Université François-Rabelais de Tours
Institut Universitaire de Technologie
Département Génie Électrique et Informatique Industrielle

Carte ATMega8535 et afficheur LCD
16 caractères x 4 lignes + connecteur ISP.

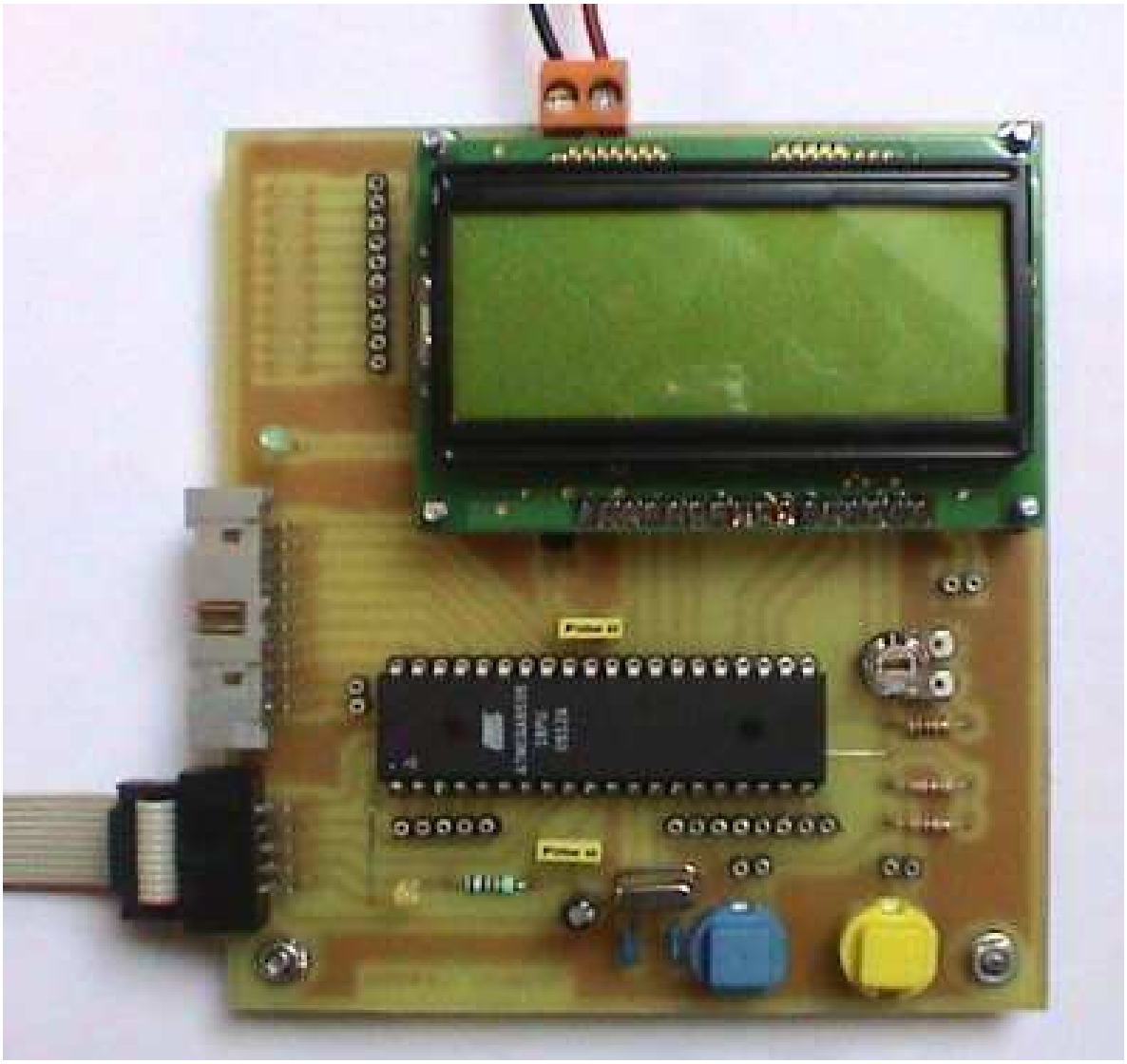

Figure 1: Vue de carte électronique (images-maquettes\http://www.thierry-lequeu.fr/data/DIV512.HTMAT8535-12.jpg

Auteurs :
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Groupe Q1

Enseignant :
Thierry LEQUEU

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Sommaire

Introduction

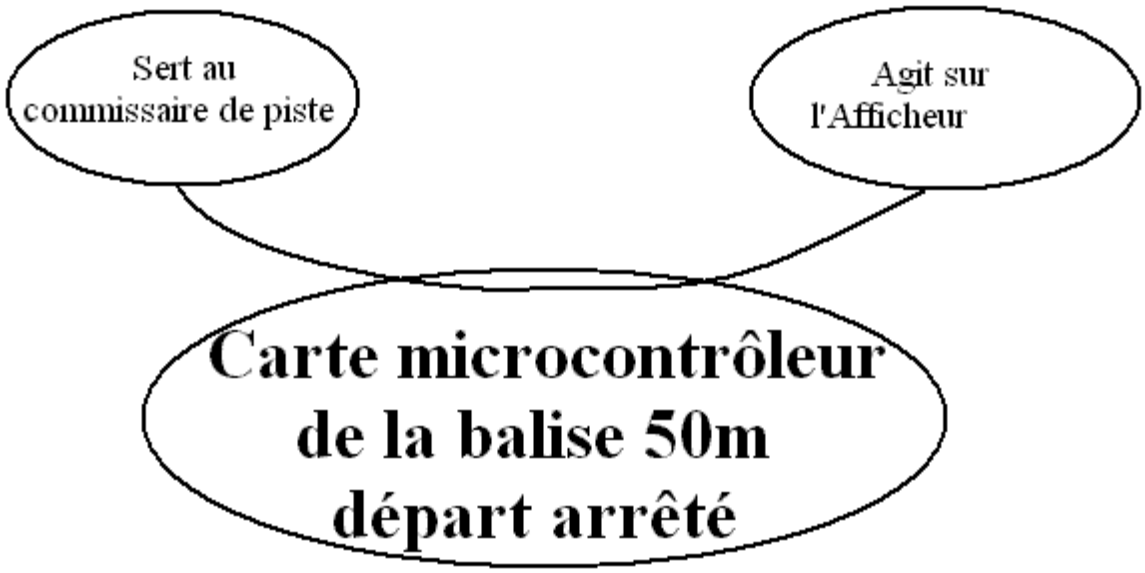
Le but de ce projet est de réaliser une carte microcontrôleur permettant de gérer le chronométrage automatique d'un départ arrêté d'un karting ainsi la gestion de son affichage sur un afficheur à LED. Cette carte est une révision d'un projet antérieur qui consistait à réaliser une carte gérant également le chronométrage et son affichage sur un cadran[1].

A noter que nous réaliserons uniquement la carte électronique, d'autres étapes nécessaires au fonctionnement de la carte seront citées lors de ce compte-rendu mais ne seront pas étudiés en détail.

1. Cahier des charges du projet

Nous evoquerons dans cette partie l'expression du besoin et les fonction de la Atmega8535.

1.1. « Bête à corne »



Permet de chronométrer un 50m départ arrêté et gérer l'affichage sur un afficheur

Illustration 1: Bête à corne/bête_à_corne.GIF

1.2. Diagramme « Pieuvre »

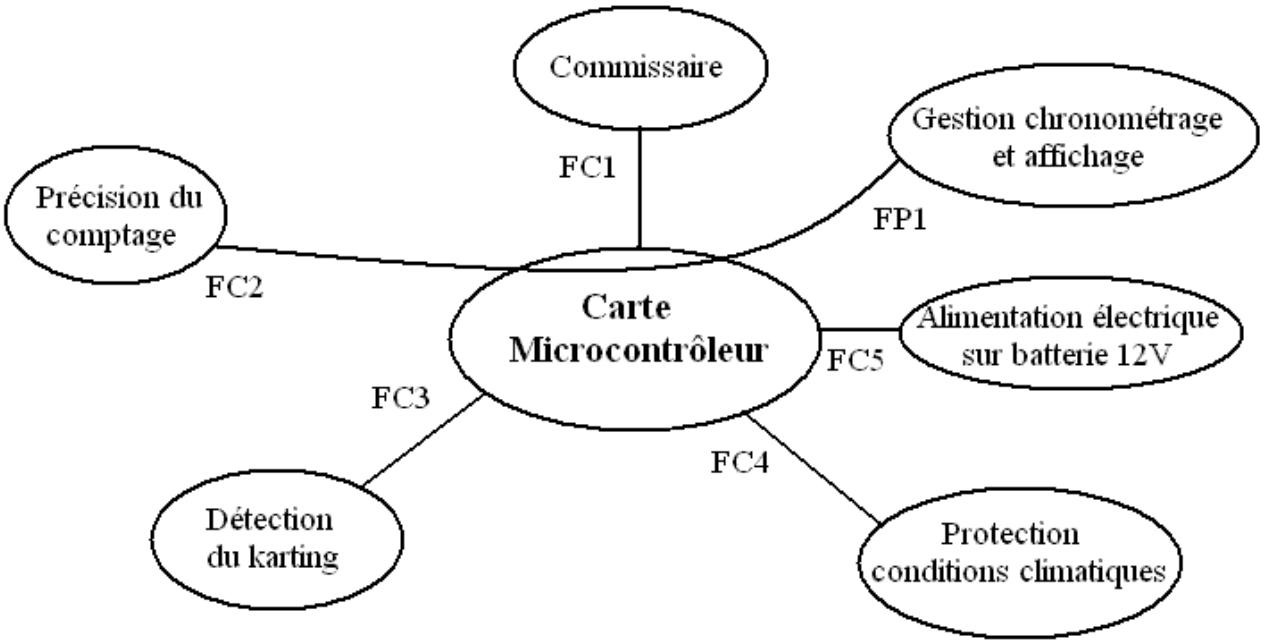


Illustration 2: Diagramme pieuvre/pieuvre.GIF

Fonction principale

Désignation	Fonction
FP1	Gérer le chronométrage du 50m départ arrêté et afficher en temps réel ce chronométrage sur l'afficheur à LED.

Fonctions contraintes

Désignation	Fonction
FC1	Permettre une utilisation simple à l'utilisateur.
FC2	Obtenir un chronométrage précis.(chronométrage au 1/100e de secondes)
FC3	Assurer une détection automatisée du karting.(ajout possible de capteurs)
FC4	Veiller à ce que la carte ne subissent les effets des conditions climatiques.
FC5	Alimentation continue sur batterie 12V. (Batterie 12 V continu)

Tableau 1: Description des fonctions\liste_contraintes.ods

1.3. Schéma fonctionnel

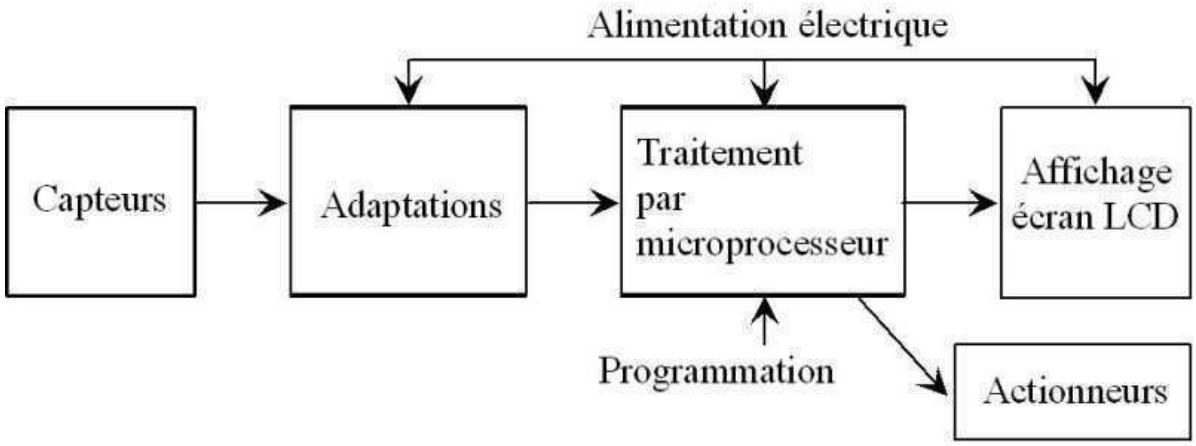


Illustration 3: Schéma fonctionnel de la carte\http://www.thierry-lequeu.fr/data/DATA354.HTM/Projet1.jpg

1.4. Planning prévisionnel

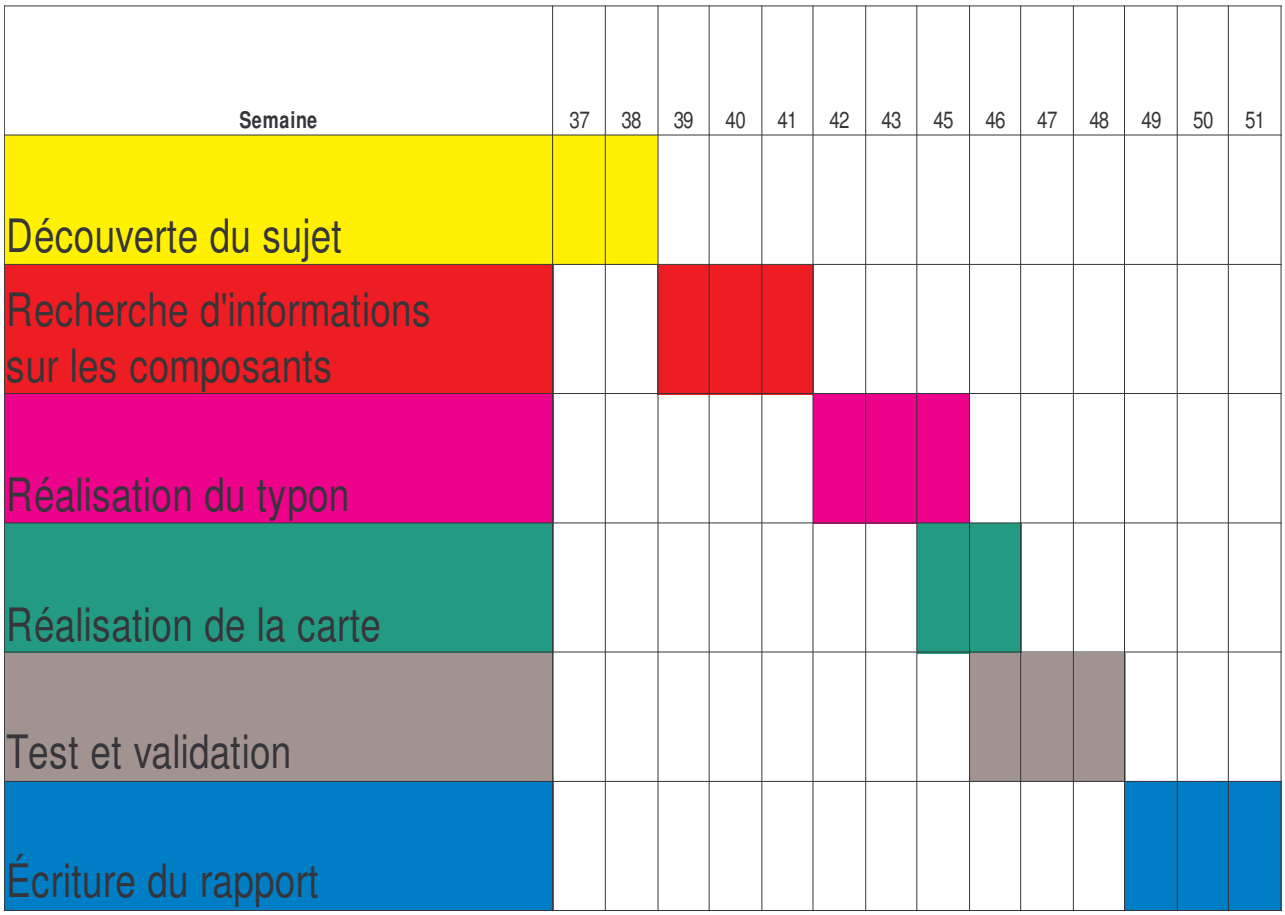


Tableau 2: Planning prévisionnel\pré_planning.ods

1.5. Planning suivi

Semaine	37	38	39	40	41	42	43	45	46	47	48	49	50	51
Découverte du sujet														
Recherche d'informations sur les composants														
Réalisation du typon														
Réalisation de la carte														
Test et validation														
Écriture du rapport														

Note : la séance de la semaine 48 n'a pas pu avoir lieu.

Tableau 3: Planning suivi lors du projet\planning.ods

2. Étude des composants utilisés

nous allons énumérer et expliquer le choix des composants que nous allons utiliser pour réaliser la carte.

2.1. Le Régulateur +5V, 0,5A

La carte est alimenté à l'aide d'une batterie 12V. Cependant les composants utilisés sur cette carte doivent être alimentés en +5V(ou utilise du +5V). Ainsi, il est nécessaire au préalable de créer à partir du 12V fournir une tension de +5V afin d'assurer l'alimentation des composants.

Le composant utilisé est un régulateur de type DC/DC de référence LM2574N-ADJ du constructeur National Semiconductor[2]. Il permet d'obtenir à partir d'une tension d'entrée (ici +12V) une tension de +5V et un courant de 0,5A .d'une manière constante quelque soit la consommation de la carte. Ce composant a été choisi dans ce but.

Cependant la tension d'entrée ne doit pas dépasser 60V, c'est pourquoi nous avons placé avant l'entrée du régulateur un condensateur de lissage qui va limiter les pics de tension au démarrage de la carte très courts mais suffisant pour détruire le régulateur..

Sur ce composant, il est également nécessaire d'envoyer sur l'entrée FeedBack une tension d'environ 1,21V afin de vérifier que le composant régule correctement . Nous utilisons pour cela un diviseur de tension à partir du +5V obtenue en sortie. La tension de FeedBack(V_{FB}) s'obtient donc par la formule suivante :

$$V_{FB}=V.(R_6/(R_6+R_7)), \text{ avec } V=5V;\ R_6=2{,}2k\Omega \text{ et } R_7=6{,}8k\Omega.$$

On obtient en une tension de FeedBack d'environ 1,22V pour ces valeurs normalisées.

Une LED est connecté au +5V afin de contrôler immédiatement si une tension est disponible en sortie.

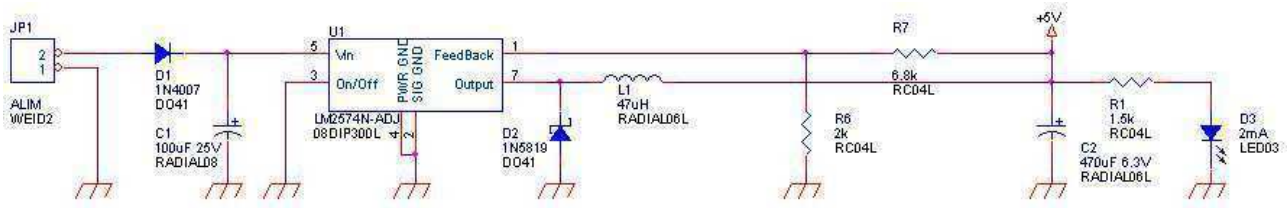


Illustration 4: Schéma du montage du régulateur\alimentation.bmp

2.2. Le Microcontôleur ATMega8535

Sur cette carte, le microcontrôleur est la composant le plus important de la carte, ainsi que sur l'ensemble du système du chronomètre puisqu'il est chargé aussi bien du chronométrage que donner « l'ordre » d'affichage aux cadrans de l'afficheur.

Il s'agit d'un composant programmable au même titre qu'un microprocesseur, néanmoins possède une mémoire intégrée de type EPPROM afin de pouvoir intégrer directement le programme sans à avoir recours à une mémoire vive supplémentaire(RAM), enfin le microcontrôleur est bien adapté pour des applications nécessitant peu d'entrées et sorties comme c'est le cas pour notre

application.

Le modèle utilisé est un ATM8535 du constructeur Atmel[3]. Il est alimenté en +5V. Il dispose de quatre ports (Ports A, B, C et D)de 8 bits chacun programmable en entrée ou en sortie; à noter que le Port A peut être programmé comme Convertisseur Analogique Numérique(CAN). Pour effacer un programme et le remplacer par un nouveau, il est nécessaire de flasher la mémoire(effacement par une tension électrique). Ceci se réalise en envoyant une tension sur la patte /RESET(9). Le programme devra être envoyé par la patte MOSI(6) avec l'aide d'un compilateur et d'une liaison série RS232 entre la carte via le connecteur CON ISP à 10 broches et le port série d'un ordinateur. Il sera également par la suite possible de lire le programme implanté dans le microcontrôleur en utilisant la même connexion par lecture de la patte MISO(7).

Dans un soucis d'obtenir une bonne précision de chronométrage, il a été décidé de remplacer l'horloge interne du microcontrôleur par un oscillateur à quartz cadencée à 16MHz(Q1) relié aux pattes XTAL1(13) et XTAL2(12).

L'envoi de données aux cadrans de l'afficheur se fera par le connecteur DATA à 20 broches.

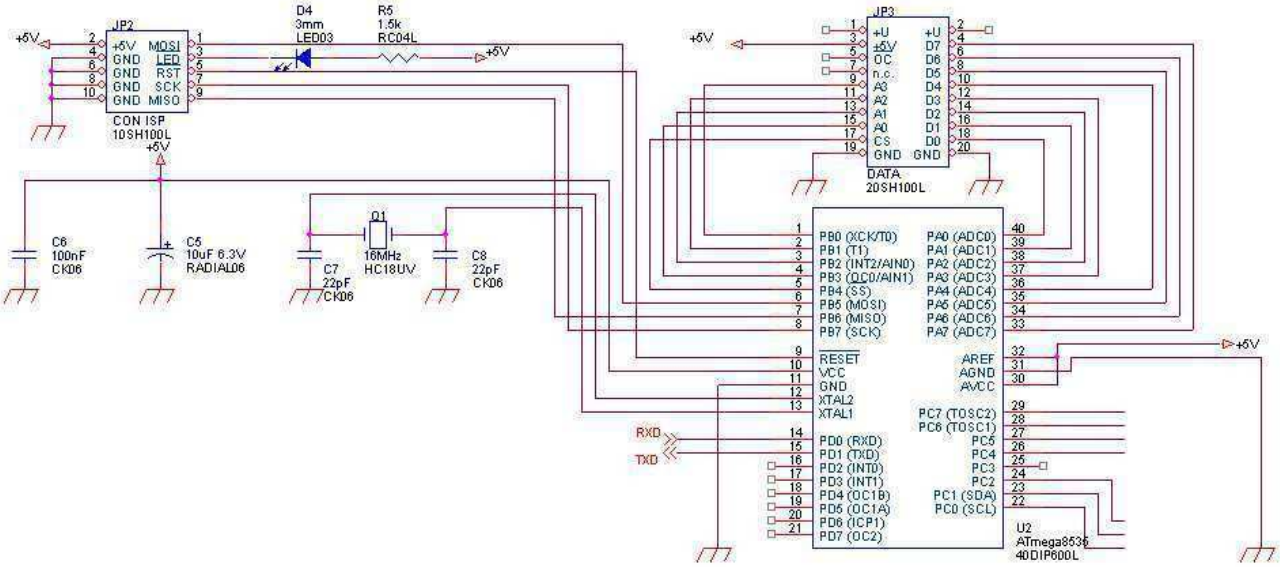


Illustration 5: Schéma du montage du microcontrôleur\ATMEGA.bmp

2.3. L'afficheur LCD 16 lignes x 4 points

L'afficheur est utilisé pour donner des informations sur le bon fonctionnement du chronométrage à l'utilisateur. Ces informations sont définies lors de la programmation du microcontrôleur, elles peuvent informer sur la détection des capteurs rajoutés(ou sur l'appuie d'un bouton) ou un contrôle du comptage.

L' afficheur choisi pour notre carte MC1604C du constructeur Everbouquet[4]. Son alimentation ne se fait pas directement par le +5V. En effet, l'écran est alimenté par la différence de potentiel entre V_{DD} et V_0, V_{DD} étant fixé à +5V et V_0 est une tension comprise entre 0 et 1V qui doit être réglée en fonction de la température ambiante. Ainsi l'afficheur LCD est alimenté avec une tension comprise entre 4V et 5V. Pour obtenir V_0, nous utilisons à partir du +5V un diviseur de tension composé d'une résistance fixe et d'un potentiomètre. Sa valeur est définie par l'équation suivante :

$$V_0 = V.(P_1/(R_2+P_1)), \text{ avec } V=5V,\ R_2= 39k\Omega \text{ et } P_{1max}= 10k\Omega.$$

A noter qu'il était possible d'utiliser un capteur de température, cependant le réglage de V_0 ne nécessite pas obligatoirement un réglage précis en fonction de la température, d'où le choix de conserver le diviseur de tension avec un potentiomètre, plus simple de mise en oeuvre et suffisant pour régler la tension de l'afficheur.

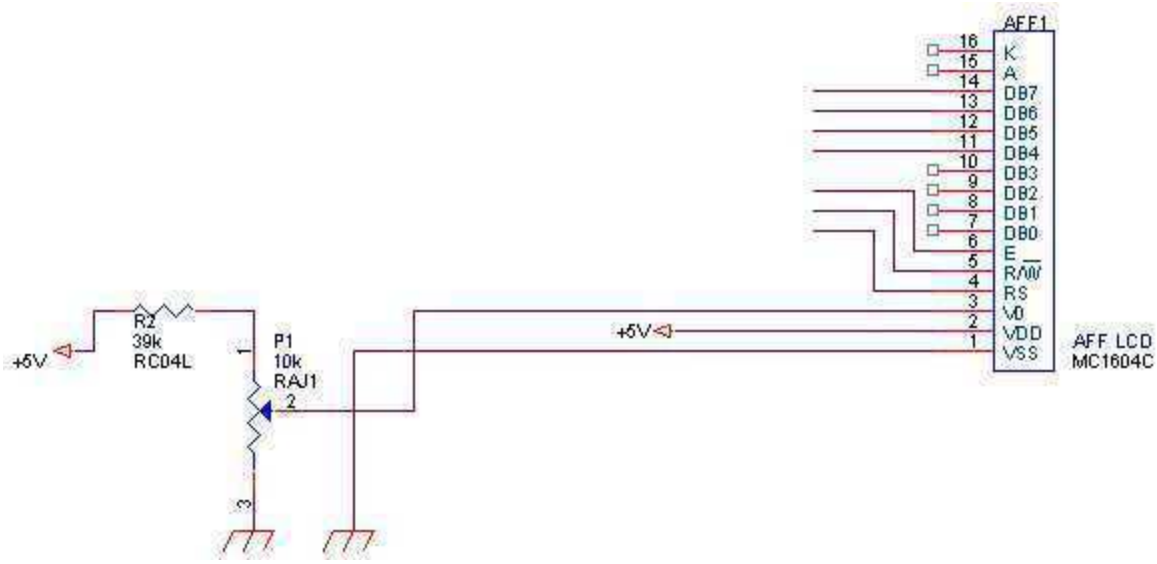


Illustration 6: Schéma du montage de l'afficheur LCD\LCD.bmp

2.4. Modules de transmission et de réception sans fil à 433MHz

Quelle que soit la configuration, la carte devra être obligatoirement à distance d'un des deux capteurs(ex. : 50m), ce qui impose comme contraintes de tirer au minimum une longueur équivalente voir supérieure à la distance entre la carte et le capteur. Pour éviter ce genre de désagrément, il serait intéressant de pouvoir contrôler à distance et sans fil l'état du capteur distant.

C'est pourquoi nous allons compléter la carte de deux modules : un de transmission et un de réception communiquant à une fréquence de 433MHz conçu par RFsolutions[5]. Les deux modules seront implantés directement sur la carte afin que celle-ci puisse être utilisée dans les deux configurations possibles(sur l'afficheur ou à distance de l'afficheur).

Aucune configuration particulière n'est nécessaire pour faire fonctionner ces deux modules, il suffit de les alimenter en +5V. Nous prendrons la précaution d'utiliser un condensateur de lissage pour protéger les modules. Un antenne adaptée à la fréquence du signal servira d'émetteur et de récepteur.

Les données reçus serons envoyé sur la patte RXD(14) du microcontrôleur et l'envoi se fait par sa patte TXD(15).

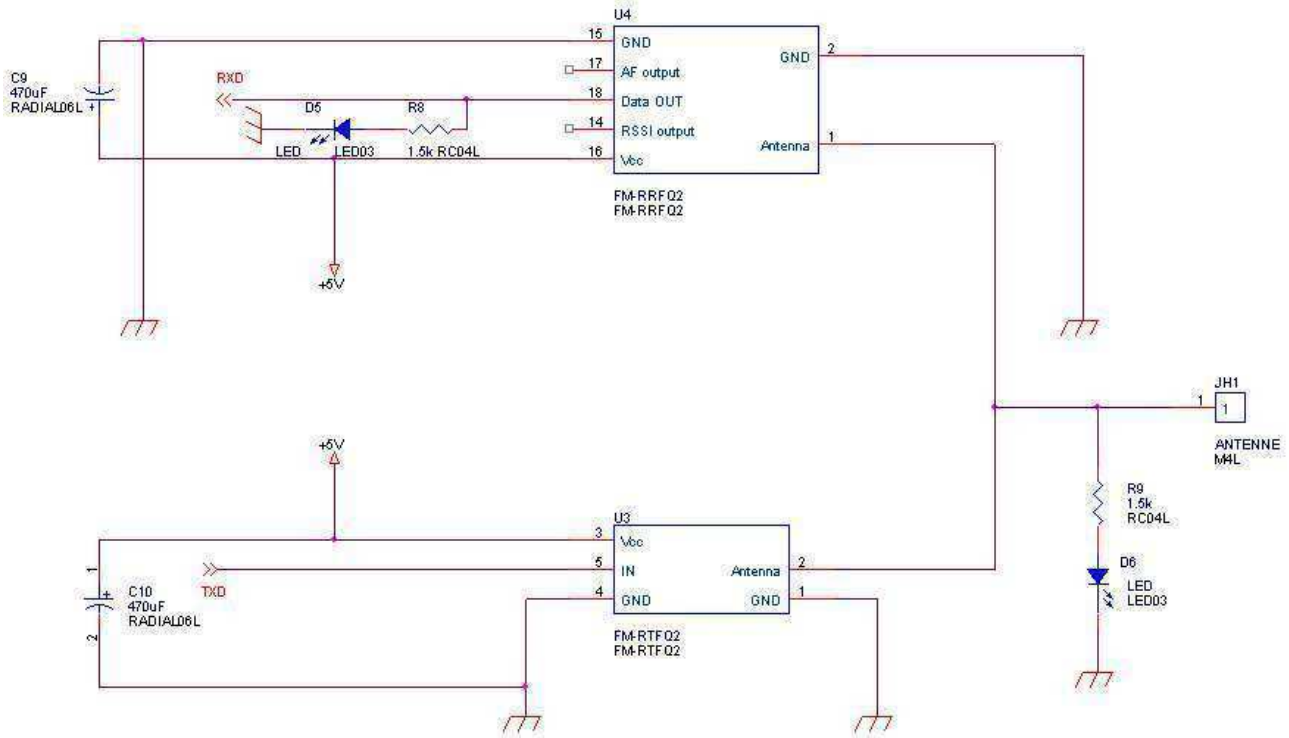


Illustration 7: Schéma du montage des modules haute fréquence\FM.bmp

3. Réalisation de la carte

Cette partie permet de lister les composants nécessaires pour la réalisation de la carte ainsi que leur coût, le schéma et le typon de la carte.

Le schéma et le typon a été réalisé avec Orcad 9.

3.1. Désignation des composants

N°	Qu.	Référence	Désignation	Empreinte
1	1	AFF1	LCD 16x4 MC	MC1604C
2	1	C1	100uF 25V	RADIAL08
3	3	C2,C9,C10	470uF 6,3V	RADIAL06L
4	1	C3, C5	10uF 25V	CK06
5	1	C4, C6	10uF 6,3V	RADIAL06
6	1	C5	10uF 6,3V	RADIAL06
7	1	C6	100nF	CK06
8	2	C7, C8	22pF	CK06
9	1	D1	1N4007	D041
10	1	D2	1N5819	DO41
11	3	D3, D5, D6	2mA	LED3
12	1	D4	3mm	LED3
13	1	JH1	ANTENNE	M4L
14	1	JP1	ALIM	WEID2
15	1	JP2	CON ISP	10SH100L
16	1	JP3	DATA	20SH100L
17	1	JP4	BP1	02PL1
18	1	JP5	BP2	02PL1
19	1	L1	10uH	RADIAL06L
20	1	L2	47uH	RADIAL06L
21	1	P1	10k	RAJ1
22	1	Q1	16MHz	HC18UV
23	2	R1,R5	1,5k	RC04L
24	1	R2	39k	RC04L
25	2	R3, R4	4,7k	RC04L
26	1	R6	2,2k	RC04L
27	1	R7	6,8k	RC04L
28	2	SW1, SW2	TOUCHE	REDROND
29	1	U1	15DF15E1	08DIP300L
30	1	U2	ATmega8535	40DIP600L
31	1	U3	FM-RTFQ2	FM-RTFQ2
32	1	U4	FM-RRFQ2	FM-RRFQ2
33	4	VIS1,VIS2, VIS3,VIS4	VISSERIE	M3L

Tableau 4: Désignation des composants\désignation_composants.ods

3.2. Coût des composants

GABORIEAU Jérémy, FONTAINE Vincent Q1

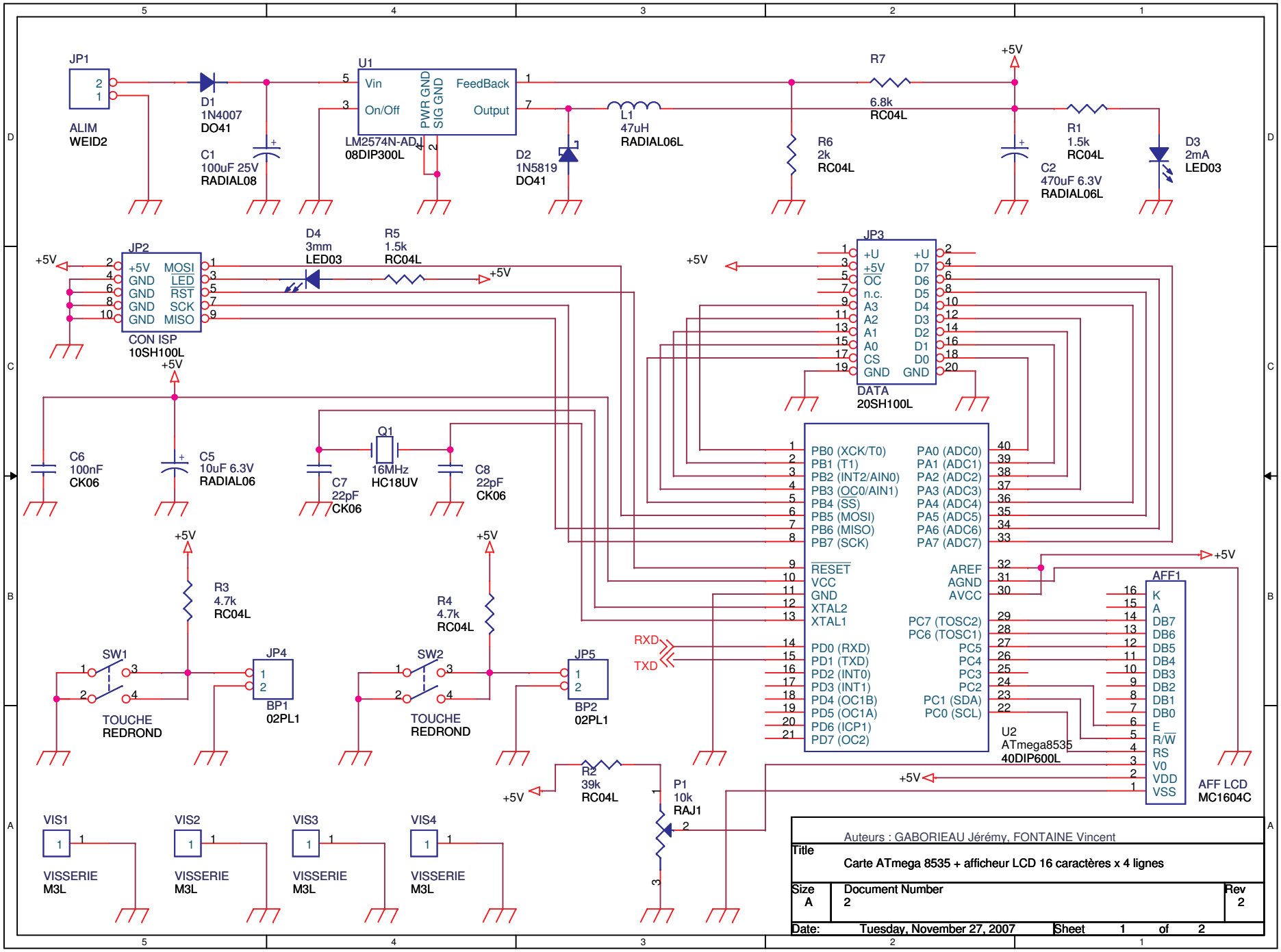
Carte ATmega 8535+ afficheur LCD 16 caractères x 4 lignes : Liste des composants
Révisé le : 4 décembre 2007

Référence	Qu.	Désignation	Fournisseur	Code Cde.	U.d.v	Prix U.	Prix T.
AFF1	1	LCD 16x4 MC	Farnell	9449019	1	23,75 €	23,75 €
C1	1	100uF 25V	Radiospares	315-1040	5	1,18 €	0,24 €
C2,C9,C10	3	470uF 6,3V	Radiospares	449-0845	5	1,21 €	0,73 €
C5	2	10uF 25V	Radiospares	449-1006	5	0,77 €	0,31 €
C6	2	100nF	IUT GEII		1	0,08 €	0,16 €
C7, C8	2	22pF	IUT GEII		1	0,02 €	0,04 €
D1	1	1N4007	IUT GEII		1	0,02 €	0,02 €
D2	1	1N5819	Radiospares	554-4994	5	1,10 €	0,22 €
D3,D5	2	LED verte 3mm 2mA	Radiospares	180-8451	10	3,43 €	0,69 €
D4, D6	2	LED jaune 3mm 2mA	Radiospares	171-1228	10	3,44 €	0,69 €
JH1	1	Visserie M4	IUT GEII		1	0,00 €	0,00 €
JP1	1	Connecteur 2 points	Radiospares	294-7642	10	2,47 €	0,25 €
JP2	1	CON ISP	Radiospares	473-8349	1	0,50 €	0,50 €
JP3	1	ANALOG	Radiospares	625-7296	1	0,54 €	0,54 €
JP4, JP5	1	Support tulipe sécable(32 plots)	Radiospares	600-7732	20	22,15 €	1,11 €
L1	1	47uH	Radiospares	432-4388	10	9,85 €	0,99 €
P1	1	10k	IUT GEII	177-223	5	3,37 €	0,67 €
Q1	1	16MHz	IUT GEII	226-1825	1	0,64 €	0,64 €
R1,R5	2	1,5k	IUT GEII	477-7962	50	1,26 €	0,05 €
R2	1	39k	IUT GEII	506-5412	50	1,26 €	0,03 €
R3, R4	2	4,7k	IUT GEII	506-5210	50	1,26 €	0,05 €
R6	1	2,2k	IUT GEII		50	1,26 €	0,03 €
R7	1	6,8k	IUT GEII		50	1,26 €	0,03 €
SW1, SW2	2	TOUCHE	CONRAD		1	0,00 €	0,00 €
U1	1	LM2574N-ADJ	Radiospares	331-3135	1	3,11 €	3,11 €
U2	1	ATmega8535	Farnell	9171444	1	5,81 €	5,81 €
U3	1	FM-RTQ2-433R	Radiospares	505-6806	1	10,50 €	10,50 €
U4	1	FM-RRQ2-433	Radiospares	505-6812	1	20,27 €	20,27 €
VIS1,VIS2, VIS3,VIS4	4	Visserie M3	IUT GEII		1	0,00 €	0,00 €
Divers	2	Antenne fouet à M4 433MHz	Radiospares	451-0747	1	6,20 €	12,40 €
Divers	32	Circuit imprimé SF 70x45 mm	Radiospares	159-6091	600	13,99 €	0,75 €
Divers	1	Support DIP 8 broches	IUT GEII		1	0,00 €	0,00 €
Divers	1	Support DIP 40 broches	IUT GEII		1	0,00 €	0,00 €

	TOTAL H.T. :	84,54 €
dont T.V.A. :	19,60%	16,57 €
	TOTAL T.T.C :	**101,11 €**

Tableau 5: Coût des composants\liste_composants.ods

3.3. Schéma symbolique de la carte


JP1
ALIM
WEID2
D1
1N4007
DO41
C1
100uF 25V
RADIAL08
U1
Vin
On/Off
PWR GND
SIG GND
FeedBack
Output
LM2574N-ADJ
08DIP300L
D2
1N5819
DO41
L1
47uH
RADIAL06L
R7
6.8k
RC04L
R6
2k
RC04L
+5V
C2
470uF 6.3V
RADIAL06L
R1
1.5k
RC04L
D3
2mA
LED03
JP2
+5V
GND
GND
GND
GND
MOSI
LED
RST
SCK
MISO
CON ISP
10SH100L
D4
3mm
LED03
R5
1.5k
RC04L
JP3
+U
+5V
OC
n.c.
A3
A2
A1
A0
CS
GND
D7
D6
D5
D4
D3
D2
D1
D0
GND
DATA
20SH100L
C6
100nF
CK06
C5
10uF 6.3V
RADIAL06
Q1
16MHz
HC18UV
C7
22pF
CK06
C8
22pF
CK06
PB0 (XCK/T0)
PB1 (T1)
PB2 (INT2/AIN0)
PB3 (OC0/AIN1)
PB4 (SS)
PB5 (MOSI)
PB6 (MISO)
PB7 (SCK)
RESET
VCC
GND
XTAL2
XTAL1
PD0 (RXD)
PD1 (TXD)
PD2 (INT0)
PD3 (INT1)
PD4 (OC1B)
PD5 (OC1A)
PD6 (ICP1)
PD7 (OC2)
PA0 (ADC0)
PA1 (ADC1)
PA2 (ADC2)
PA3 (ADC3)
PA4 (ADC4)
PA5 (ADC5)
PA6 (ADC6)
PA7 (ADC7)
AREF
AGND
AVCC
PC7 (TOSC2)
PC6 (TOSC1)
PC5
PC4
PC3
PC2
PC1 (SDA)
PC0 (SCL)
U2
ATmega8535
40DIP600L
AFF1
K
A
DB7
DB6
DB5
DB4
DB3
DB2
DB1
DB0
E
R/W
RS
V0
VDD
VSS
AFF LCD
MC1604C
RXD
TXD
R3
4.7k
RC04L
R4
4.7k
RC04L
SW1
TOUCHE
REDROND
JP4
BP1
02PL1
SW2
TOUCHE
REDROND
JP5
BP2
02PL1
R2
39k
RC04L
P1
10k
RAJ1
VIS1
VISSERIE
M3L
VIS2
VISSERIE
M3L
VIS3
VISSERIE
M3L
VIS4
VISSERIE
M3L
Auteurs : GABORIEAU Jérémy, FONTAINE Vincent
Title
Carte ATmega 8535 + afficheur LCD 16 caractères x 4 lignes
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Date:
Tuesday, November 27, 2007
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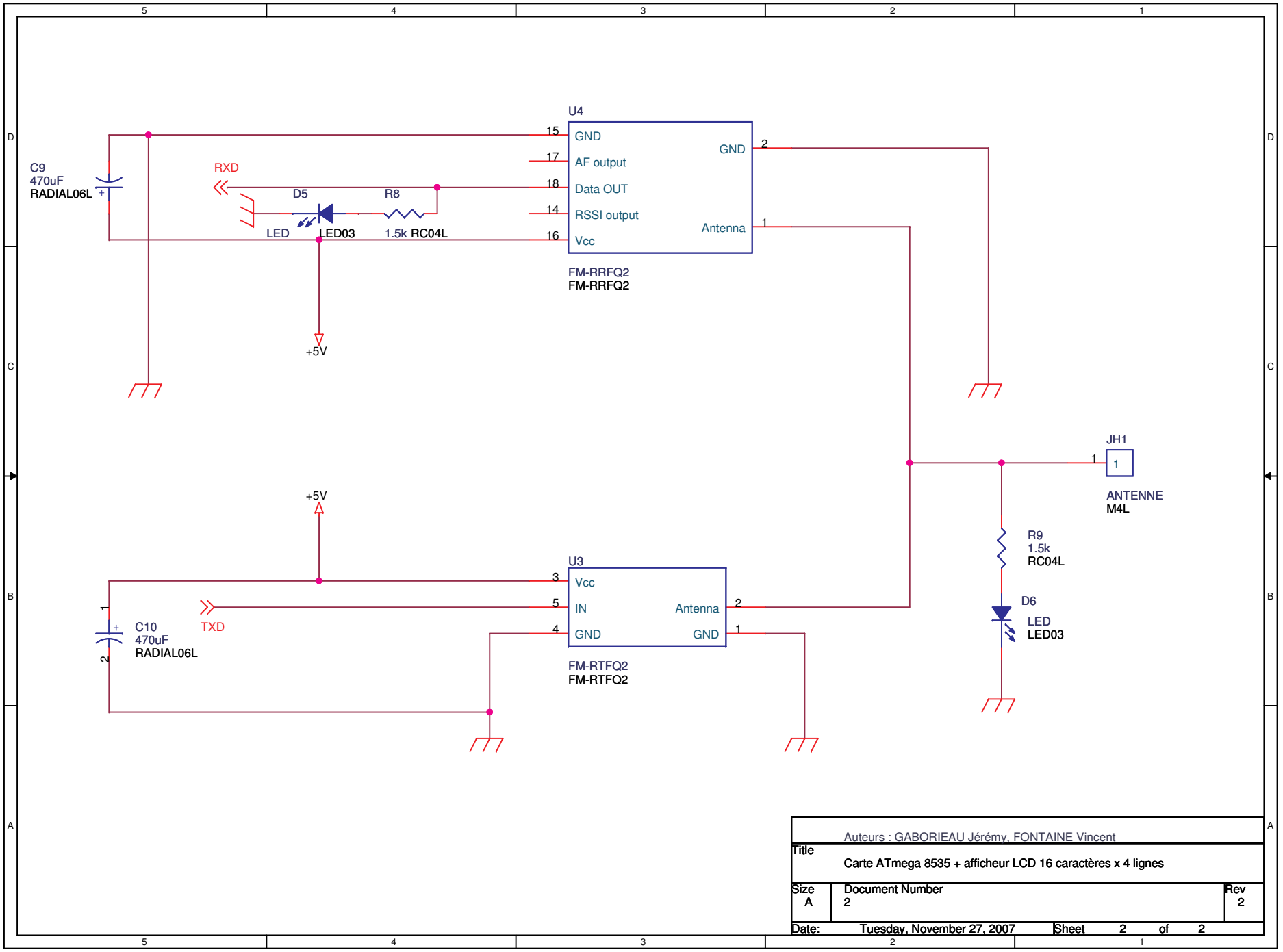
2


U4
15 GND
17 AF output
18 Data OUT
14 RSSI output
16 Vcc
GND 2
Antenna 1
FM-RRFQ2
FM-RRFQ2
C9
470uF
RADIAL06L
RXD
D5
R8
LED
LED03
1.5k RC04L
+5V
JH1
1
ANTENNE
M4L
R9
1.5k
RC04L
D6
LED
LED03
U3
3 Vcc
5 IN
4 GND
Antenna 2
GND 1
FM-RTFQ2
FM-RTFQ2
+5V
TXD
C10
470uF
RADIAL06L
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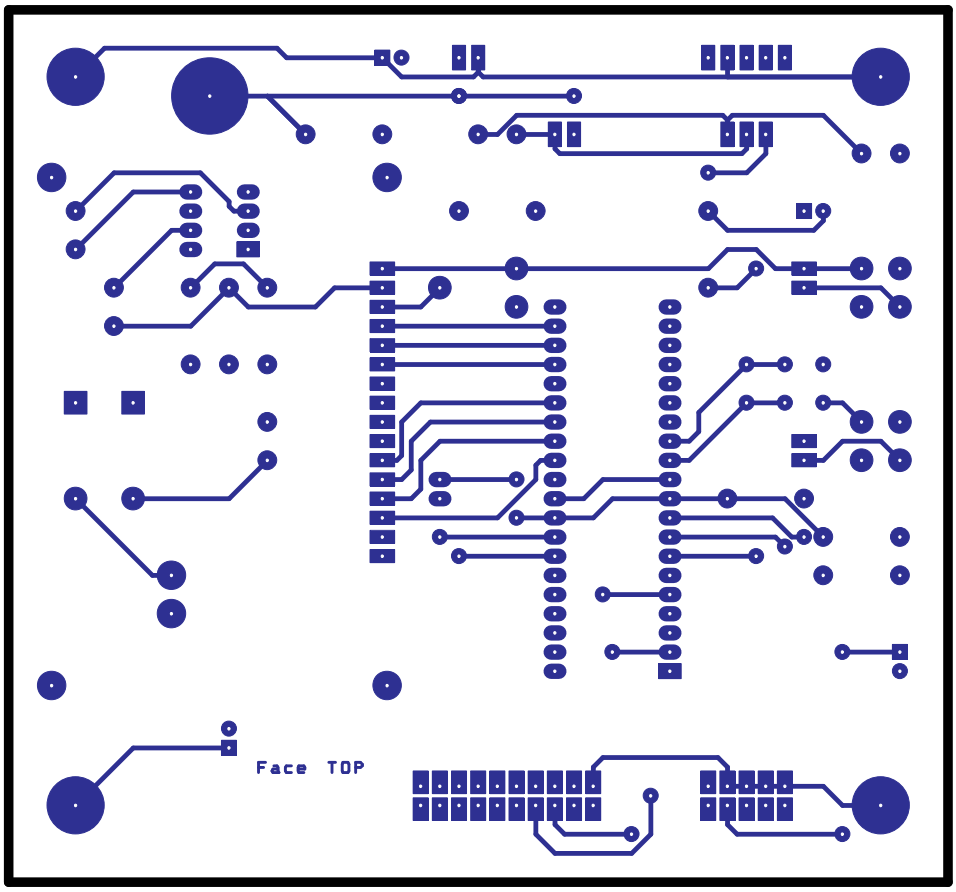
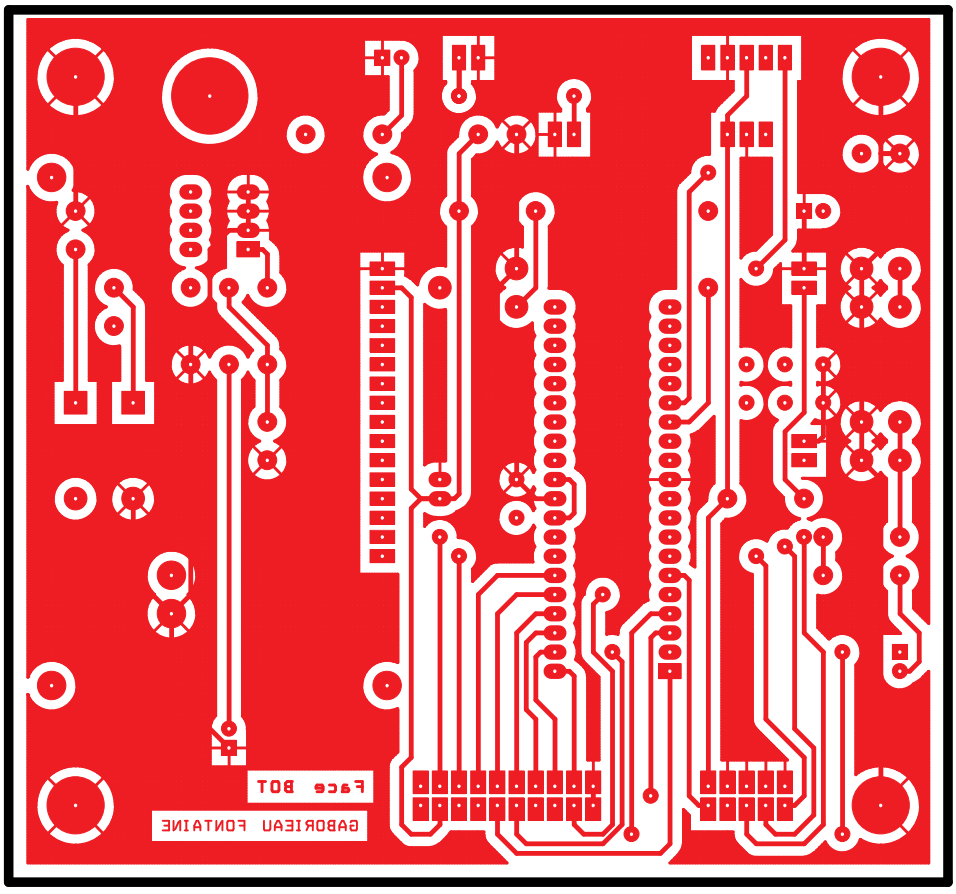
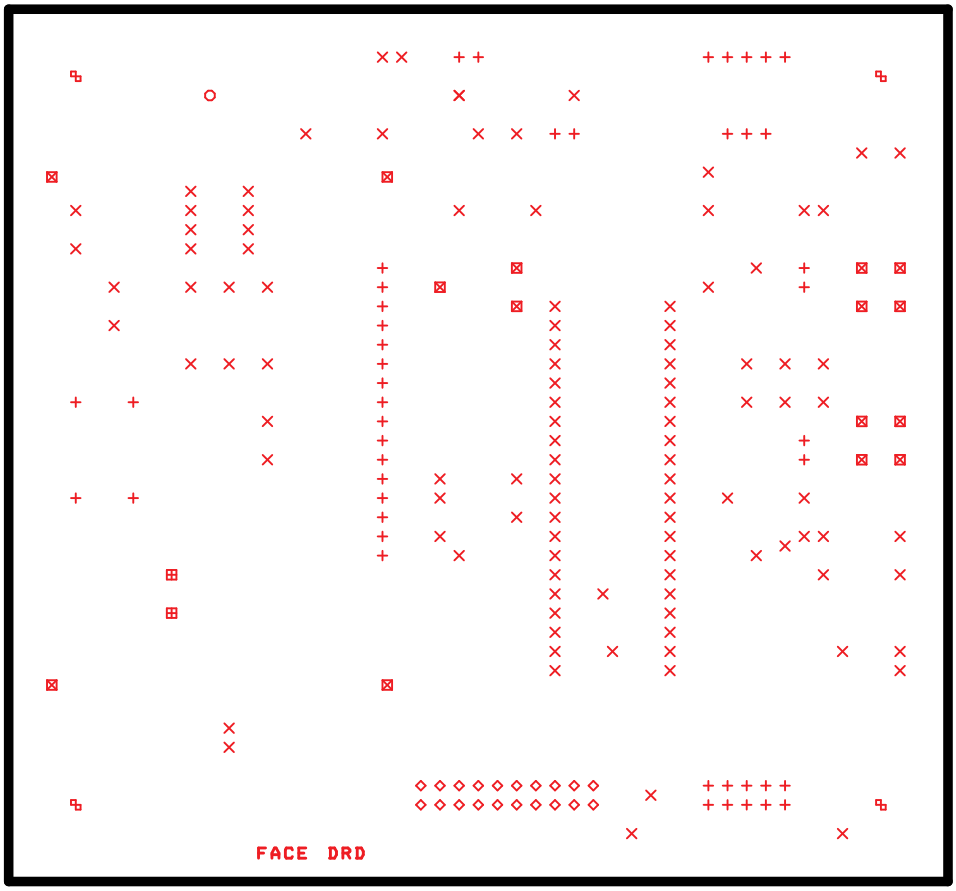
3.4. Typon de la carte

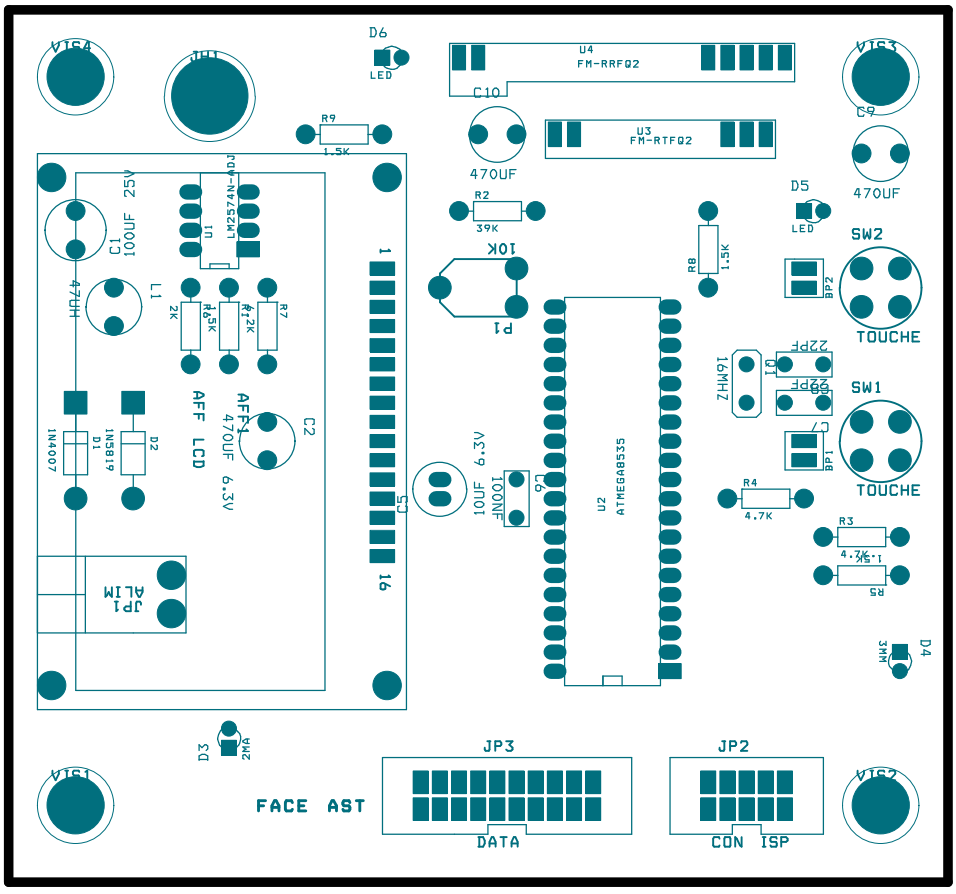
- Typon face composant(TOP).
- Typon face cuivre(BOT).
- Typon de perçage(DRD).
- Typon vue des composants(AST).


Face TOP


Face BOT
GABORIEAU FONTAINE



DRILL CHART				
SYM	DIAM	TOL	QTY	NOTE
×	0.787 mm		109	
+	0.991 mm		46	
◇	1.000 mm		20	
⊠	1.194 mm		15	
⊞	1.499 mm		2	
⚑	3.200 mm		4	
○	4.191 mm		1	
TOTAL			197	


VIS4
VIS3
VIS1
VIS2
D6
LED
U4
FM-RRFQ2
C10
470UF
U3
FM-RTFQ2
C9
470UF
R9
1.5K
R2
39K
10K
P1
D5
LED
R8
1.5K
SW2
TOUCHE
SW1
TOUCHE
22PF
22PF
16MHZ
Q1
C7
18PF
R4
4.7K
R3
4.7K
R5
1.5K
D4
3MM
U2
ATMEGA8535
C3
100NF
C5
100UF 6.3V
U1
LM2574N-ADJ
C1
100UF 25V
L1
47UH
R6
2K
R5
4.5K
R7
4.2K
AFF LCD
AFF1
C2
470UF 6.3V
D1
IN5819
D2
IN4007
JP1
ALIM
1
16
D3
PWR
JP3
DATA
JP2
CON ISP
FACE AST

Conclusion

Le but principal de ce projet de hui semaines était de réaliser une carte électronique capable d'afficher à l'aide d'un afficheur les informations recueillis par les différents capteurs et de les traiter à l'aide d'un microcontrôleur. Nous avons choisi ce projet pour sa richesse dans les fonctions à réaliser. Sur ces huit semaines, nous avons dû faire preuve d'autonomie et de sérieux afin de finir la carte dans les temps donnés. Ce travail en binôme nous a permis d'échanger nos connaissances dans diverses domaines et de se compléter pour résoudre les problèmes rencontrés.

Index des tables

Index des illustrations

Références des documents techniques

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Documents annexes

National Semiconductor

June 1999

LM2574/LM2574HV
SIMPLE SWITCHER™ 0.5A Step-Down Voltage Regulator

General Description

The LM2574 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 0.5A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V, 12V, 15V, and an adjustable output version.

Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation and a fixed-frequency oscillator.

The LM2574 series offers a high-efficiency replacement for popular three-terminal linear regulators. Because of its high efficiency, the copper traces on the printed circuit board are normally the only heat sinking needed.

A standard series of inductors optimized for use with the LM2574 are available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies.

Other features include a guaranteed ±4% tolerance on output voltage within specified input voltages and output load conditions, and ±10% on the oscillator frequency. External shutdown is included, featuring 50 µA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

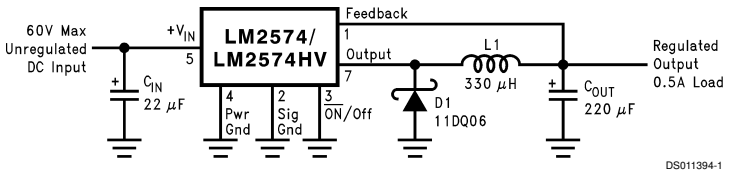
Features

- 3.3V, 5V, 12V, 15V, and adjustable output versions
- Adjustable version output voltage range, 1.23V to 37V (57V for HV version) ±4% max over line and load conditions
- Guaranteed 0.5A output current
- Wide input voltage range, 40V, up to 60V for HV version
- Requires only 4 external components
- 52 kHz fixed frequency internal oscillator
- TTL shutdown capability, low power standby mode
- High efficiency
- Uses readily available standard inductors
- Thermal shutdown and current limit protection

Applications

- Simple high-efficiency step-down (buck) regulator
- Efficient pre-regulator for linear regulators
- On-card switching regulators
- Positive to negative converter (Buck-Boost)

Typical Application (Fixed Output Voltage Versions)



Note: Pin numbers are for 8-pin DIP package.

Patent Pending
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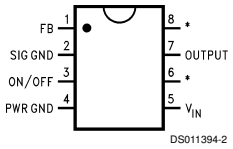
Connection Diagrams

8-Lead DIP

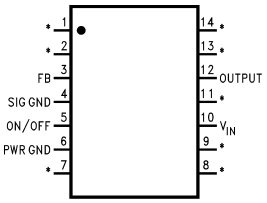


DS011394-2

* No internal connection, but should be soldered to PC board for best heat transfer.

Top View
Order Number LM2574-3.3HVN, LM2574HVN-5.0, LM2574HVN-12, LM2574HVN-15, LM2574HVN-ADJ, LM2574N-3.3, LM2574N-5.0, LM2574N-12, LM2574N-15 or LM2574N-ADJ
See NS Package Number N08A

14-Lead Wide Surface Mount (WM)



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Top View
Order Number LM2574HVM-3.3, LM2574HVM-5.0, LM2574HVM-12, LM2574HVM-15, LM2574HVM-ADJ, LM2574M-3.3 LM2574M-5.0, LM2574M-12, LM2574M-15 or LM2574M-ADJ
See NS Package Number M14B

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Maximum Supply Voltage	
LM2574	45V
LM2574HV	63V
$\overline{ON}$ /OFF Pin Input Voltage	$-0.3V \le V \le +V_{IN}$
Output Voltage to Ground (Steady State)	−1V
Minimum ESD Rating (C = 100 pF, R = 1.5 kΩ)	2 kV
Storage Temperature Range	−65˚C to +150˚C
Lead Temperature (Soldering, 10 seconds)	260˚C
Maximum Junction Temperature	150˚C
Power Dissipation	Internally Limited

Operating Ratings

Temperature Range	
LM2574/LM2574HV	$-40˚C \le T_J \le +125˚C$
Supply Voltage	
LM2574	40V
LM2574HV	60V

LM2574-3.3, LM2574HV-3.3 Electrical Characteristics

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.**

Symbol	Parameter	Conditions	LM2574-3.3 LM2574HV-3.3		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{OUT}	Output Voltage	V_{IN} = 12V, I_{LOAD} = 100 mA	3.3		V
				3.234	V(Min)
				3.366	V(Max)
V_{OUT}	Output Voltage LM2574	$4.75V \le V_{IN} \le 40V$, $0.1A \le I_{LOAD} \le 0.5A$	3.3		V
				3.168/**3.135**	V(Min)
				3.432/**3.465**	V(Max)
V_{OUT}	Output Voltage LM2574HV	$4.75V \le V_{IN} \le 60V$, $0.1A \le I_{LOAD} \le 0.5A$	3.3		
				3.168/**3.135**	V(Min)
				3.450/**3.482**	V(Max)
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 0.5A	72		%

LM2574-5.0, LM2574HV-5.0 Electrical Characteristics

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.**

Symbol	Parameter	Conditions	LM2574-5.0 LM2574HV-5.0		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{OUT}	Output Voltage	V_{IN} = 12V, I_{LOAD} = 100 mA	5		V
				4.900	V(Min)
				5.100	V(Max)
V_{OUT}	Output Voltage LM2574	$7V \le V_{IN} \le 40V$, $0.1A \le I_{LOAD} \le 0.5A$	5		V
				4.800/**4.750**	V(Min)
				5.200/**5.250**	V(Max)
V_{OUT}	Output Voltage LM2574HV	$7V \le V_{IN} \le 60V$, $0.1A \le I_{LOAD} \le 0.5A$	5		
				4.800/**4.750**	V(Min)
				5.225/**5.275**	V(Max)
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 0.5A	77		%

LM2574-12, LM2574HV-12 Electrical Characteristics

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.**

Symbol	Parameter	Conditions	LM2574-12 LM2574HV-12		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{OUT}	Output Voltage	V_{IN} = 25V, I_{LOAD} = 100 mA	12		V
				11.76	V(Min)
				12.24	V(Max)
V_{OUT}	Output Voltage LM2574	15V ≤ V_{IN} ≤ 40V, 0.1A ≤ I_{LOAD} ≤ 0.5A	12		V
				11.52/**11.40**	V(Min)
				12.48/**12.60**	V(Max)
V_{OUT}	Output Voltage LM2574HV	15V ≤ V_{IN} ≤ 60V, 0.1A ≤ I_{LOAD} ≤ 0.5A	12		
				11.52/**11.40**	V(Min)
				12.54/**12.66**	V(Max)
η	Efficiency	V_{IN} = 15V, I_{LOAD} = 0.5A	88		%

LM2574-15, LM2574HV-15 Electrical Characteristics

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.**

Symbol	Parameter	Conditions	LM2574-15 LM2574HV-15		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{OUT}	Output Voltage	V_{IN} = 30V, I_{LOAD} = 100 mA	15		V
				14.70	V(Min)
				15.30	V(Max)
V_{OUT}	Output Voltage LM2574	18V ≤ V_{IN} ≤ 40V, 0.1A ≤ I_{LOAD} ≤ 0.5A	15		V
				14.40/**14.25**	V(Min)
				15.60/**15.75**	V(Max)
V_{OUT}	Output Voltage LM2574HV	18V ≤ V_{IN} ≤ 60V, 0.1A ≤ I_{LOAD} ≤ 0.5A	15		
				14.40/**14.25**	V(Min)
				15.68/**15.83**	V(Max)
η	Efficiency	V_{IN} = 18V, I_{LOAD} = 0.5A	88		%

LM2574-ADJ, LM2574HV-ADJ Electrical Characteristics

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.** Unless otherwise specified, V_{IN} = 12V, I_{LOAD} = 100 mA.

Symbol	Parameter	Conditions	LM2574-ADJ LM2574HV-ADJ		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{FB}	Feedback Voltage	V_{IN} = 12V, I_{LOAD} = 100 mA	1.230		V
				1.217	V(Min)
				1.243	V(Max)

LM2574-ADJ, LM2574HV-ADJ
Electrical Characteristics (Continued)

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.** Unless otherwise specified, V_{IN} = 12V, I_{LOAD} = 100 mA.

Symbol	Parameter	Conditions	LM2574-ADJ LM2574HV-ADJ		Units (Limits)
			Typ	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{FB}	Feedback Voltage	7V ≤ V_{IN} ≤ 40V, 0.1A ≤ I_{LOAD} ≤ 0.5A	1.230		V
	LM2574	V_{OUT} Programmed for 5V. Circuit of *Figure 2*		1.193/**1.180**	V(Min)
				1.267/**1.280**	V(Max)
V_{FB}	Feedback Voltage	7V ≤ V_{IN} ≤ 60V, 0.1A ≤ I_{LOAD} ≤ 0.5A	1.230		
	LM2574HV	V_{OUT} Programmed for 5V. Circuit of *Figure 2*		1.193/**1.180**	V(Min)
				1.273/**1.286**	V(Max)
η	Efficiency	V_{IN} = 12V, V_{OUT} = 5V, I_{LOAD} = 0.5A	77		%

All Output Voltage Versions
Electrical Characteristics

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.** Unless otherwise specified, V_{IN} = 12V for the 3.3V, 5V, and Adjustable version, V_{IN} = 25V for the 12V version, and V_{IN} = 30V for the 15V version. I_{LOAD} = 100 mA.

Symbol	Parameter	Conditions	LM2574-XX LM2574HV-XX		Units (Limits)
			Typ	Limit (Note 2)	
DEVICE PARAMETERS					
I_b	Feedback Bias Current	Adjustable Version Only, V_{OUT} = 5V	50	100/**500**	nA
f_O	Oscillator Frequency	(see Note 10)	52		kHz
				47/**42**	kHz(Min)
				58/**63**	kHz(Max)
V_{SAT}	Saturation Voltage	I_{OUT} = 0.5A (Note 4)	0.9		V
				1.2/**1.4**	V(max)
DC	Max Duty Cycle (ON)	(Note 5)	98		%
				93	%(Min)
I_{CL}	Current Limit	Peak Current, (Notes 4, 10)	1.0		A
				0.7/**0.65**	A(Min)
				1.6/**1.8**	A(Max)
I_L	Output Leakage Current	(Notes 6, 7) Output = 0V		2	mA(Max)
		Output = −1V	7.5		mA
		Output = −1V		30	mA(Max)
I_Q	Quiescent Current	(Note 6)	5		mA
				10	mA(Max)
I_{STBY}	Standby Quiescent Current	$\overline{ON}$ /OFF Pin= 5V (OFF)	50		μA
				200	μA(Max)
θ_{JA}	Thermal Resistance	N Package, Junction to Ambient (Note 8)	92		
θ_{JA}		N Package, Junction to Ambient (Note 9)	72		˚C/W
θ_{JA}		M Package, Junction to Ambient (Note 8)	102		
θ_{JA}		M Package, Junction to Ambient (Note 9)	78		

All Output Voltage Versions
Electrical Characteristics (Continued)

Specifications with standard type face are for T_J = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.** Unless otherwise specified, V_{IN} = 12V for the 3.3V, 5V, and Adjustable version, V_{IN} = 25V for the 12V version, and V_{IN} = 30V for the 15V version. I_{LOAD} = 100 mA.

Symbol	Parameter	Conditions	LM2574-XX LM2574HV-XX		Units (Limits)
			Typ	Limit (Note 2)	
$\overline{ON}$ /OFF CONTROL Test Circuit *Figure 2*					
V_{IH}	$\overline{ON}$ /OFF Pin Logic Input Level	V_{OUT} = 0V	1.4	2.2/**2.4**	V(Min)
V_{IL}		V_{OUT} = Nominal Output Voltage	1.2	1.0/**0.8**	V(Max)
I_H	$\overline{ON}$ /OFF Pin Input Current	$\overline{ON}$ /OFF Pin = 5V (OFF)	12	30	µA µA(Max)
I_{IL}		$\overline{ON}$ /OFF Pin = 0V (ON)	0	10	µA µA(Max)

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: All limits guaranteed at room temperature (Standard type face) and at temperature extremes (bold type face). All room temperature limits are 100% production tested. All limits at temperature extremes are guaranteed via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level.

Note 3: External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2574 is used as shown in the *Figure 2* test circuit, system performance will be as shown in system parameters section of Electrical Characteristics.

Note 4: Output pin sourcing current. No diode, inductor or capacitor connected to output pin.

Note 5: Feedback pin removed from output and connected to 0V.

Note 6: Feedback pin removed from output and connected to +12V for the Adjustable, 3.3V, and 5V versions, and +25V for the 12V and 15V versions, to force the output transistor OFF.

Note 7: V_{IN} = 40V (60V for high voltage version).

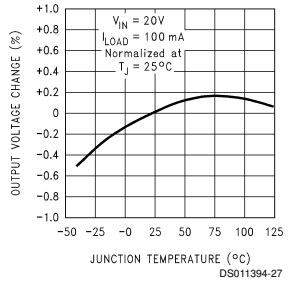
Note 8: Junction to ambient thermal resistance with approximately 1 square inch of printed circuit board copper surrounding the leads. Additional copper area will lower thermal resistance further. See application hints in this data sheet and the thermal model in Switchers Made Simple software.

Note 9: Junction to ambient thermal resistance with approximately 4 square inches of 1 oz. (0.0014 in. thick) printed circuit board copper surrounding the leads. Additional copper area will lower thermal resistance further. (See Note 8.)

Note 10: The oscillator frequency reduces to approximately 18 kHz in the event of an output short or an overload which causes the regulated output voltage to drop approximately 40% from the nominal output voltage. This self protection feature lowers the average power dissipation of the IC by lowering the minimum duty cycle from 5% down to approximately 2%.

Typical Performance Characteristics (Circuit of *Figure 2*)

Normalized Output Voltage



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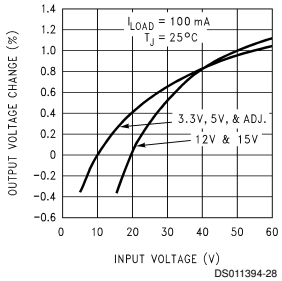
Line Regulation



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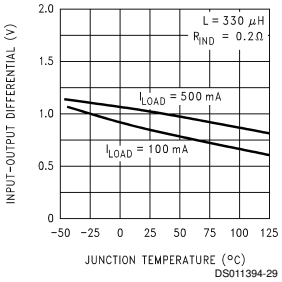
Dropout Voltage



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Features

- High-performance, Low-power AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 130 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz
  - On-chip 2-cycle Multiplier
- Nonvolatile Program and Data Memories
  - 8K Bytes of In-System Self-Programmable Flash
    Endurance: 10,000 Write/Erase Cycles
  - Optional Boot Code Section with Independent Lock Bits
    In-System Programming by On-chip Boot Program
    True Read-While-Write Operation
  - 512 Bytes EEPROM
    Endurance: 100,000 Write/Erase Cycles
  - 512 Bytes Internal SRAM
  - Programming Lock for Software Security
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Four PWM Channels
  - 8-channel, 10-bit ADC
    8 Single-ended Channels
    7 Differential Channels for TQFP Package Only
    2 Differential Channels with Programmable Gain at 1x, 10x, or 200x for TQFP Package Only
  - Byte-oriented Two-wire Serial Interface
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated RC Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
  - 32 Programmable I/O Lines
  - 40-pin PDIP, 44-lead TQFP, 44-lead PLCC, and 44-pad MLF
- Operating Voltages
  - 2.7 - 5.5V for ATmega8535L
  - 4.5 - 5.5V for ATmega8535
- Speed Grades
  - 0 - 8 MHz for ATmega8535L
  - 0 - 16 MHz for ATmega8535

8-bit AVR® Microcontroller with 8K Bytes In-System Programmable Flash

ATmega8535
ATmega8535L

Advance Information

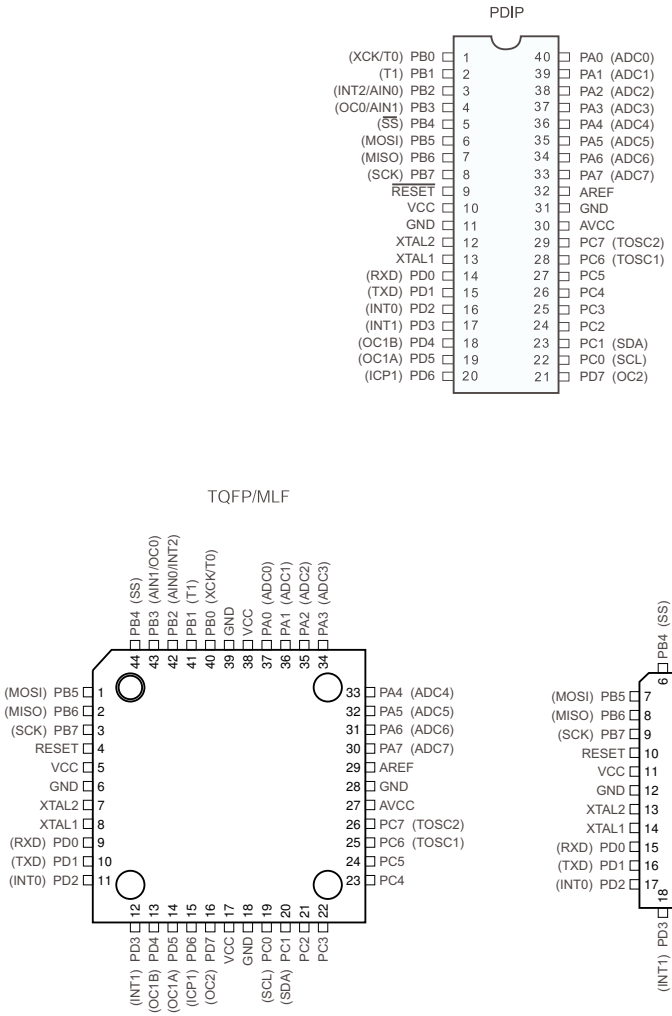
Summary

Rev. 2502CS–AVR–04/03

Note: This is a summary document. A complete document is available on our web site at *www.atmel.com*.

Pin Configurations

Figure 1. Pinout ATmega8535



Disclaimer

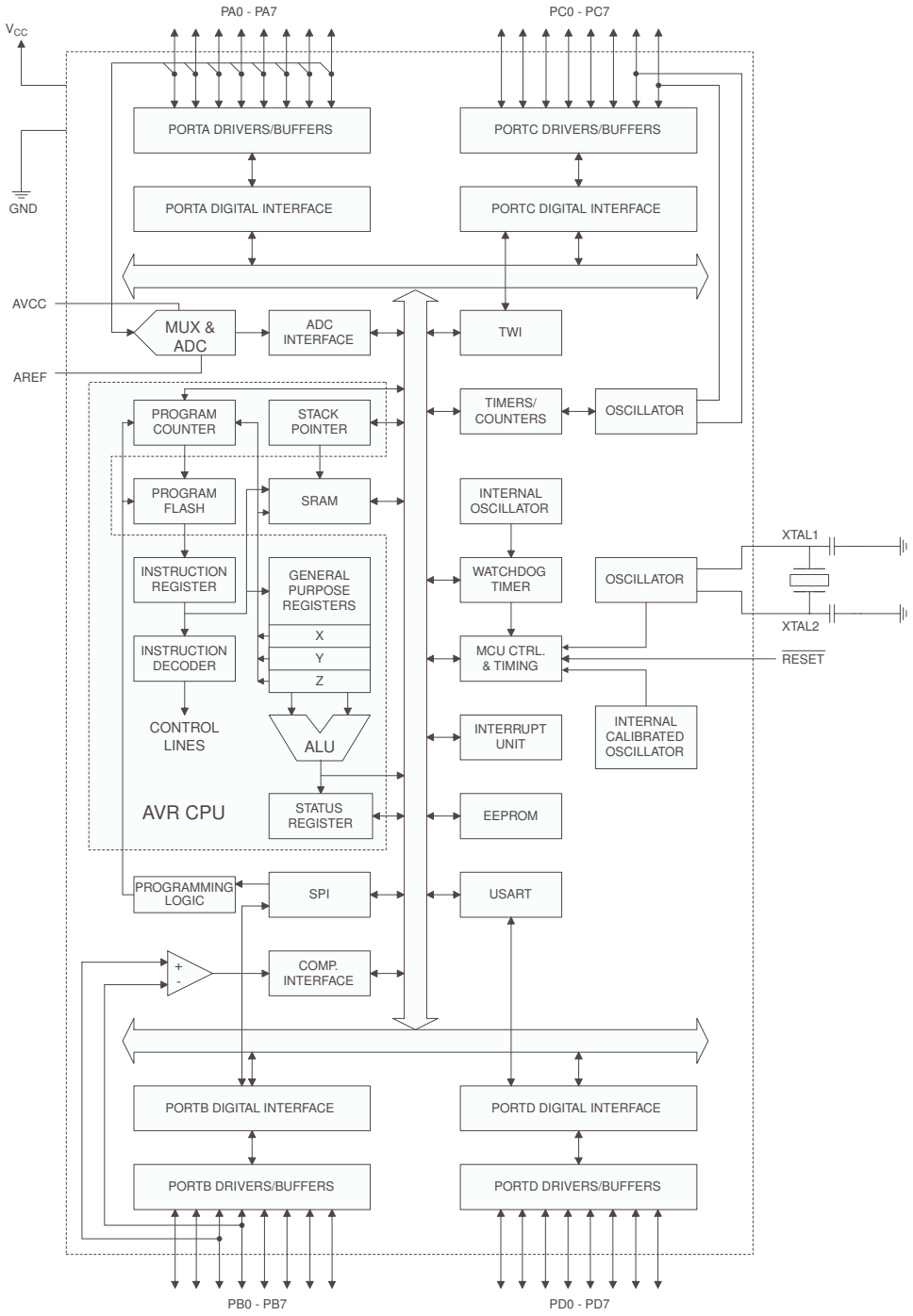
Typical values contained in this data sheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.

Overview

The ATmega8535 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing instructions in a single clock cycle, the ATmega8535 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

Block Diagram

Figure 2. Block Diagram



The AVR core combines a rich instruction set with 32 general purpose working registers. All 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega8535 provides the following features: 8K bytes of In-System Programmable Flash with Read-While-Write capabilities, 512 bytes EEPROM, 512 bytes SRAM, 32 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain in TQFP package, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. In Extended Standby mode, both the main Oscillator and the asynchronous timer continue to run.

The device is manufactured using Atmel's high density nonvolatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega8535 is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega8535 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, In-Circuit Emulators, and evaluation kits.

AT90S8535 Compatibility

The ATmega8535 provides all the features of the AT90S8535. In addition, several new features are added. The ATmega8535 is backward compatible with AT90S8535 in most cases. However, some incompatibilities between the two microcontrollers exist. To solve this problem, an AT90S8535 compatibility mode can be selected by programming the S8535C fuse. ATmega8535 is pin compatible with AT90S8535, and can replace the AT90S8535 on current Printed Circuit Boards. However, the location of fuse bits and the electrical characteristics differs between the two devices.

AT90S8535 Compatibility Mode

Programming the S8535C fuse will change the following functionality:

- The timed sequence for changing the Watchdog Time-out period is disabled. See "Timed Sequences for Changing the Configuration of the Watchdog Timer" on page 43 for details.
- The double buffering of the USART Receive Register is disabled. See "AVR USART vs. AVR UART – Compatibility" on page 142 for details.

Pin Descriptions

V_{CC} — Digital supply voltage.

GND — Ground.

Port A (PA7..PA0) — Port A serves as the analog inputs to the A/D Converter.

Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B (PB7..PB0) — Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B also serves the functions of various special features of the ATmega8535 as listed on page 57.

Port C (PC7..PC0) — Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port D (PD7..PD0) — Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port D also serves the functions of various special features of the ATmega8535 as listed on page 61.

$\overline{\text{RESET}}$ — Reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in Table 15 on page 35. Shorter pulses are not guaranteed to generate a reset.

XTAL1 — Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2 — Output from the inverting Oscillator amplifier.

AVCC — AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to V_{CC}, even if the ADC is not used. If the ADC is used, it should be connected to V_{CC} through a low-pass filter.

AREF — AREF is the analog reference pin for the A/D Converter.

Register Summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C	8
0x3E (0x5E)	SPH	–	–	–	–	–	SP10	SP9	SP8	10
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	10
0x3C (0x5C)	OCR0	Timer/Counter0 Output Compare Register								82
0x3B (0x5B)	GICR	INT1	INT0	INT2	–	–	–	IVSEL	IVCE	47, 66
0x3A (0x5A)	GIFR	INTF1	INTF0	INTF2	–	–	–	–	–	67
0x39 (0x59)	TIMSK	OCIE2	TOIE2	TICIE1	OCIE1A	OCIE1B	TOIE1	OCIE0	TOIE0	82, 112, 130
0x38 (0x58)	TIFR	OCF2	TOV2	ICF1	OCF1A	OCF1B	TOV1	OCF0	TOV0	83, 113, 131
0x37 (0x57)	SPMCR	SPMIE	RWWSB	–	RWWSRE	BLBSET	PGWRT	PGERS	SPMEN	224
0x36 (0x56)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	–	TWIE	177
0x35 (0x55)	MCUCR	SM2	SE	SM1	SM0	ISC11	ISC10	ISC01	ISC00	30, 65
0x34 (0x54)	MCUCSR	–	ISC2	–	–	WDRF	BORF	EXTRF	PORF	38, 66
0x33 (0x53)	TCCR0	FOC0	WGM00	COM01	COM00	WGM01	CS02	CS01	CS00	80
0x32 (0x52)	TCNT0	Timer/Counter0 (8 Bits)								82
0x31 (0x51)	OSCCAL	Oscillator Calibration Register								28
0x30 (0x50)	SFIOR	ADTS2	ADTS1	ADTS0	–	ACME	PUD	PSR2	PSR10	56,85,132,199,219
0x2F (0x4F)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	FOC1A	FOC1B	WGM11	WGM10	107
0x2E (0x4E)	TCCR1B	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10	110
0x2D (0x4D)	TCNT1H	Timer/Counter1 – Counter Register High Byte								111
0x2C (0x4C)	TCNT1L	Timer/Counter1 – Counter Register Low Byte								111
0x2B (0x4B)	OCR1AH	Timer/Counter1 – Output Compare Register A High Byte								111
0x2A (0x4A)	OCR1AL	Timer/Counter1 – Output Compare Register A Low Byte								111
0x29 (0x49)	OCR1BH	Timer/Counter1 – Output Compare Register B High Byte								111
0x28 (0x48)	OCR1BL	Timer/Counter1 – Output Compare Register B Low Byte								111
0x27 (0x47)	ICR1H	Timer/Counter1 – Input Capture Register High Byte								111
0x26 (0x46)	ICR1L	Timer/Counter1 – Input Capture Register Low Byte								111
0x25 (0x45)	TCCR2	FOC2	WGM20	COM21	COM20	WGM21	CS22	CS21	CS20	125
0x24 (0x44)	TCNT2	Timer/Counter2 (8 Bits)								127
0x23 (0x43)	OCR2	Timer/Counter2 Output Compare Register								128
0x22 (0x42)	ASSR	–	–	–	–	AS2	TCN2UB	OCR2UB	TCR2UB	128
0x21 (0x41)	WDTCR	–	–	–	WDCE	WDE	WDP2	WDP1	WDP0	40
0x20[1] (0x40)[1]	UBRRH	URSEL	–	–	–	UBRR[11:8]				165
	UCSRC	URSEL	UMSEL	UPM1	UPM0	USBS	UCSZ1	UCSZ0	UCPOL	163
0x1F (0x3F)	EEARH	–	–	–	–	–	–	–	EEAR8	17
0x1E (0x3E)	EEARL	EEPROM Address Register Low Byte								17
0x1D (0x3D)	EEDR	EEPROM Data Register								17
0x1C (0x3C)	EECR	–	–	–	–	EERIE	EEMWE	EEWE	EERE	17
0x1B (0x3B)	PORTA	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	63
0x1A (0x3A)	DDRA	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	63
0x19 (0x39)	PINA	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	63
0x18 (0x38)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	63
0x17 (0x37)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	63
0x16 (0x36)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	64
0x15 (0x35)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	64
0x14 (0x34)	DDRC	DDC7	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	64
0x13 (0x33)	PINC	PINC7	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0	64
0x12 (0x32)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	64
0x11 (0x31)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	64
0x10 (0x30)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	64
0x0F (0x2F)	SPDR	SPI Data Register								139
0x0E (0x2E)	SPSR	SPIF	WCOL	–	–	–	–	–	SPI2X	139
0x0D (0x2D)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	137
0x0C (0x2C)	UDR	USART I/O Data Register								160
0x0B (0x2B)	UCSRA	RXC	TXC	UDRE	FE	DOR	PE	U2X	MPCM	161
0x0A (0x2A)	UCSRB	RXCIE	TXCIE	UDRIE	RXEN	TXEN	UCSZ2	RXB8	TXB8	162
0x09 (0x29)	UBRRL	USART Baud Rate Register Low Byte								165
0x08 (0x28)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	199
0x07 (0x27)	ADMUX	REFS1	REFS0	ADLAR	MUX4	MUX3	MUX2	MUX1	MUX0	215
0x06 (0x26)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	217
0x05 (0x25)	ADCH	ADC Data Register High Byte								218
0x04 (0x24)	ADCL	ADC Data Register Low Byte								218
0x03 (0x23)	TWDR	Two-wire Serial Interface Data Register								179
0x02 (0x22)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE	180
0x01 (0x21)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	–	TWPS1	TWPS0	179

Register Summary (Continued)

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
0x00 (0x20)	TWBR	Two-wire Serial Interface Bit Rate Register								177

Notes:
1. Refer to the USART description for details on how to access UBRRH and UCSRC.
2. For compatibility with future devices, reserved bits should be written to zero if accessed. Reserved I/O memory addresses should never be written.
3. Some of the status flags are cleared by writing a logical one to them. Note that the CBI and SBI instructions will operate on all bits in the I/O Register, writing a one back into any flag read as set, thus clearing the flag. The CBI and SBI instructions work with registers 0x00 to 0x1F only.

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PART NO.: MC1604C-SERIES

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CONTENTS

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RECORD OF REVISION

DATE	PAGE	SUMMARY

3. General specifications

3.1 General specifications

PLEASE REFER TO:

"CUSTOMER ACCEPTANCE STANDARD SPECIFICATIONS (MS-10-0069)"

3.2 This individual specification is prior to general specifications

3.3 NUMBERING SYSTEM

MC1604C	B	W	-	S	Y	M	L	O	U	N
	(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)

(1).CHARACTER FONTS :

PLEASE ERFER TO

"CUSTOMER ACCEPTANCE STANDARD SPECIFICATIONS (MS-10-0069)"

(2).LCM TEMPERATURE :

"nil" : NORMAL TEMP

"W" : WIDE TEMP

(3).LCD TYPE :

"T" : TN TYPE "S" : STN TYPE

"H" : HTN TYPE "F" : FSTN TYPE

(4).LCD COLOR :

"Y" : YELLOW-GREEN "B" : BLUE(STN/NEGATIVE)/BLACK(FSTN/NEGATIVE)

"G" : GRAY "W" : WHITE(FSTN/POSITIVE)

(5).LCD POLARIZE TYPE

"nil" : TRANSFLECTIVE

"M" : TRANSMISSIVE

(6).BACKLIGHT TYPE :

"L" : LED BACKLIGHT

"E" : EL BACKLIGHT

"R" : REFLECTIVE

(7).BACKLIGHT COLOR :

LED TYPE :

"nil" : YELLOW-GREEN "A" : AMBER

"O" : ORANGE "R" : RED

EL TYPE :

"nil" : WHITE "B" : BLUE-GREEN

(8). VIEWING DIRECTION :

"nil" : 6 O'CLOCK "3" : 3 O'CLOCK

"U" : 12 O'CLOCK "9" : 9 O'CLOCK

(9).BACKLIGHT TYPE :

"nil" : LED(+),LED(-)---NORMAL "N" : LED(+),LED(-)---EXCHANGE

4. Mechanical data

(1) NUMBER OF CHARACTER ---------- 16 CH * 4 LINE

(2) MODULE SIZE ---------- 72.0 W * 48.0 H * "**C**" T (Max) mm

(3) EFFECTIVE AREA ---------- 61.8 W * 25.2 H mm

(4) CHARACTER PATTERN ---------- 5 * 7DOTS + CURSOR

(5) CHARACTER SIZE ---------- 2.96 W * 4.16 H mm

(6) CHARACTER PITCH ---------- 3.55 mm

(7) DOT SIZE ---------- 0.56 W * 0.56 H mm

(8) DOT PITCH ---------- 0.60 W * 0.60 H mm

NOTE : The dimension of "C" , please refer to Outline dimension on PAGE 8/10

5. Absolute maximum ratings

5.1 Electrical absolute maximum ratings

I T E M	*SYMBOL*	*MIN.*	*MAX.*	*UNIT*	*COMMENT*
POWER SUPPLY FOR LOGIC	V_{DD}-V_{SS}	0	6.0	V	------
INPUT VOLTAGE	V_I	V_{SS}	V_{DD}	V	------
STATIC ELECTRICITY	------	------	100	V	NOTE(1)
POWER SUPPLY FOR B.L	NOTE(2)	------	NOTE(2)	NOTE(2)	NOTE(2)

NOTE (1): ELECTRO-STATIC DISCHARGE RESISTANCE IS TESTED BY CHARGING A 200PF CAPACITOR AND DISCHARGING IT BY CONTACT WITH A INTERFACE CONNECTOR PIN.

NOTE (2):

B.L TYPE	*SYMBOL*	*MAX.*	*UNIT*	*COMMENT*
ARRAY LED	V_{LED}	5.0	V	YELLOW-GREEN,AMBER,ORANGE,RED
EL	V_{EL}	150	Vrms	f_{EL}: 1.0KHz 60SEC.MAX
	f_{EL}	2.0	KHz	AC115Vrms 60SEC.MAX

5.2 Environmental absolute maximum ratings

I T E M	*CONDITION*	*OPERATION*		*STORAGE*		*COMMENT*
		MIN.	*MAX.*	*MIN.*	*MAX.*	
AMBIENT TEMPERATURE	NORMAL	0℃	50℃	-20℃	70℃	------
	WIDE	-20℃	70℃			
HUMIDITY	------	NOTE (3)		NOTE (3)		NO CONDENSATION
VIBRATION NOTE (3)	------	------	0.5G	------	2G	10~300Hz XYZ DIRECTIONS 1 Hr EACH
SHOCK NOTE (4)	------	------	3G	------	50G	10 msec XYZ DIRECTIONS 1 TIME EACH
CORROSIVE GAS	------	NOT ACCEPTABLE		NOT ACCEPTABLE		-------

NOTE (3): Ta ≦ 50℃: 90% RH MAX.

Ta > 50℃: ABSOLUTE HUMIDITY MUST BE LOWER THAN THE HUMIDITY OF 90% RH AT 50℃. (80%RH AT 60℃)

NOTE(4):1G=9.8m/s^2

6. Electrical characteristics

$Ta = 25℃$ $V_{DD} = 5.0 \pm 0.25\ V$

I T E M	*SYMBOL*	*CONDITION*		*MIN.*	*TYP.*	*MAX.*	*UNIT*
INPUT VOLTAGE	V_{IH}	----------		2.2	------	------	V
	V_{IL}			------	------	0.6	V
OUTPUT VOLTAGE	V_{OH}	$-I_{OH}$ =0.2 mA		2.4	------	------	V
	V_{OL}	I_{OL} = 1.2 mA		------	------	0.4	V
POWER SUPPLY CURRENT	I_{DD}	V_{DD} = 5.0V		------	2.0	3.0	mA
RECOMMENDED LCD DRIVING VOLTAGE, NOTE(1)	V_{DD}-V_O	STN/ FSTN DUTY =1/16 Φ=10° NOTE(2)	Ta=-20°C	------	4.8	------	V
			Ta= 0°C	------	4.7	------	V
			Ta= 25°C	------	4.5	------	V
			Ta= 50°C	------	4.3	------	V
			Ta= 70°C	------	4.2	------	V
		TN DUTY =1/16 Φ=25° NOTE(2)	Ta=-20°C	------	4.5	------	V
			Ta= 0°C	------	4.4	------	V
			Ta= 25°C	------	4.2	------	V
			Ta= 50°C	------	4.0	------	V
			Ta= 70°C	------	3.9	------	V
POWER SUPPLY CURRENT FOR B.L	NOTE(3)	NOTE(3)		------	NOTE(3)	NOTE(3)	NOTE(3)

NOTE (1): RECOMMENDED LCD DRIVING VOLTAGE MAY FLUCTUATE ABOUT ±0.5V BY EACH MODULE.

(2): $\theta = 0°$: VIEWING DIRECTION AT 6 O'CLOCK

$\theta = 180°$: VIEWING DIRECTION AT 12 O'CLOCK

(3): LED CURRENT OF DIFFERENT BACKLIGHT TYPE

B.L TYPE	*SYMBOL*	*CONDITION*	*MIN.*	*TYP.*	*MAX.*	*UNIT.*	*LED COLOR*
ARRAY LED	I_{LED}	V_{LED} =5.0V	-----	170	220	mA	YELLOW-GREEN、AMBER、ORANGE、RED
EL	I_{EL}	V_{EL} =115Vrms f_{EL} = 400Hz	-----	2.0	-----	mArms	----------

7. Optical characteristics

TN TYPE LCD *Ta = 25℃ V_{DD}-V_O =4.2V*

I T E M	*SYMBOL*	*CONDITION*	*MIN.*	*TYP.*	*MAX.*	*UNIT*	*NOTE*
VIEWING ANGLE	Φ2-Φ1	K = 1.4 NOTE(1)	20	30	----	deg.	NOTE(2)
CONTRAST RATIO	K	Φ = 25° NOTE(1)	2.0	3.0	----	----	NOTE(2)
RESPONSE TIME	tr (rise)	Φ = 25° NOTE(1)	----	150	250	ms	NOTE(2)
	tf (fall)	Φ = 25° NOTE(1)	----	150	250	ms	NOTE(2)

STN TYPE LCD *Ta = 25℃ V_{DD}-V_O =4.5V*

I T E M	*SYMBOL*	*CONDITION*	*MIN.*	*TYP.*	*MAX.*	*UNIT*	*NOTE*
VIEWING ANGLE	Φ2-Φ1	K = 2.0 NOTE(1)	30	40	----	deg.	NOTE(2)
CONTRAST RATIO	K	Φ = 10° NOTE(1)	3.0	4.0	----	----	NOTE(2)
RESPONSE TIME	tr (rise)	Φ = 10° NOTE(1)	----	200	350	ms	NOTE(2)
	tf (fall)	Φ = 10° NOTE(1)	----	300	400	ms	NOTE(2)

FSTN TYPE LCD *Ta = 25℃ V_{DD}-V_O =4.5V*

I T E M	*SYMBOL*	*CONDITION*	*MIN.*	*TYP.*	*MAX.*	*UNIT*	*NOTE*
VIEWING ANGLE	Φ2-Φ1	K = 2.0 NOTE(1)	30	40	----	deg.	NOTE(2)
CONTRAST RATIO	K	Φ = 10° NOTE(1)	4.0	5.0	----	----	NOTE(2)
RESPONSE TIME	tr (rise)	Φ = 10° NOTE(1)	----	200	350	ms	NOTE(2)
	tf (fall)	Φ = 10° NOTE(1)	----	300	400	ms	NOTE(2)

Brightness for backlight

SYMBOL	*CONDITION*	*MIN.*	*TYP.*	*MAX.*	*UNIT*	*B.L TYPE*	*NOTE*
B	Φ = 0° θ = 0°	4.0	----	----	cd/m^2	EL	NOTE(2) NOTE(3)
		5.0	----	----		LED	

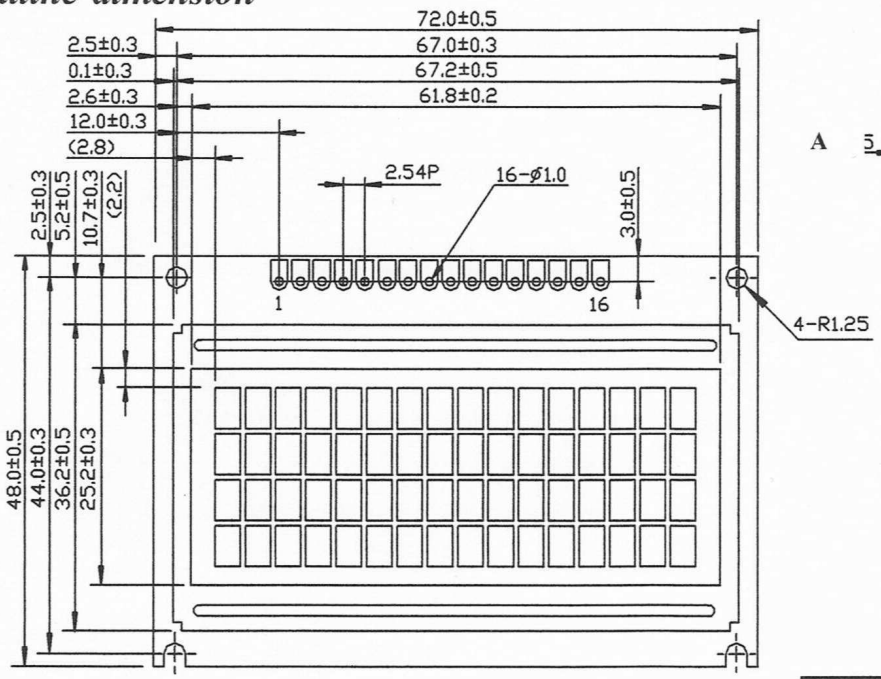
NOTE (1): θ = 0° : VIEWING DIRECTION AT 6 O'CLOCK

θ = 180° : VIEWING DIRECTION AT 12 O'CLOCK

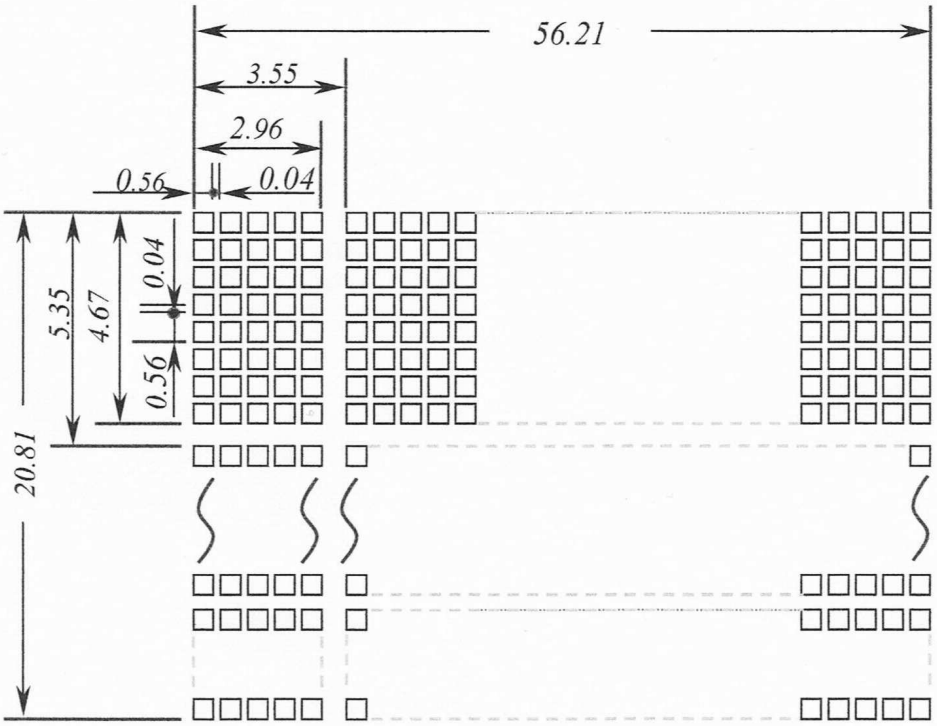
NOTE (2):SEE CUSTOMER ACCEPTANCE STANDARD SPECIFICATION FOR DEFINITION OF OPTICAL CHARACTERISTICS.

NOTE (3):UNDER NORMAL TEMPERATURE AND HUMIDITY IN A DARK ROOM.

8. Outline dimension



TYPE	A	C
LED B.L	9.0	15.0
EL & NO B.L	4.9	10.0

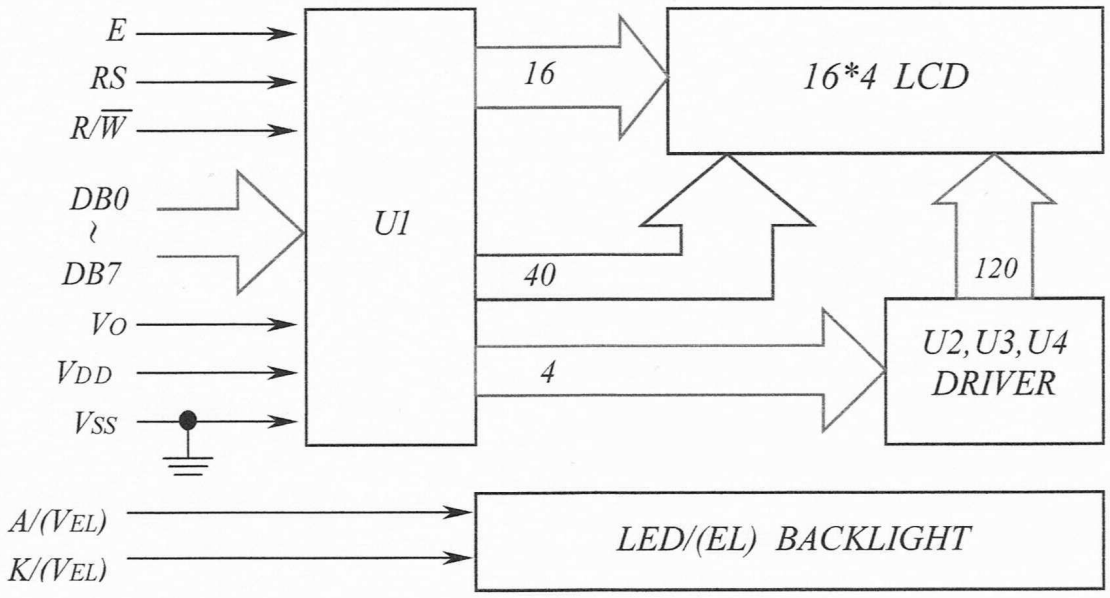


NOTE :
1.UNIT : mm
2.SCALE : NTS

Interface pin connection

PIN NO.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
SYMBOL	V_{SS}	V_{DD}	V_0	RS	R/$\overline{W}$	E	DB0	DB1
PIN NO.	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
SYMBOL	DB2	DB3	DB4	DB5	DB6	DB7	A/(V_{EL})	K/(V_{EL})

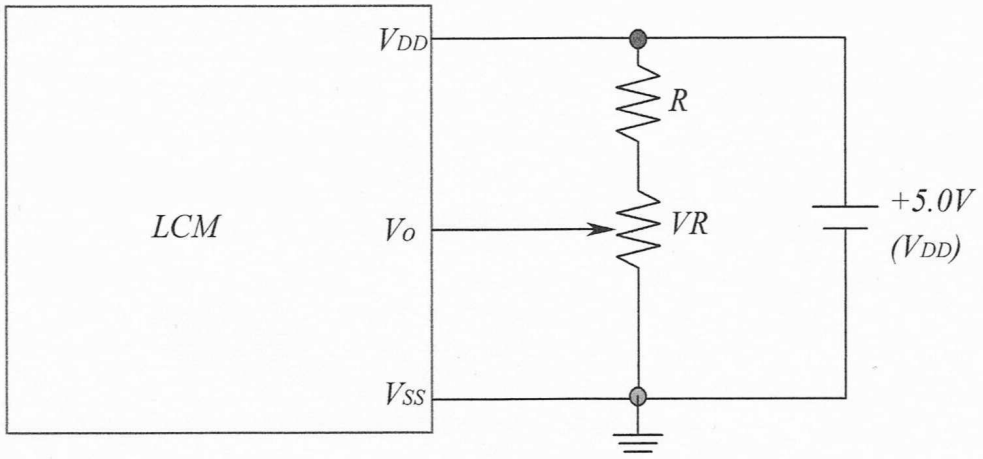
9. Block diagram



Display data address charts

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
LINE 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13
LINE 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53
LINE 3	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27
LINE 4	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	60	61	62	63	64	65	66	67

10. Power supply for LCM

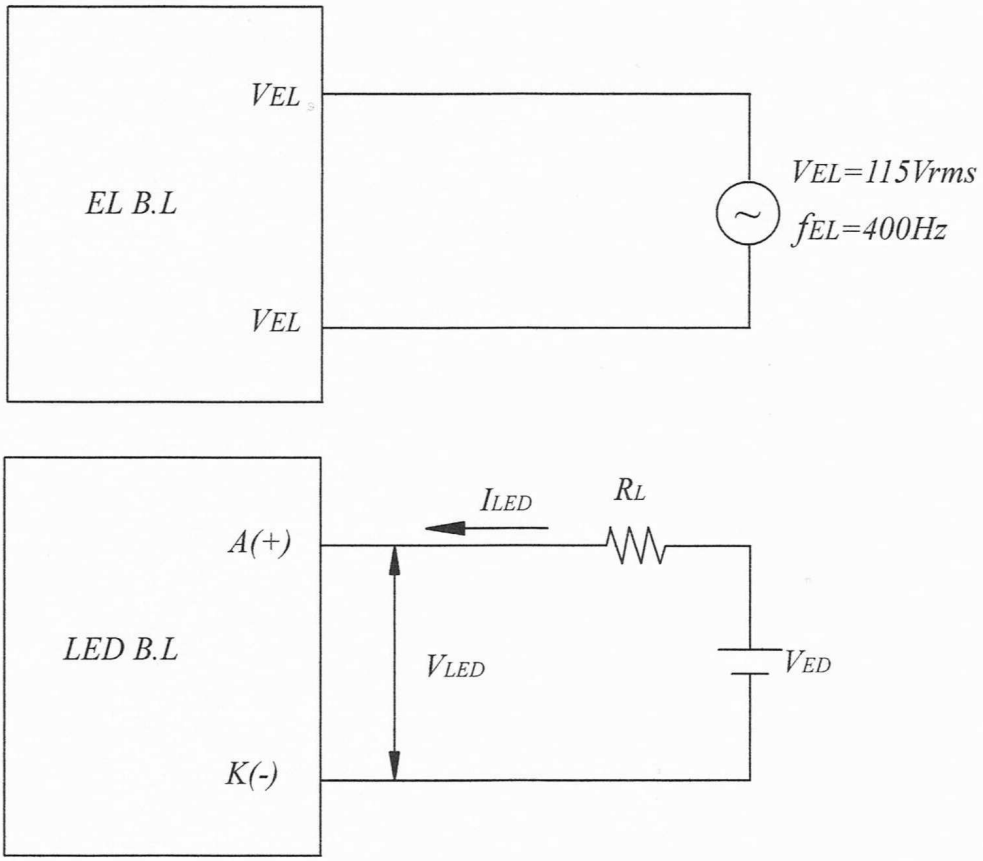


RECOMMENDED RESISTOR R: VDD-VO≧1.5V

VDD–VO: LCD DRIVING VOLTAGE

VR: 10KΩ~20KΩ

10.1 Power supply for backlight

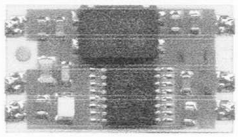


ITEM	*LED TYPE*	*CONDITION*
Limit resister of LED (R_L)	ARRAY LED	$R_L \geqq ((V_{ED} - 5.0V) / I_{LED})$, $I_{LED} \leqq 220mA$

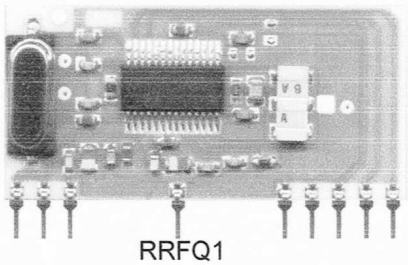
FM TRANSMITTER & RECEIVER HYBRID MODULES.

FM-RTFQ SERIES FM-RRFQ SERIES

- FM Radio Transmitter & Receivers
- Available As 315 or 433 or 868MHz
- Transmit Range Up To 250m
- Miniature Packages
- Data Rate upto 9.6Kbps
- No Adjustable Components
- Very Stable Operating Frequency
- Operates from –20 to +85^{0}C



RTFQ1



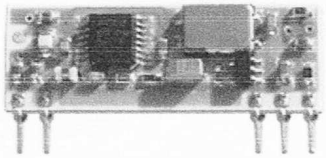
RRFQ1

Transmitter

- 3-12 Supply Voltage
- SIL or DIL Package

Receiver

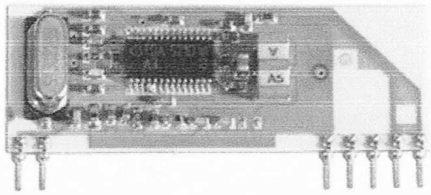
- PLL XTAL Design
- CMOS/TTL Output
- RSSI Output
- **Standby Mode (max 100nA)**
- 5V Supply Voltage



RTFQ2

Applications

- Wireless Security Systems
- Car Alarms
- Remote Gate Controls
- Remote Sensing
- Data Capture
- Sensor Reporting



RRFQ2

Description

These miniature RF modules provide a cost effective high performance FM Radio data link, at either 315, 433.92 or 868MHz. Manufactured using laser trimmed Thick Film ceramic Hybrid the modules exhibits extremely stable electronic characteristics over an Industrial Temperature range. The hybrid technology uses no adjustable components and ensures very reliable operation.

This transmitter and receiver pair enables the simple implementation of a data link at distances upto 75 metres in-building and 250 metres open ground.

These modules will suit one-to-one and multi-node wireless links in applications including car and building security, EPOS and inventory tracking, remote industrial process monitoring and computer networking. Because of their small size and low power requirements, both modules are ideal for use in portable, battery-powered applications such as hand-held terminals.

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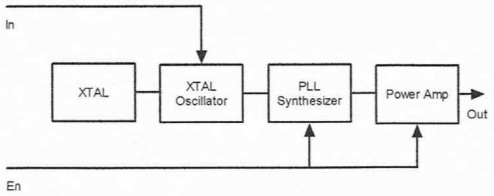
Transmitters

There are two versions of transmitter:

RTFQ1; A Dual in Line Package operating at 3.3V. This provides the most rugged mechanical fixing to the host PCB. Power Down mode is also available.

RTFQ2; A Single in Line Package incorporating a voltage regulator for 3-12V operation. (Compatible with many other RF transmitter modules available)

Transmitter Block Diagram



Part Numbering

Part Number	Description
FM-RTFQ1-315	DIL FM Transmitter Module 315 MHz
FM-RTFQ1-433	DIL FM Transmitter Module 433.92 MHz
FM-RTFQ1-868	DIL FM Transmitter Module 868.35 MHz
FM-RTFQ2-433R	SIL FM Transmitter Module 433.92 MHz 3-12V I/P
FM-RTFQ2-868R	SIL FM Transmitter Module 868.35 MHz 3-12V I/P

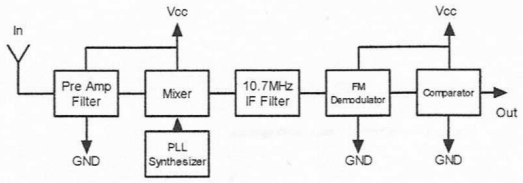
Receivers

There are two versions of receiver:

RRFQ1: A Single in Line Package with sleep / Power down mode.

RRFQ2: A Single in Line Package, pin compatible with many other receivers

Receiver Block Diagram



Part Numbering

Part Number	Description
FM-RRFQ1-315	SIL FM Receiver Module 315 MHz
FM-RRFQ1-433	SIL FM Receiver Module 433.92 MHz
FM-RRFQ1-868	SIL FM Receiver Module 868.35 MHz
FM-RRFQ2-433	SIL FM Receiver Module 433.92 MHz
FM-RRFQ2-868	SIL FM Receiver Module 868.35 MHz

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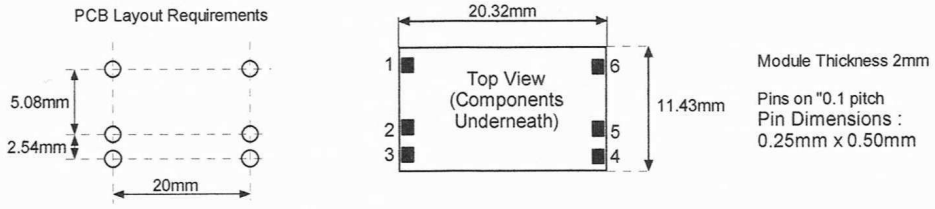
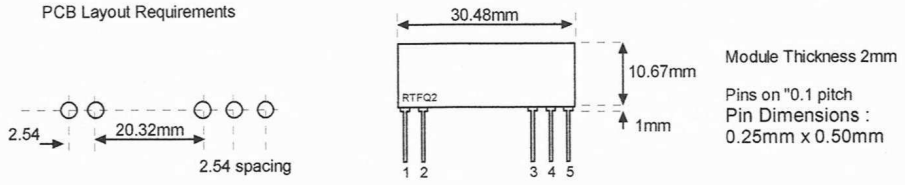
RTFQ1 Mechanical Dimensions



RTFQ2 Mechanical Dimensions



Pin Description

RTFQ1	RTFQ2	Name	Description
1	N/A	En	Enable (active high)
2	5	IN	Data input
3	1	GND	Ground, Connect to RF earth return path
4	3	Vcc	Supply Voltage
5	4	GND	Ground, Connect to RF earth return path
6	2	EA	External Antenna

Technical Specifications

Electrical Characteristics	MIN	TYPICAL	MAX	DIMENSION
Supply Voltage RTFQ1	2.1	3.3	4.00	V
Supply Voltage RTFQ2	2.5		12.00	V
Supply Current		7	8	mA
Standby Current (IN = EN = Low)			100	nA
Frequency		315.0 433.92 868.35		MHz
RF Output into 50Ω (Vcc=3.3V)		+5 / +5 / +1		dBm
Initial Frequency Accuracy	-35	0	+35	KHz
FM Deviation	25	30	35	KHz
Harmonic Spurious Emissions		-50		dBc
Input High Voltage RTFQ1	1.5		Vcc	V
Input High Voltage RTFQ2	1.5		5.5	V
Power up Time (En to full RF)			1	mS
Power up Time (Power on to full RF)			5	mS
Max Data Rate			9.6	KHz
Operating Temperature	-25		+80	°C

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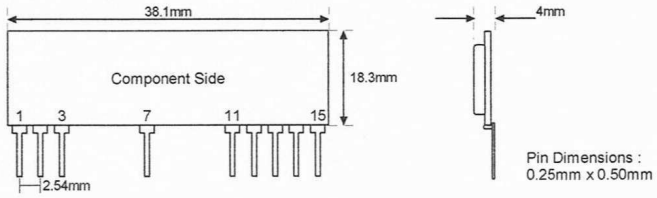
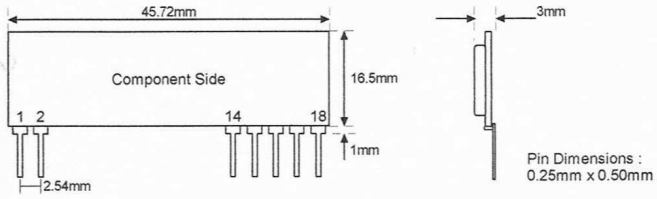
RRFQ1 Mechanical Details



RRFQ2 Mechanical Details



Pin Description

RRFQ1	RRFQ2	Pin Description
1	16	+Vcc
2, 7,11	2,15	GND
3	1	Data In (Antenna)
12		NC
13	14	Received Signal Strength Output
N/A	17	AF Output
14	18	Data Out
15	N/A	Power Down 0V = Standby 5V = Operating

RSSI Output*

RF In (dBm)	RSSI (V)
-120	1.20
-110	1.32
-100	1.50
-90	1.78
-80	2.06
-70	2.35
-60	2.62
-50	2.72
-40	2.75

RSSI Output

The RSSI provides a DC Voltage proportional to the peak value of the receive data signal. This output can be used as an indicator for the received signal strength to use in wake-up circuits etc.

An RC circuit is normally used to provide the timing for the RSSI signal. The modules have a 10nF capacitor internally connected to GND, therefore a pull down resistor (to GND) connected to the RSSI pin may be used to generate a simple RC network time constant for the RSSI signal output.

Please note that the maximum output current is typically 950µA, the discharge current is lower than 2µA

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Technical Specifications

Electrical Characteristics	Min	Typical	Max	Dimension	Notes
Supply Voltage (Vcc)	4.5	5	5.5	V	
Supply Current (Operating)		5.7	6.8	mA	
Supply Current (Standby)			100	nA	
Receiver Frequency		315.00 433.92 868.35		MHz	
R.F Sensitivity (100% AM) 315 ,433MHZ versions 868MHz versions		 -103 -100		dBm	
3dB Bandwidth		+/-150		KHz	
Data Rate	300		9,600	Hz	
Turn on Time			5	mSecs	1
Turn on Time		8		mSecs	2
Level of Emitted Spectrum			-70	dBm	
Low Level Output Voltage			0.8	V	I = 200uA
High Level Output Voltage	Vcc-1			V	I = 200uA
RSSI Output		0.95		mA	
Operating Temperature Range	-25		+80	°C	

Notes
1. Time from PD pin going high to stable data. (RRFQ1 only)
2. Time from Power ON to stable data.

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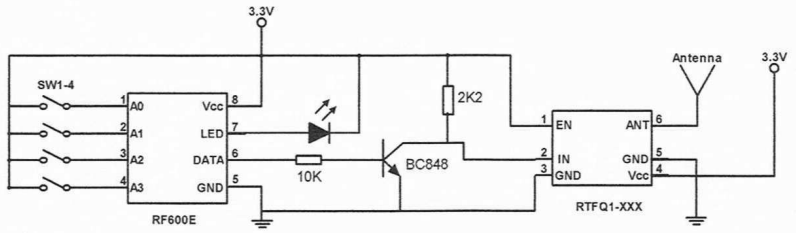
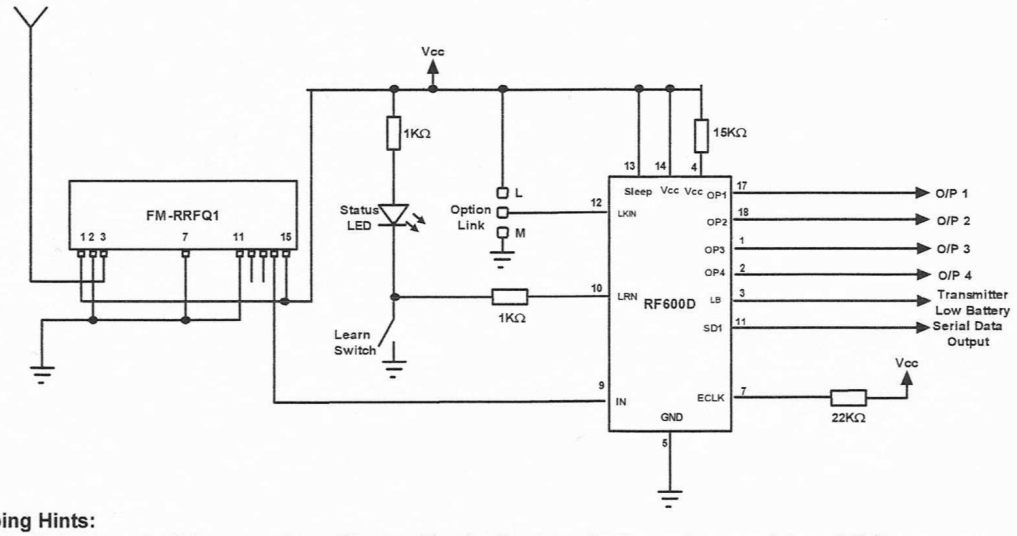
Typical Application

The following circuits show a remote control system with 'self learning feature' for more information please see Datasheet DS600

Transmitter Circuit



Receiver Circuit



Prototyping Hints:

It is essential when building any Low Power Radio System that you have a 'clean' DC power source. Typically the ripple voltage should be less than 10mV Peak to Peak. Normally a 470uF decoupling capacitor is sufficient de-coupling for an AC derived DC power source.

Never place a Transmitter or Receiver directly into Vero-Board or any similar prototyping board. This will severely restrict the range. Rather, use small lengths of wire from the prototyping board to the pins of the Transmitter or Receiver.

A useful antenna, for testing purposes, for both the Transmitter and Receiver on 433MHz is to use a piece of wire 17.3cm long (23.8cm at 315MHz) soldered directly to the antenna pin.

For more information or general enquiries, please contact;

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