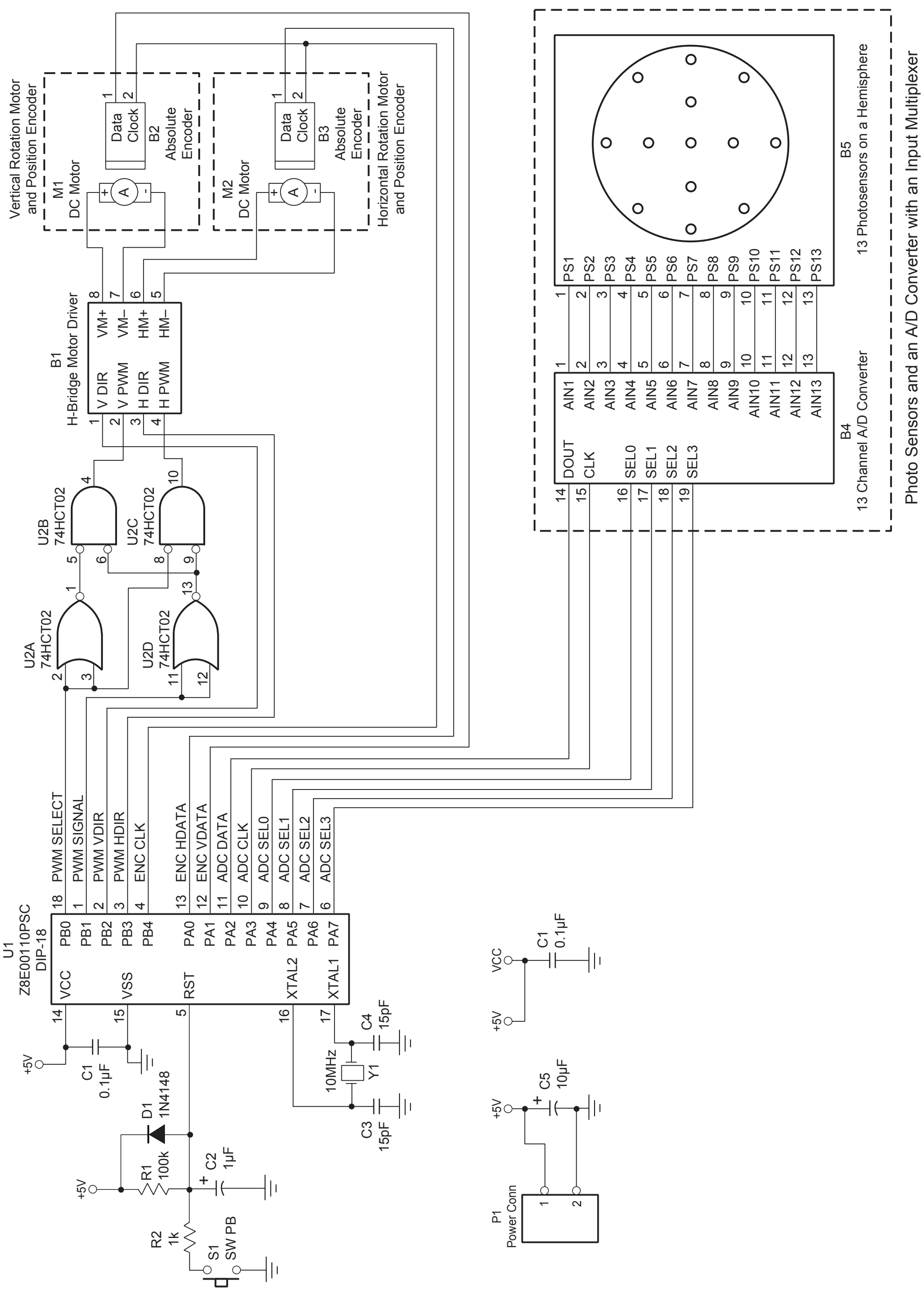


Figure 73. Sun Tracking Schematic Diagram



Tandy Light Control

Submitted by: Jerry Heep

Abstract

The Tandy Corporate headquarters building is a two-tower complex located in downtown Fort Worth, Texas. There are over 1800 lamp sockets on the east and west tower shear walls. Designed to accomodate 40-watt lamps, the sockets are arranged in an array that is six across at the upper levels and pyramid down to 14 across at the third-floor level. A strip of lamps, six wide, is used to display public service messages, for example: United Way, Stock-Show, May Fest, and Think Best. Prior to 1998, adding or removing the light bulbs from the sockets created these messages. Due to the height above street level, window washers from a local company were hired to build messages.

A better system was developed using Z8 OTPs. This system allows the building engineer to control these Tandy Center lights by computer.

The system consists of a master computer, two custom light computers, and 420 lamp controller boards. Each controller board contains a Z86E08 OTP, and can control up to five lamps. Twelve boards are used on each floor of both towers.

The master computer, a conventional PC, is located in the Tandy Center engineering office. This computer runs a Visual Basic program to allow message creation, editing, and downloading. The message is formed by using a predefined library of letters, or by clicking individual lamps on and off. Once the message design is complete, it is compiled and downloaded to the two light computers, which are located on the tenth floor of each tower. The download is accomplished with standard 1200 baud RS-232, using a very simple packet protocol. There is no hardware handshaking.

There are slightly more than 50 branch circuits feeding the lamps in each tower. Each branch may contain 18 to 30 lamps. The light computer takes the lamp data downloaded from the master computer and converts it into lamp locations. The light computer signals individual lamp controllers using the AC power source as a medium.

The controllers can display simple messages or can be programmed to display up to eight screens that are separated by up to 255 seconds of display time per screen. The Z8 knows 16 light commands.

Figure 74. Tandy Light Control Block Diagram

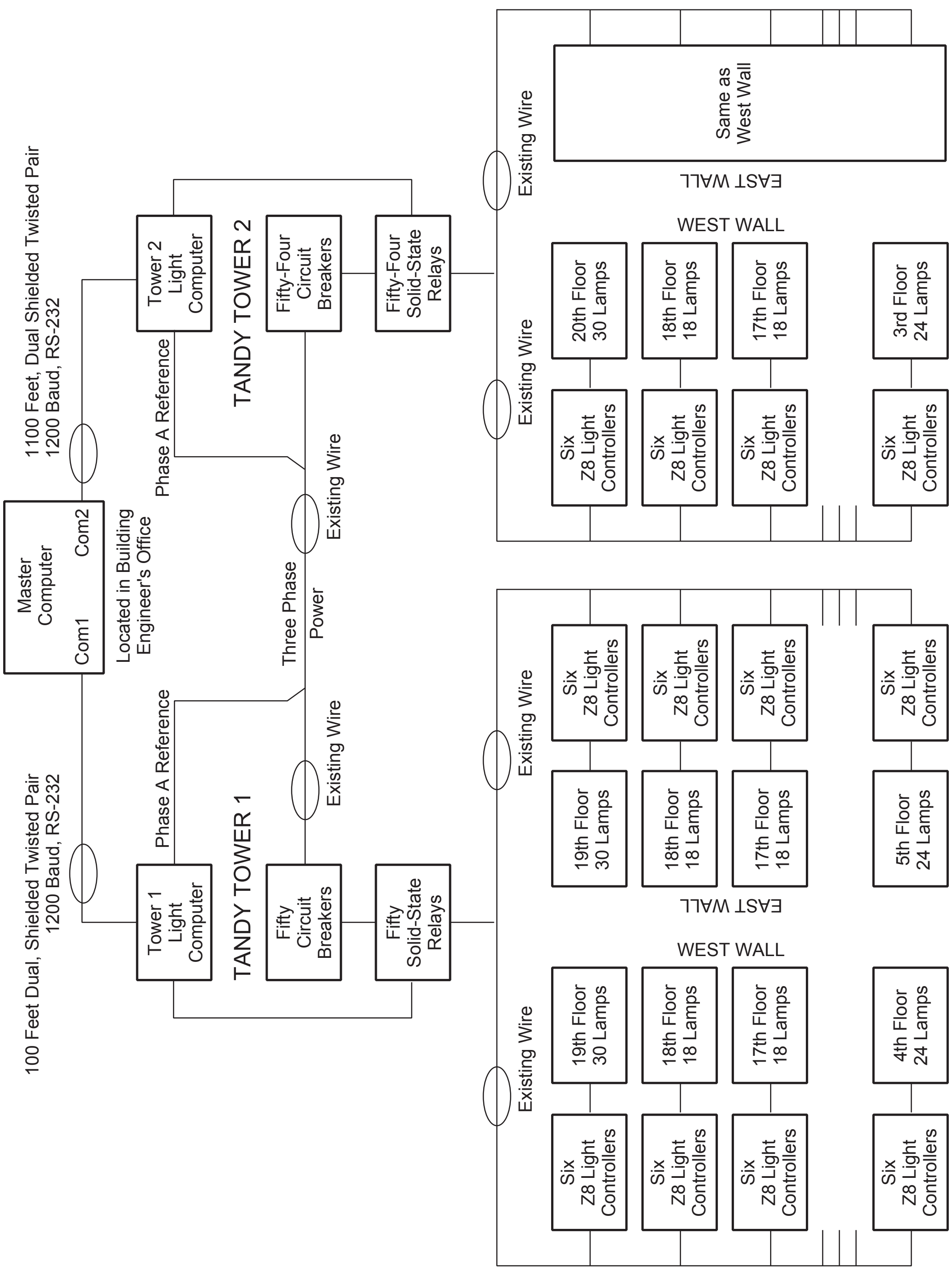
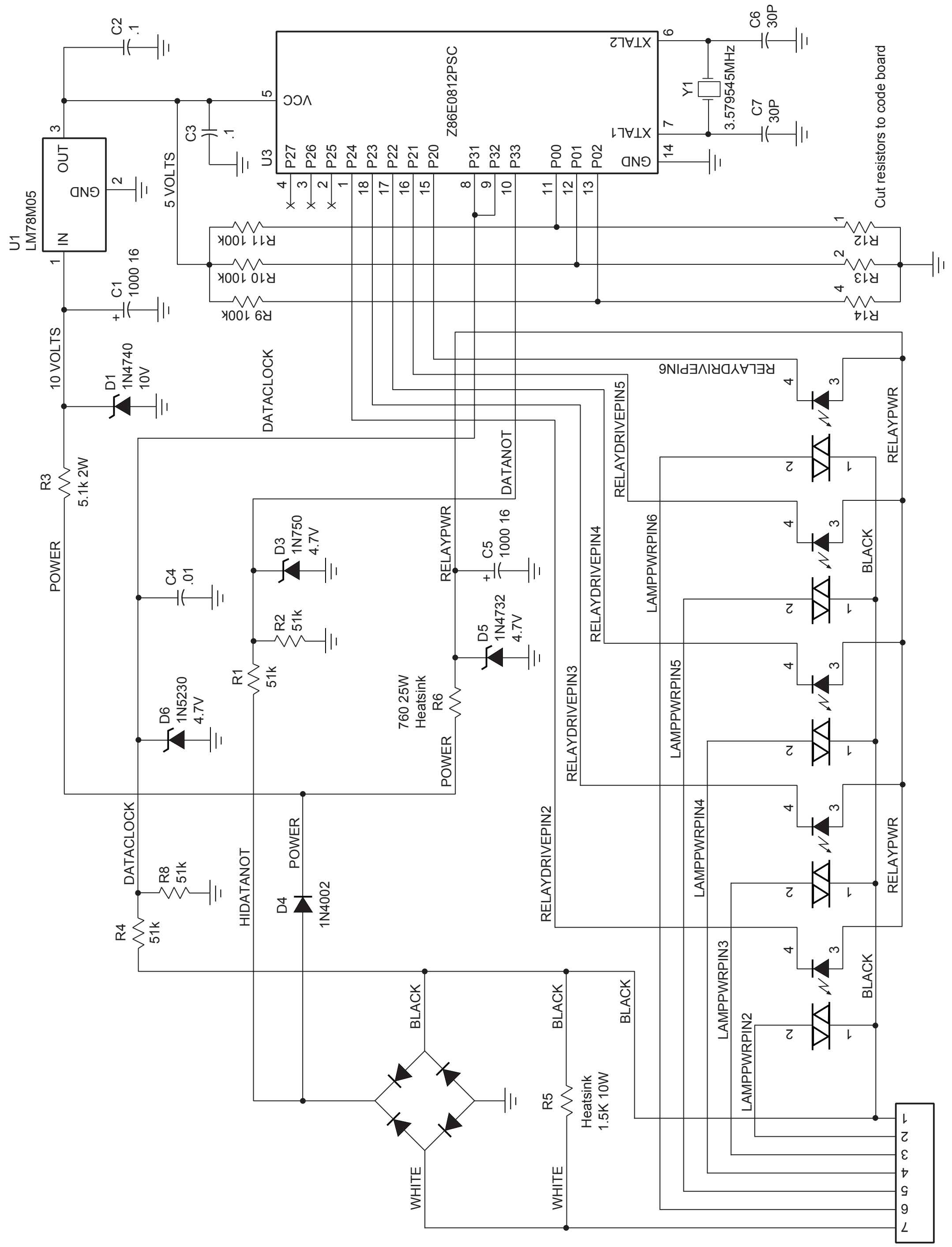


Figure 75. Tandy Light Control Schematic Diagram



Temperature Measuring Device

Submitted by: Hong Yu Qing

Abstract

The purpose of this Z8-based system is to measure temperature in a simple and precise way. A 9-volt battery powers the temperature-measuring device, eliminating the use of complex wiring.

The Z8 features two analog comparators that measure absolute temperature. An IrDA encoder sends the measured value through an infrared LED. A notebook computer with an IrDA interface receives the IrDA serial-infrared data.

The AD590 temperature sensors IC1 and IC2 generate a constant current that is proportional to absolute temperature. R1 and R2 determine the reference voltage V_{REF}. The V_{REF} is connected to the comparator's inverting input (P3.3). Lines P2.5 and P2.6 are configured as outputs.

In the beginning of every cycle, capacitor C1 is discharged through D1 by setting P2.5 to Low. When the Z86E04 timer turns on, P2.5 is set to High. C1 is charged with constant current. The constant current is produced by the IC1 temperature sensor and is proportional to the absolute temperature until the voltage reaches V_{REF}. As the comparator interrupt takes place, the timer stops and P2.5 is set to Low and C1 starts discharging.

The absolute temperature (t) equation is:

$$T = C \times V_{REF} \div T$$

where T is the time C1 takes to charge.

The measured temperatures are encoded using a software IrDA encoder, according to Infrared Data Associated protocols. The encoded measured temperatures are sent via infrared LEDs D3 and D4. S1 and S2 select the communicating baud rate. The data sending cycle is selected by S3 and S4.

Figure 76. Temperature Measuring Device Block Diagram

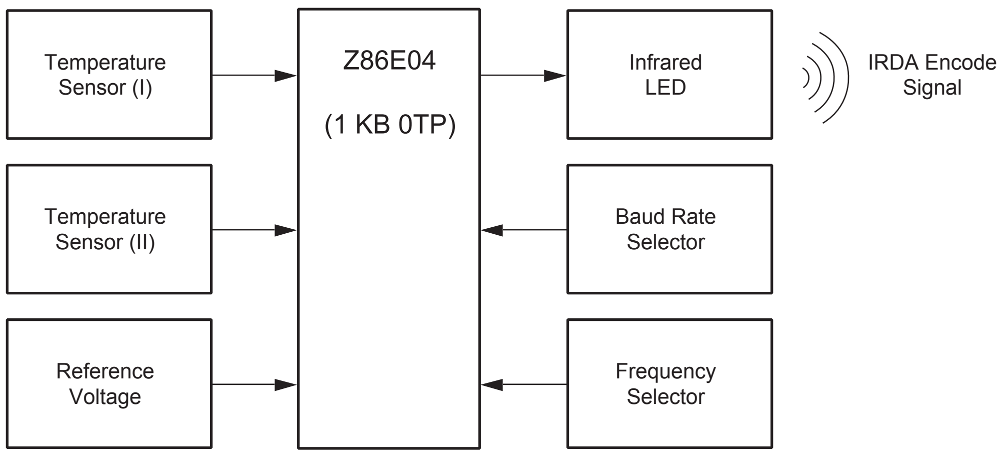
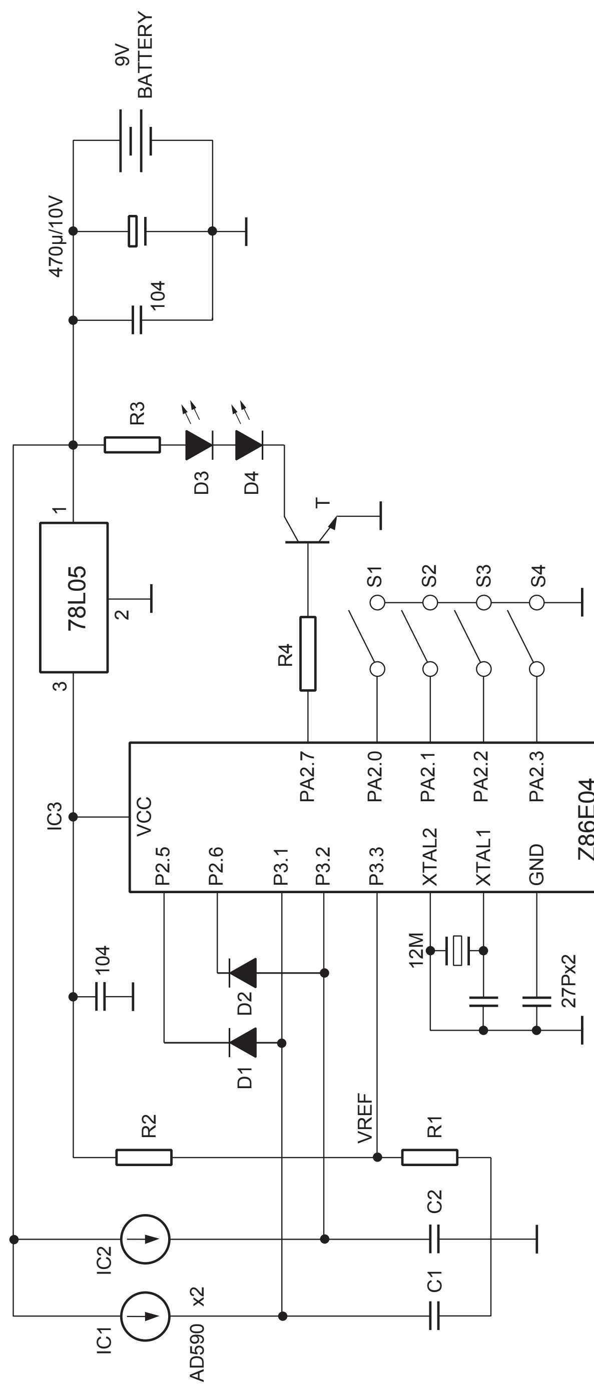


Figure 77. Temperature Measuring Device Schematic Diagram



S3	S4	FREQUENCY
OFF	OFF	2 SECOND
ON	OFF	1 SECOND
OFF	ON	1/2 SECOND
ON	ON	1/4 SECOND

S1	S2	BAUD RATE
OFF	OFF	600
ON	OFF	1200
OFF	ON	2400
ON	ON	4800

Transmission Trainer

Submitted by: Robert Ashby

Abstract

The Transmission Trainer enables CDL (Commercial Driver's License) students to learn to shift the gears of large trucks in a classroom setting prior to actual highway experience driving a truck, where inexperience may potentially be hazardous on public roads.

The Transmission Trainer consists of mock-up clutch, brake, and accelerator pedals. Mounted to the clutch is a momentary switch that closes when the clutch is activated. The brake and accelerator pedals include mounted potentiometers that reflect the position of the pedal.

A transmission tower set next to the driver includes momentary switches that close as the user attempts to shift into any one of the six positions of the transmission. The tower also includes solenoids that, when activated, prevent the gear shift from going into position. A small motor with an offset weight attached to the gear shift provides the realistic vibration when shifting gears.

A set of displays provides feedback of RPM, speed, incline of the road, and weight of the vehicle. The instructor can use a set of provided buttons to adjust the weight or incline while the driver experiences different situations and different responses of the vehicle to different situations.

Reading of the accelerator and brake is accomplished using the time to charge a capacitor method of A/D conversion. A small speaker or piezoelectric buzzer provides the changing engine noise (using T_{OUT} mode).

The ZiLOG chip can easily figure the mathematics to provide the driver with a realistic situation in shifting that can take years to perfect in the real world of the highway. Factors that are taken into account are incline, weight of vehicle, road speed, and position of the accelerator pedal. The gears must be closely matched in order to complete the shift.

The feedback of motor sound, RPM and speed gauges, and the vibration on the gear shift allows students to learn shifting techniques in a variety of situations without spending large amounts of time and money with an actual vehicle. It is ideal to be able to demonstrate this method in a classroom situation, which could save the driver and teaching institution thousands of dollars in time and money and prevent repairs on vehicles.

Figure 78. Transmission Trainer Block Diagram

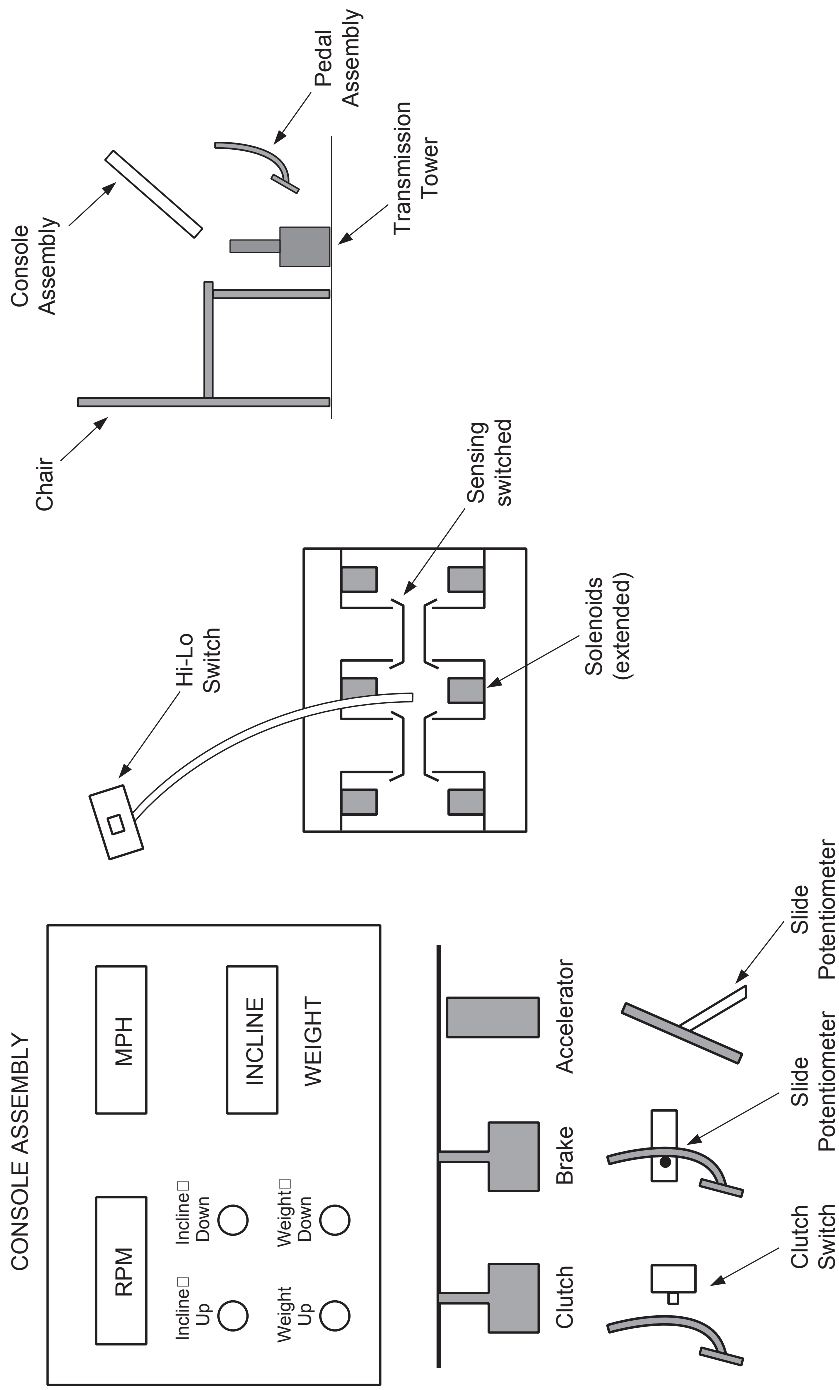
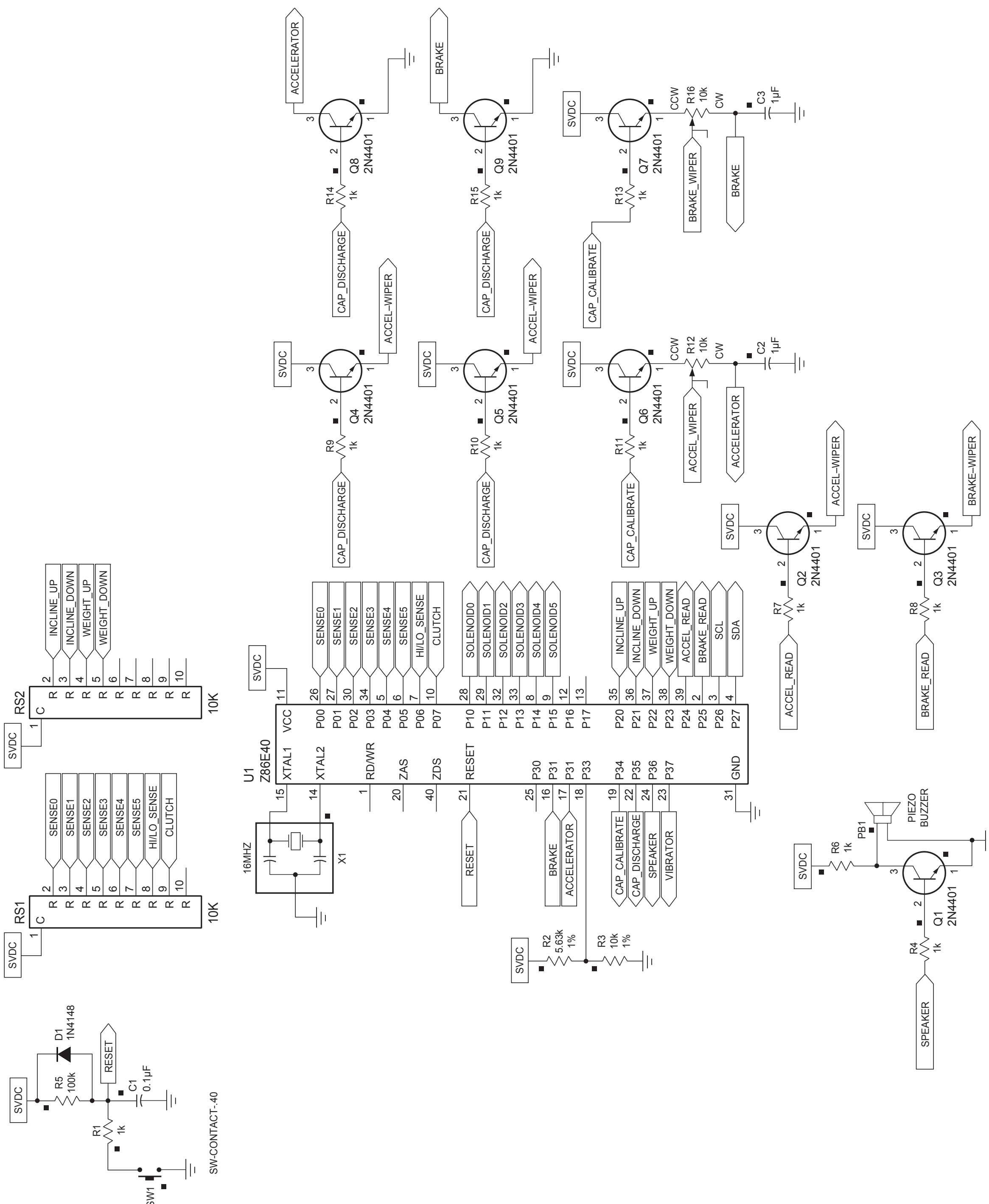


Figure 79. Transmission Trainer Schematic Diagram



UFO Flight Regulation System

Submitted by: Martin Gundel

Abstract

The heart of the UFO Flight Regulation System is a ZiLOG Z86E08 microcontroller. Because the receiver of this radio-control system is sensitive to electromagnetic interference, the Z8 operates in low-EMI mode with a clock frequency of 4 MHz.

The versatile interrupt capability of the Z8 makes it possible to measure the pulse width of the sensor and generate 4 PWM output signals to drive the motors.

For sensing the inclination of an aircraft, a two-axis acceleration-sensor, the Analog Devices ADXL202, is employed. The output is a PWM signal with a pulse width between 2.5 to 7.5 ms and a frequency of about 100 Hz; making it possible for the UFO to accelerate at a rate of ±2g. If the sensor is at plane level, the output pulse is about 5 ms long. An acceleration of 1 g is equal to a pulse variation of 1.25 ms. This variation corresponds to an inclination of 90 degrees. To measure an inclination of one degree, there must be a resolution of 13 microseconds or better. Timer 0 is clocked by 1 MHz, to achieve a better resolution.

Two radio control channels move the UFO in the X and Y directions. Another channel determines the average speed of the motors for take-off and landing. The signals of the RC unit are also pulses, with a pulse width between 1 and 2 milliseconds. The necessary resolution to obtain a good regulation is 6 bits.

The four motors are driven by four PWM output stages. The Z8 microcontroller software calculates the necessary impulse width for the motors to keep the UFO on a plane level.

Depending on the RC signals, the motor speed is changed slightly to move the aircraft. The output PWM signals are generated under the control of Timer 1.

A soft start for the motors is absolutely necessary. The PWM signal of the motors attains the same frequency, but are slightly shifted, to prevent high current peaks.

Figure 80. UFO Flight Regulation System Block Diagram

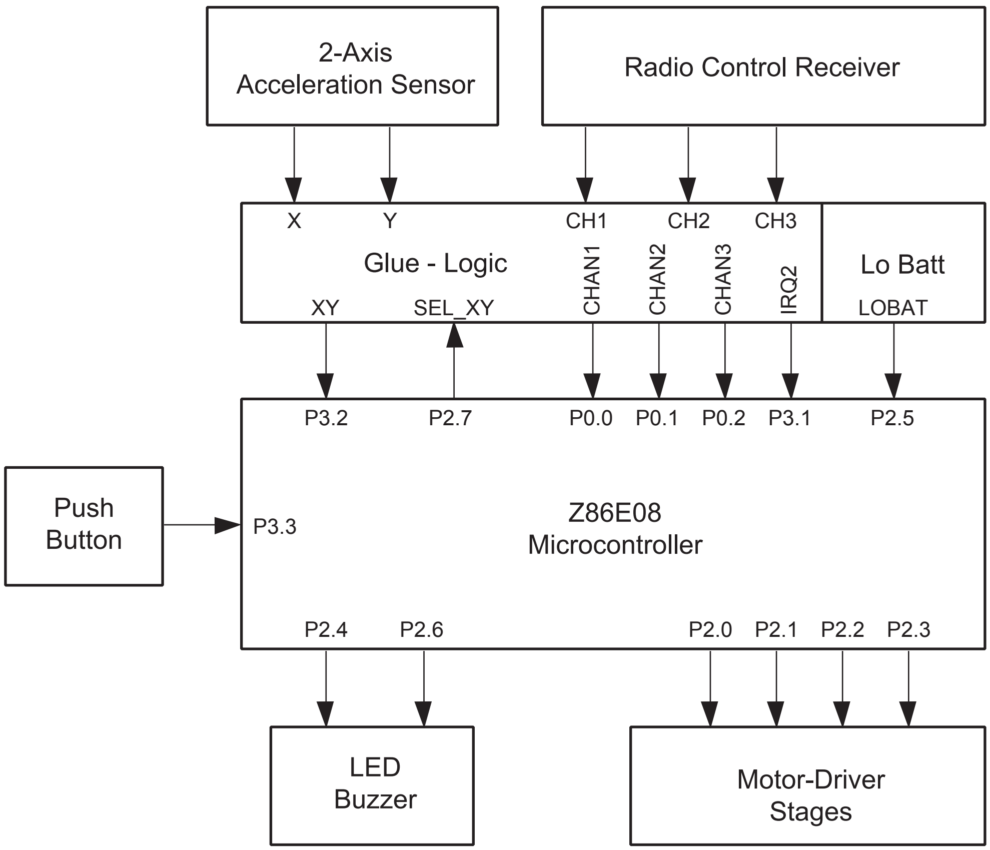
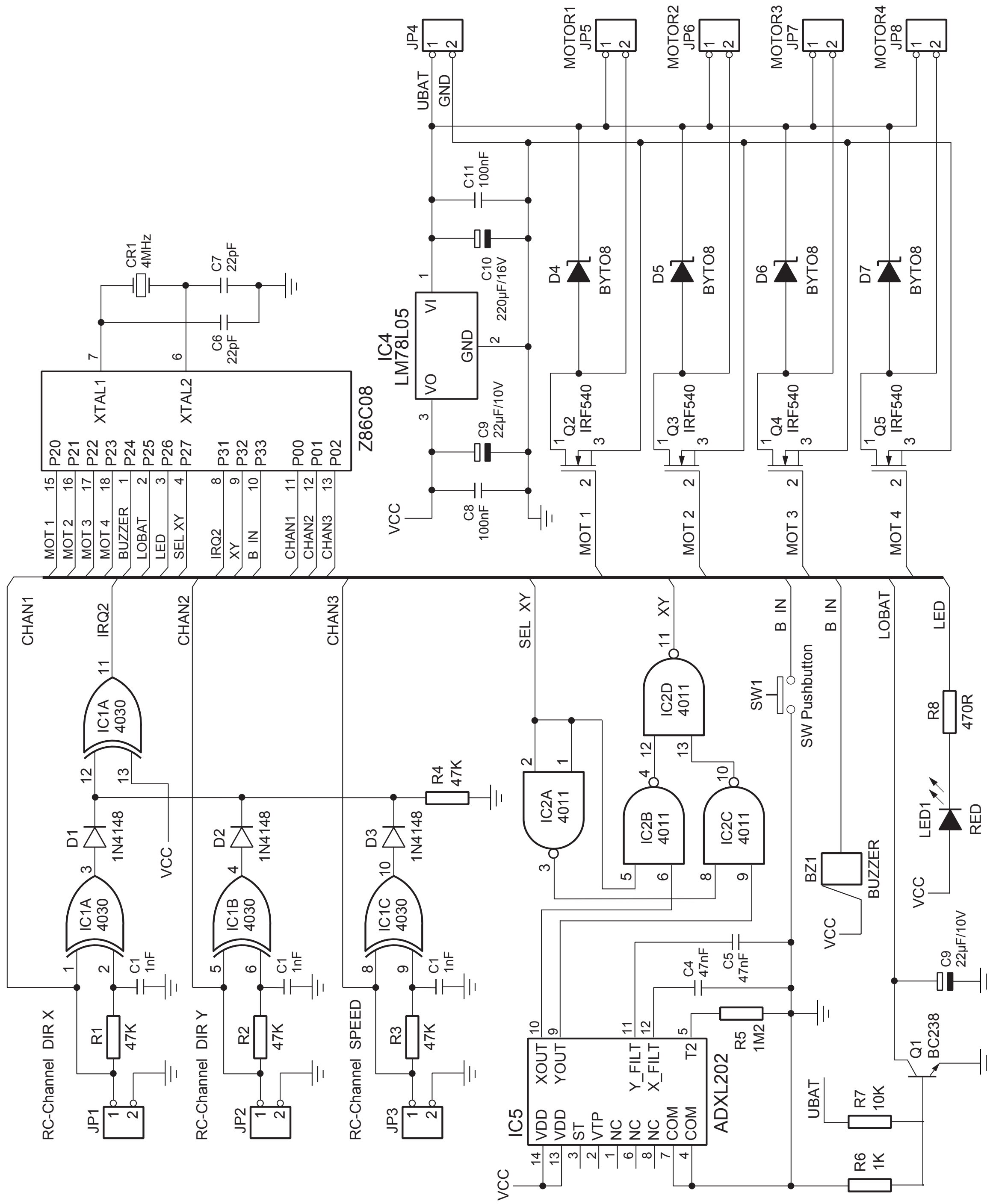


Figure 81. UFO Flight Regulation System Schematic Diagram



Vehicle Anti-Theft Module

Submitted by: James Doscher and Harvey Weinberg

Abstract

Traditional car alarms protect a vehicle from theft when a door is opened, a window is broken, or the ignition is disabled. These alarms cannot protect from being towed by a tow or flatbed truck, or the wheels from being stolen. These challenges can be solved by adding a tilt-sensing module to the alarm system. The tilt sensor must be able to resolve very small changes in the inclination of the car.

It is possible to free the wheels of a sports car by lifting one end of the car as little as 1.5 degrees. The module must be intelligent enough to reject minor long-term changes in tilt due to settling suspension, melting snow, and (relatively) large short-term movement due to wind or passing trucks.

The Z86C06 provides the system intelligence, while the tilt sensor is the ADXL202 dual-axis accelerometer from Analog Devices. Conventional liquid tilt sensors are inconvenient to use because of their fragility. In addition, the high resolution required in this application would necessitate a high-accuracy A/D converter (12-bit or better) if using a liquid tilt sensor. The ADXL202 outputs a 14-bit accurate PWM signal that is proportional to the inclination. The PWM signal is read by the Z86C06 by using both timers simultaneously. One timer is used with the 6-bit prescaler, while the other timer counts at full speed. The concatenation of the two timers results in a 14-bit timer range.

A software temperature-compensation method must be considered, because the tilt sensor grows in temperature sensitivity such that changes in temperature may appear to be changes in inclination. An intelligent algorithm can sample one set of tilt samples measured every half-second, and compare the result to the previous set of samples. If the rate of change of tilt (da/dt) does not fall within a specified window (for example, 0.0125 to 0.3 degrees per second), no alarm signal is issued. Because the temperature does not change significantly in 0.5 seconds, temperature drift is ignored. The windowing function also rejects false alarms due to minor long-term and large short-term tilt changes.

Low power consumption (1 mA average current) is required, because the alarm runs while the car is off. Because sampling only occurs twice per second, the Z86C06 is in STOP mode most of the time to conserve power. To reduce the power consumption even further, the Z86C06 cycles power to the ADXL202, turning it off between sample periods.

Communication to the main alarm module occurs via the Z86C06 SPI interface.

Figure 82. Vehicle Anti-Theft Module Block Diagram

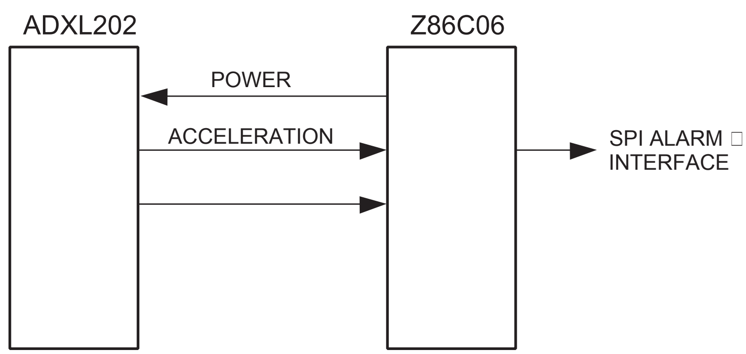
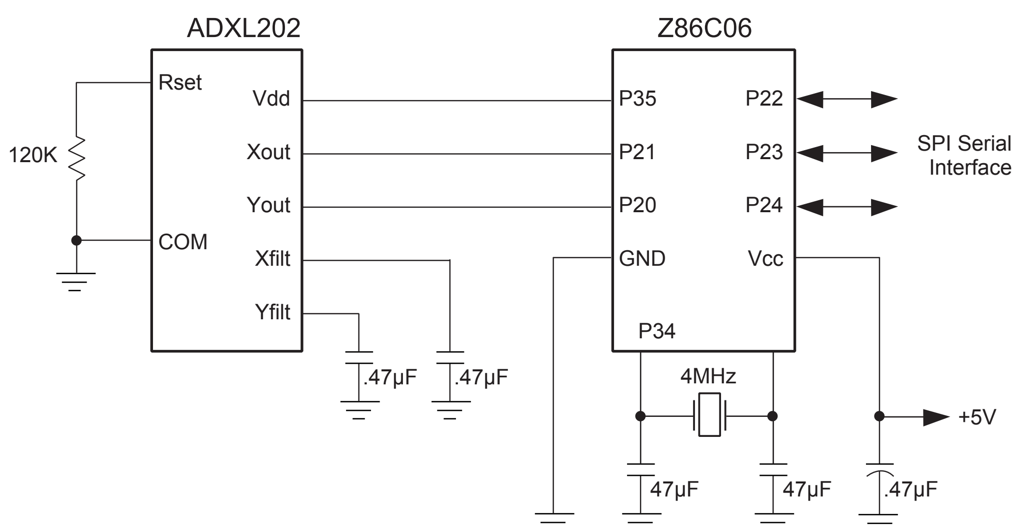


Figure 83. Vehicle Anti-Theft Module Schematic Diagram



Windmill Commander

Submitted by: Nathan Novosel

Abstract

Using the Z8 OTP microcontroller to serve as a windmill commander to heat water to a comfortable temperature can extend the swimming season of many home pools. The Z8 microcontroller harnesses the maximum wind energy by controlling the windmill blade pitch and the alternator output current. The resistive load for heating can receive a wide range of electric current without constraint on frequency, voltage, or current levels. As a result, the load is the ideal type for a variable-speed alternator, driven by the wind.

The Z8 microcontroller, the heart of the windmill commander, responds to control inputs, monitors system status, and controls the output power by both alternator control and windmill blade pitch control. Additionally, a battery charger function is included in the Z8 program to maintain battery power for periods of decreased wind activity.

The Z8 microcontroller determines the speed of the alternator, and the output power by measuring the voltage across the load resistors. Using the flash A/D converter in the Z86E83, the instantaneous voltage drops across the load resistors can be measured. The output power can be determined by averaging over several AC cycles. The temperature is measured by utilizing two analog channels that receive a differential voltage from a thermistor in the pool water. The flash converter allows accurate differential measurements, because the high speed of the flash converter can minimize sampling time between channels.

The required output temperature is set by push-button control, with one button serving to increment and the other to decrement the target temperature. A two-digit LED display shows the temperature setting for five seconds following push-button entry, and then returns to power-off state.

The Z8 microcontroller is programmed to determine the state of the system, based on the alternator speed and output power. Using coefficients for the particular windmill hardware that are programmed into the OTP memory, the windmill commander can determine how to adapt to the particular conditions at any given moment.

The commander controls the state of the system by varying the field current to the alternator by using pulse-width modulation (PWM) and a power MOS transistor. The field current directly controls the output current of the alternator that causes the mechanical load to the windmill to change proportionally. The windmill commander can adjust the blade pitch to adapt to both the load and the wind conditions as determined by the propeller speed (derived from the alternator frequency). The position of the blade pitch is determined by a potentiometer

located in the drive actuator configured as a resistor divider to provide an analog voltage that corresponds to the pitch position.

The power supply utilizes a 12-volt battery, and a battery charger function is built into the Z8 program to maintain battery voltage. The battery voltage is divided and measured by another channel of the Z8 A/D converter, and the microcontroller triggers an SCR to supply current to the battery via a ballast resistor.

Figure 84. Windmill Commander Block Diagram

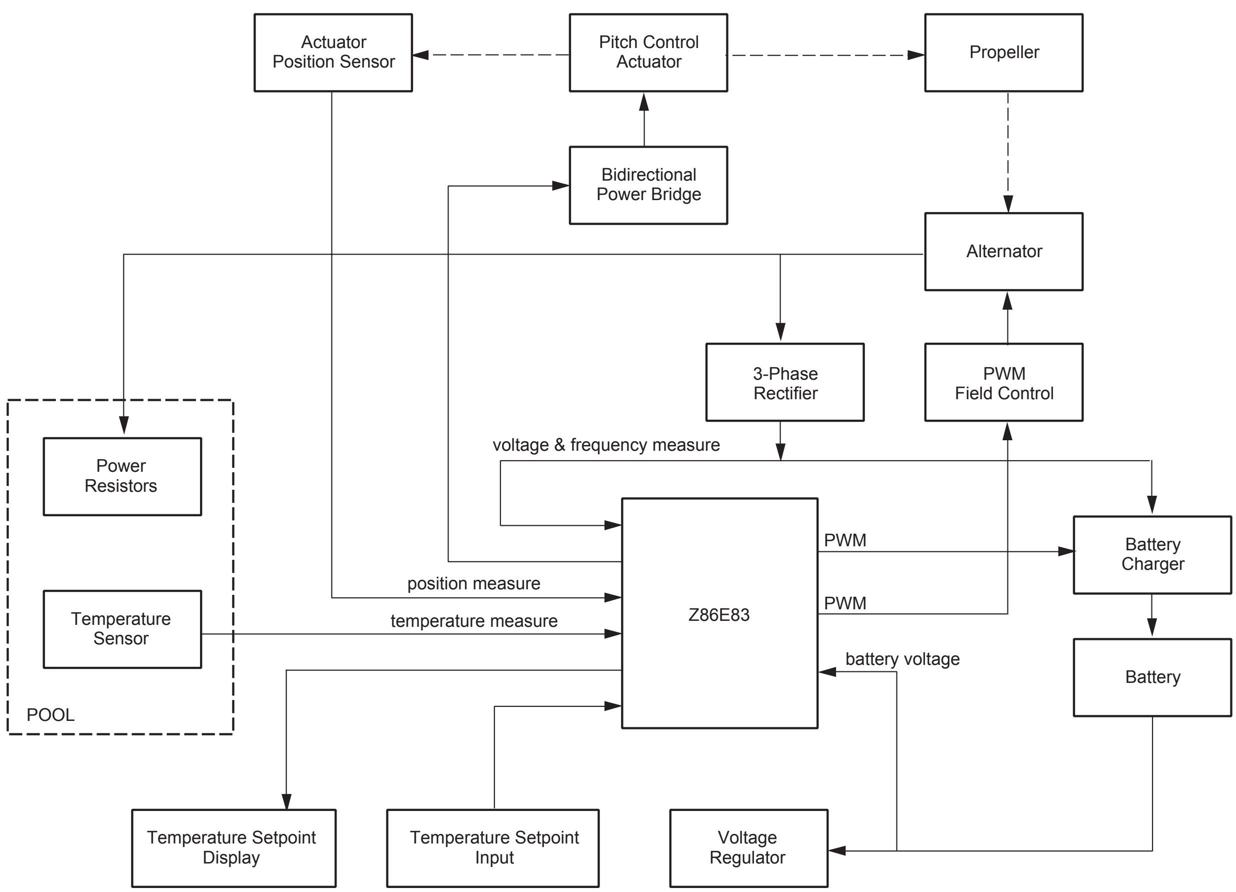
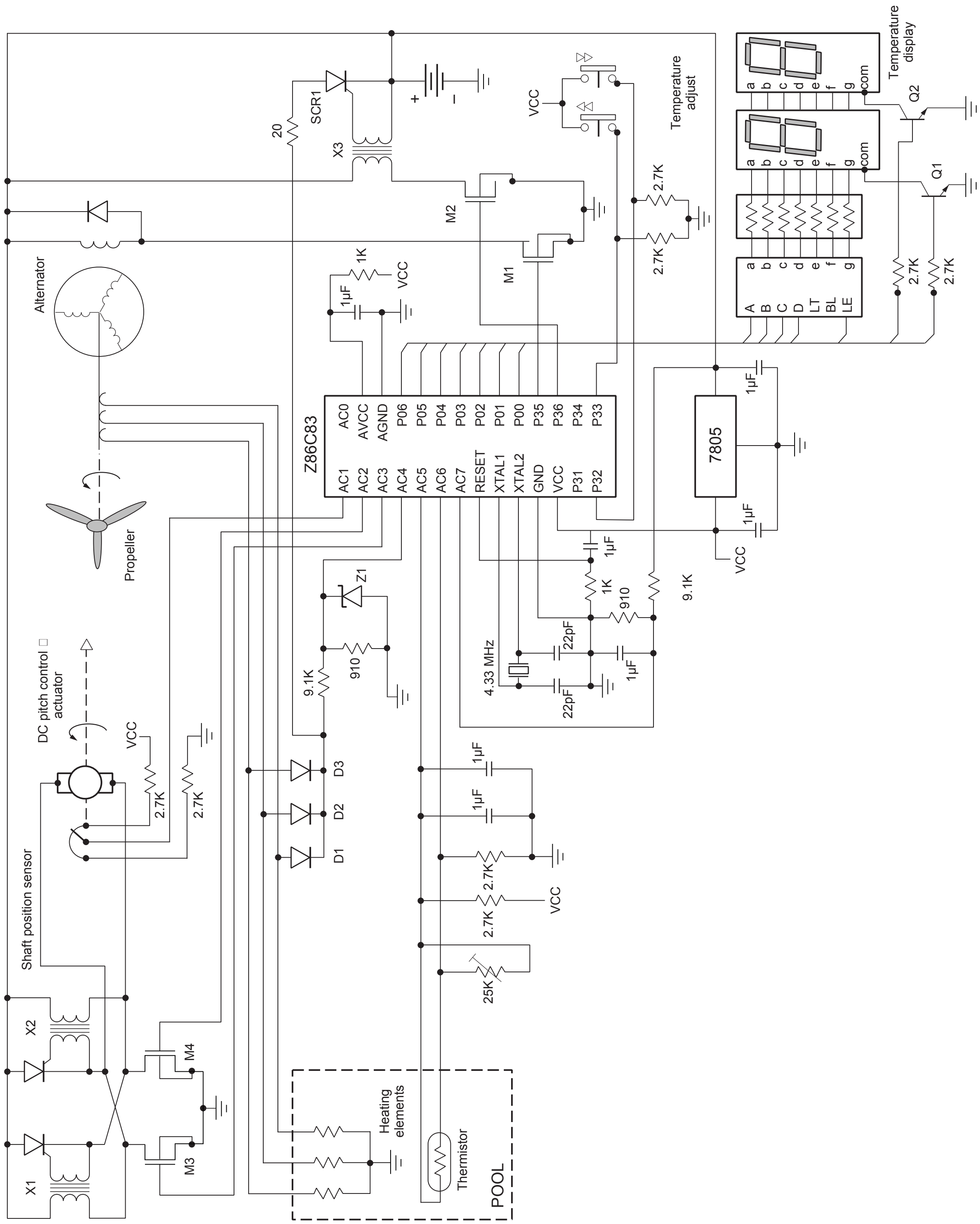


Figure 85. Windmill Commander Schematic Diagram



Wireless Accelerometer

Submitted by: Mark Nelson

Abstract

One of the frustrations of playing video games is the tangle of wires connected from the computer to the controller. Another frustration is the wire length that limits the distance and freedom of playing the games. A solution to this problem is to use a ZiLOG Z8 microcontroller, Analog Devices accelerometer, and the Abacom transmitter-receiver pair for wireless operation.

The accelerometer is the Analog Devices micromachined ADXL202, which is an A2G device used for measuring tilt in two axes, making it ideal for joystick applications. The output is pulse-width modulated and easily read by the microcontroller.

The heart of this system is the ZiLOG Z86C06 microcontroller, which samples the accelerometer digital outputs and the states of six push-buttons. It stores the instantaneous values into a register where it is converted into serial format to be output to the transmitter section. The high clock frequency of the microcontroller enables the sampling to be fast enough to recreate the original PWM information from the accelerometer and push-buttons. Serial transmission at 9600 baud ensures that the operator does not notice any delay in the video.

The Abacom XRT418 transmitter offers a maximum data rate of 10 Kbps and operates at 418 MHz. The serial data from the microcontroller is applied to the digital input and is transmitted to a matching receiver at the PC. Its range is 100 meters, suitable for use with very large monitors.

The Abacom RCVR 418 receiver offers analog and digital outputs. Test results indicate that reconstruction of the input signal is very good. The design uses another Z8 microcontroller to translate the incoming serial stream into a digital output byte. The accelerometer bits are converted to current sources to drive the game port inputs.

This design highlights the many functions and processing capabilities of the Z8 microcontroller. The Z8 collects PWM information, converts it to a standard serial stream, and recreates the original data states at a remote location. With further programming at the receiver, the Z8 can adapt to other game protocols.

Figure 86. Wireless Accelerometer Block Diagram

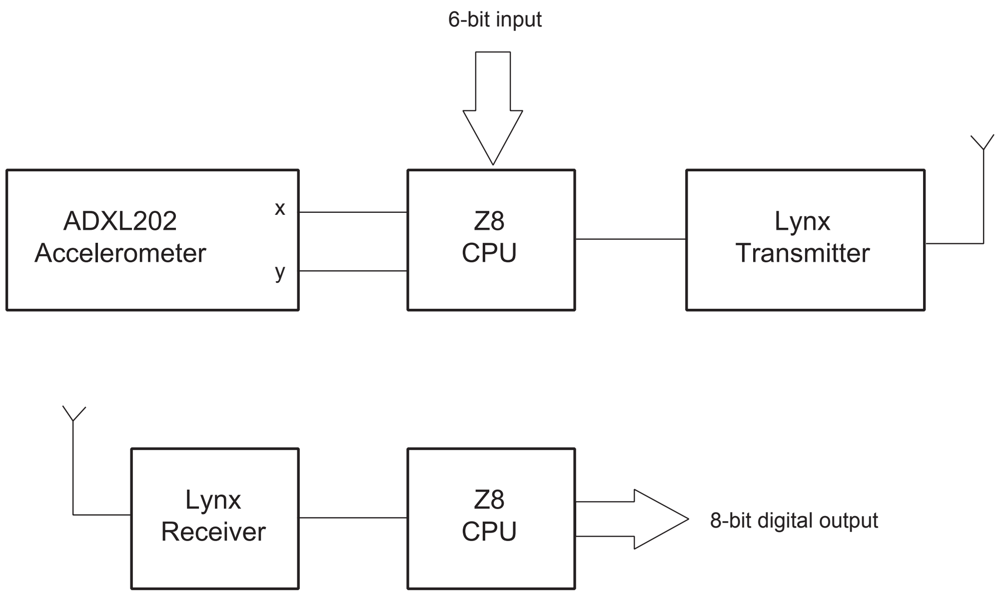
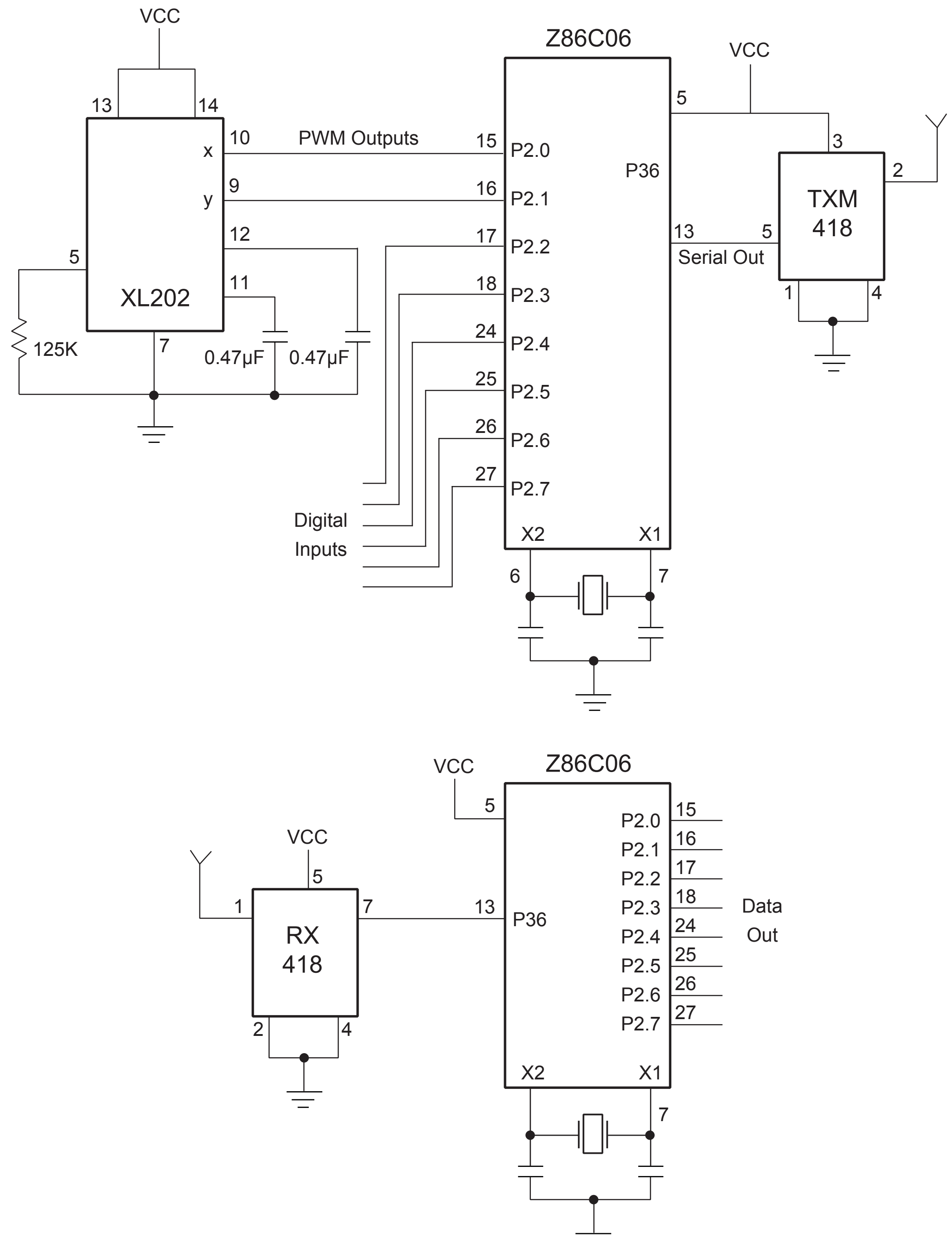


Figure 87. Wireless Accelerometer Schematic Diagram



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