LAMPIRAN

LAMPIRAN 1

Foto Alat

Node Sensor

Node Sink

LAMPIRAN 2

Node Sensor

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
#define trigPin 3
#define echoPin 2
//***************HCSR04***************
*******//
#include <NewPing.h>
#define TRIGGER_PIN  3  // Arduino pin tied
to trigger pin on the ultrasonic sensor.
#define ECHO_PIN     4  // Arduino pin tied to
echo pin on the ultrasonic sensor.
#define MAX_DISTANCE 300 // Maximum
distance we want to ping for (in centimeters).
Maximum sensor distance is rated at 400-
500cm.
NewPing sonar(TRIGGER_PIN, ECHO_PIN,
MAX_DISTANCE); // Creating the NewPing
Object.
//************TIPPINGBUCKET********
*********//
#define RainPin 2// Tipping Bucket Hall
Effect
bool RainHigh=false;
const float LowAmt = 0.5;
const float HiAmt = 0.5;
float RainAccum = 0.0;
//***********WATER
FLOW*****************//
#define waterflow A6 // Waterflow Hall Effect
float radius = 0.47;// tire radius (in inches)-
CHANGE THIS FOR YOUR OWN BIKE
int FlowVal;
long timer;// time between one full rotation (in
ms)
//float mph;
float circumference;
int maxFlowCounter = 10;//min time (in ms)
of one rotation (for debouncing)
int FlowCounter;
// Sleep
#include <avr/sleep.h>
#include <avr/power.h>
// Watchdog timer
#include <avr/wdt.h>
//*************NRF24L01*************
**//
  RF24 radio(7, 8); // CNS, CE
  const byte address[6] = "00001";
//timing milis
  unsigned long interval = 1000; //interval
waktu per detik
  unsigned long interval2 = 5000;
  unsigned long interval3 = 10;
  unsigned long previousMillis = 0;
  unsigned long time_since_last_reset = 0;
//Struct
struct data{

  float RainAccum;
  float mph;
  int distance;
}
packet;
//Global Variables
volatile int f_wdt = 1;
int counter = 0;
int packetCounter = 0;
void flow(){
    FlowCounter = maxFlowCounter;
    circumference = 2*3.14*radius;
    pinMode(waterflow, INPUT);
    Serial.write(12);//clear
    cli();//stop interrupts
    TCCR1A = 0;// set entire TCCR1A register
to 0
    TCCR1B = 0;// same for TCCR1B
    TCNT1  = 0;
    // set timer count for 1khz increments
    OCR1A = 1999;// = (1/1000) /
((1/(16*10^6))*8) - 1
    // turn on CTC mode
    TCCR1B |= (1 << WGM12);
    // Set CS11 bit for 8 prescaler
    TCCR1B |= (1 << CS11);
    // enable timer compare interrupt
    TIMSK1 |= (1 << OCIE1A);
    sei();//allow interrupts
  }
//waterflow
  ISR(TIMER1_COMPA_vect) {//Interrupt at
freq of 1kHz to measure reed switch
    FlowVal = analogRead(waterflow);
      if (FlowVal <= 90){//sensor aktif rendah
       if (FlowCounter == 0){//min time
between pulses has passed
```

```
        packet.mph =
((25.39*float(circumference))/float(timer)*0.8
86);//hitung m/s
        timer = 0;//reset timer
        FlowCounter = maxFlowCounter;//reset
reedCounter
      }
      else{
       if (FlowCounter > 0){//don't let
reedCounter go negative
        FlowCounter -= 1;//decrement
reedCounter
          }
        }
      }
      else{//if reed switch is open
       if (FlowCounter > 0){//don't let
reedCounter go negative
         FlowCounter -= 1;//decrement
reedCounter
          }
        }
       if (timer > 2000){
         packet.mph = 0;//if no new pulses from
reed switch- tire is still, set mph to 0
          }
      else{
       timer += 1;//increment timer
        }
   //delay(1000);
  }
//Tipping Bucket
  void TippingBucket(){
   for(int i=0; i>0; i++){
   if (digitalRead(RainPin)==HIGH)
   {
    RainHigh=true;
   }
   else
   {
    RainHigh=false;
   }
  }
 }
//HCSR04.....
  void distance(){
    unsigned int uS = sonar.ping();
    packet.distance = (uS /
US_ROUNDTRIP_CM);
  }
  void counterHandler()
  {
   // Increment the sleep counter
   counter++;
   if(counter == 1) {    //perulangan mode
sleep
   // Reset the counter to 0
    counter = 0;
   // Power up components
    power_all_enable();
   // Power up the radio
    radio.powerUp();
   // Wait for radio to power up
    delay(2);
   } else {
   // Sleep time isn't over yet, sleep some more
    enterSleep();
   }
  }
  void enterSleep()
  {
   // Start the watchdog timer
   f_wdt = 0;
   // Power down the radio
   radio.powerDown();
   // Enter sleep
   sleep_enable();
   sleep_mode();
   // Wake from sleep
   sleep_disable();
   //delay(1100);
   // Increment the interrupt counter
   counterHandler();
  }
  ISR(WDT_vect)
  {
   // Stop the watchdog timer
   f_wdt = 1;
  }
  void setupWDT()
  {
  // Setup the Watchdog timer for an
interruption every 8 seconds
  // Setup the Watchdog timer for an
interruption every 8 seconds
   MCUSR &= ~(1<<WDRF);
   WDTCSR |= (1<<WDCE) | (1<<WDE);
   WDTCSR = 1<<WDP0 | 1<<WDP3;
   WDTCSR |= _BV(WDIE);
  }
void nrfsetup(){
   radio.begin();
   radio.setChannel(108);
   // Define the radio's bitrate (using cards
lowest bitrate)
   radio.setDataRate(RF24_250KBPS);
   radio.setPALevel(RF24_PA_MIN);
}
void proses()
```

```
{
  unsigned long currentMillis = millis();
  if((currentMillis - previousMillis)>=interval)
      {
//**********************//Tipping
Bucket//************************//
    TippingBucket();
if((RainHigh==false)&&(digitalRead(RainPin
)==HIGH))
       {
        RainHigh=true;
        packet.RainAccum+=LowAmt;
       }
     if
((RainHigh==true)&&(digitalRead(RainPin)=
=LOW))
       {
        RainHigh=false;
        packet.RainAccum+=HiAmt;
       }
      Serial.print("Curah Hujan = ");
      Serial.print( packet.RainAccum );
      Serial.print(" mm ");
//************************//Water
Flow//*****************************//
     flow();
     Serial.print("Kecepatan Air =");
     Serial.print(packet.mph);
     Serial.print(" m/s ");
//*************************//HCSR04//***
*****************************//
     distance();
     Serial.print("Ping: ");
     Serial.print(packet.distance);
     Serial.println(" cm "); //If you would like
ping in inches, remove
"US_ROUNDTRIP_CM" and the 6backslash,
don't forget to rename "cm" to "inches"
     Serial.println(millis());
//*************************//nRF//******
*************************//
     radio.write(&packet, sizeof(packet));
      previousMillis = millis();
    }
}
void proses2()
{
   enterSleep();
}
void setup() {
   // Disable Brown out detection (uses power)
   sleep_bod_disable();
   // Sleep mode setup

set_sleep_mode(SLEEP_MODE_PWR_DOW
N);
   // Watchdog timer setup
   setupWDT();
   nrfsetup();
   Serial.begin(9600);
   radio.openWritingPipe(address);
   radio.stopListening();
   pinMode(trigPin, OUTPUT);
   pinMode(echoPin, INPUT);
}
void loop()
{
   time_since_last_reset = millis();
   while((millis() - time_since_last_reset) <
interval2)
   {
    delayMicroseconds(10);
    proses();
   }
   //Serial.println("");
   time_since_last_reset = millis();
   while((millis() - time_since_last_reset) <
interval3)
   {
    delayMicroseconds(10);
    proses2();
   }
   //Serial.println("");
```

Node Sink

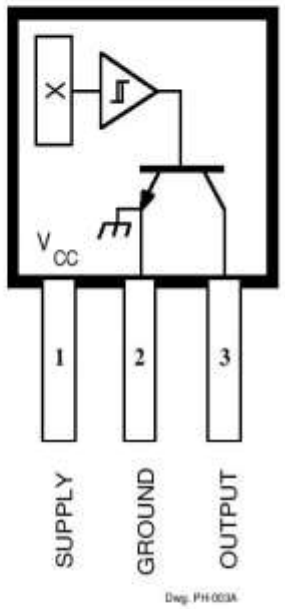
```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
RF24 radio(7, 8); // CNS, CE

const byte address[6] = "00001";

unsigned long previousMillis = 0;
int interval = 1000;

struct data{

  float RainAccum = 0.0;
  float mph;
  int distance;
}
packet;

void setup() {
  Serial.begin(9600);
  delay(500);
  Serial.println(F("Receiver"));

  radio.begin();
  radio.setChannel(108);
  radio.setDataRate(RF24_250KBPS);
  radio.openReadingPipe(0, address);
  radio.setPALevel(RF24_PA_MIN);
  radio.startListening();
}
void loop() {
  //delay(1000);
  unsigned long currentMillis = millis();
  if((currentMillis -
previousMillis)>=interval)
  {
  if (radio.available()) {
      while (radio.available())
        {
          radio.read(&packet, sizeof(packet));
        }
      Serial.write(" Curah Hujan= ");
      Serial.print(packet.RainAccum);
      Serial.print(" mm ");
      Serial.write(" Debit = ");
      Serial.print(packet.mph);
      Serial.print(" m/s ");
      Serial.write(" Jarak = ");
      Serial.print(packet.distance);
      Serial.print(" cm ");
      Serial.print(" Timing = ");
      Serial.print(millis());
      Serial.println(" ms ");

    }
     //else {
     //Serial.println("NC");
     previousMillis = millis();
    //}
    }
  }
```

LAMPIRAN III
***Datasheet* Sensor *Hall Effect* A3144**

3141 THRU 3144

Data Sheet 27621.6B*

SENSITIVE HALL-EFFECT SWITCHES FOR HIGH-TEMPERATURE OPERATION



Pinning is shown viewed from branded side.

ABSOLUTE MAXIMUM RATINGS at T_A = +25°C

Supply Voltage, V_{CC} ..... **28 V**
Reverse Battery Voltage, V_{RCC} ..... **-35 V**
Magnetic Flux Density, B ..... **Unlimited**
Output OFF Voltage, V_{OUT} ..... **28 V**
Reverse Output Voltage, V_{OUT} ..... **-0.5 V**
Continuous Output Current, I_{OUT} ..... **25 mA**
Operating Temperature Range, T_A
Suffix 'E–' ..... **-40°C to +85°C**
Suffix 'L–' ..... **-40°C to +150°C**
Storage Temperature Range,
T_S ..... **-65°C to +170°C**

These Hall-effect switches are monolithic integrated circuits with tighter magnetic specifications, designed to operate continuously over extended temperatures to +150°C, and are more stable with both temperature and supply voltage changes. The unipolar switching characteristic makes these devices ideal for use with a simple bar or rod magnet. The four basic devices (3141, 3142, 3143, and 3144) are identical except for magnetic switch points.

Each device includes a voltage regulator for operation with supply voltages of 4.5 to 24 volts, reverse battery protection diode, quadratic Hall-voltage generator, temperature compensation circuitry, small-signal amplifier, Schmitt trigger, and an open-collector output to sink up to 25 mA. With suitable output pull up, they can be used with bipolar or CMOS logic circuits. The A3141– and A3142– are improved replacements for the UGN/UGS3140–; the A3144– is the improved replacement for the UGN/UGS3120–.

The first character of the part number suffix determines the device operating temperature range. Suffix 'E–' is for the automotive and industrial temperature range of -40°C to +85°C. Suffix 'L–' is for the automotive and military temperature range of -40°C to +150°C. Three package styles provide a magnetically optimized package for most applications. Suffix '–LT' is a miniature SOT89/TO-243AA transistor package for surface-mount applications; suffix '–UA' is a three-lead ultra-mini-SIP.

FEATURES and BENEFITS

- Superior Temp. Stability for Automotive or Industrial Applications
- 4.5 V to 24 V Operation … Needs Only An Unregulated Supply
- Open-Collector 25 mA Output … Compatible with Digital Logic
- Reverse Battery Protection
- Activate with Small, Commercially Available Permanent Magnets
- Solid-State Reliability
- Small Size
- Resistant to Physical Stress

Always order by complete part number, e.g., **A3141ELT** .

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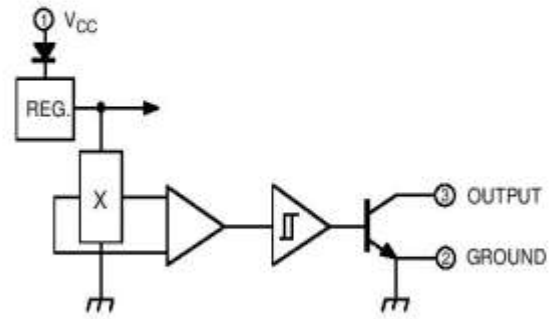
3141 THRU 3144
SENSITIVE HALL-EFFECT SWITCHES FOR HIGH-TEMP. OPERATION

FUNCTIONAL BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS at V_{CC} = 8 V over operating temperature range.

Characteristic	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
Supply Voltage	V_{CC}	Operating	4.5	—	24	V
Output Saturation Voltage	$V_{OUT(SAT)}$	I_{OUT} = 20 mA, B > B_{OP}	—	175	400	mV
Output Leakage Current	I_{OFF}	V_{OUT} = 24 V, B < B_{RP}	—	<1.0	10	µA
Supply Current	I_{CC}	B < B_{RP} (Output OFF)	—	4.4	9.0	mA
Output Rise Time	t_r	R_L = 820 Ω, C_L = 20 pF	—	0.04	2.0	µs
Output Fall Time	t_f	R_L = 820 Ω, C_L = 20 pF	—	0.18	2.0	µs

MAGNETIC CHARACTERISTICS in gauss over operating supply voltage range.

Characteristic		Part Numbers*											
		A3141–			A3142–			A3143–			A3144–		
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.
B_{OP}	at T_A = 25°C	50	100	160	130	180	230	220	280	340	70	—	350
	over operating temp. range	30	100	175	115	180	245	205	280	355	35	—	450
B_{RP}	at T_A = 25°C	10	45	130	75	125	175	165	225	285	50	—	330
	over operating temp. range	10	45	145	60	125	190	150	225	300	25	—	430
B_{hys}	at T_A = 25°C	20	55	80	30	55	80	30	55	80	20	55	—
	over operating temp. range	20	55	80	30	55	80	30	55	80	20	55	—

NOTES: Typical values are at T_A = +25°C and V_{CC} = 8 V.
B_{OP} = operate point (output turns ON); B_{RP} = release point (output turns OFF); B_{hys} = hysteresis (B_{OP} - B_{RP}).
1 gauss (G) is exactly equal to 0.1 millitesla (mT).
*Complete part number includes a suffix to identify operating temperature range (E- or L-) and package type (-LT or -UA).

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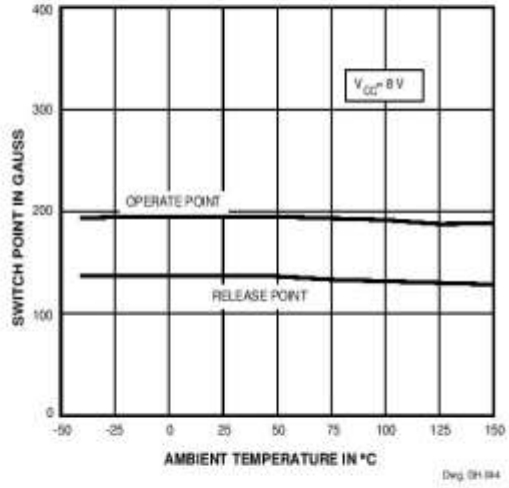
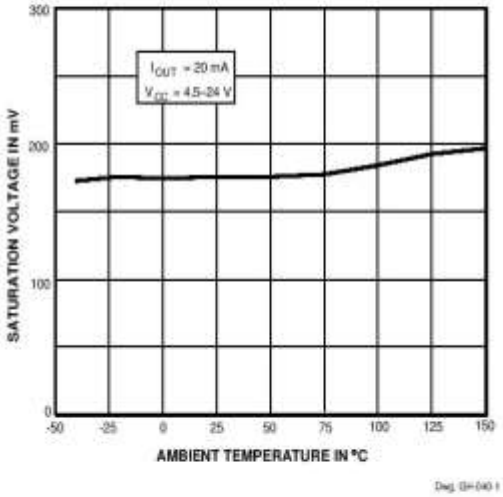
TYPICAL OPERATING CHARACTERISTICS

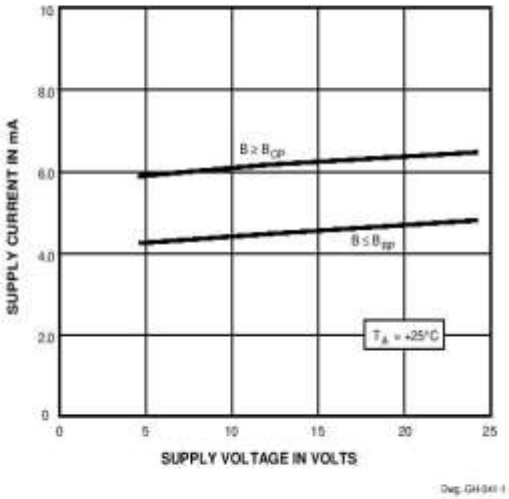
A3142– SWITCH POINTS



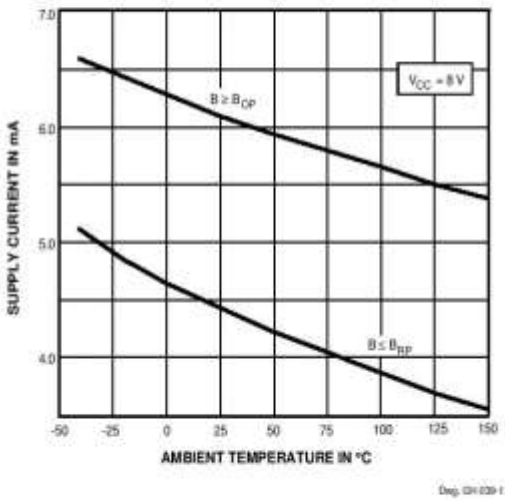
OUTPUT SATURATION VOLTAGE



SUPPLY CURRENT



SUPPLY CURRENT

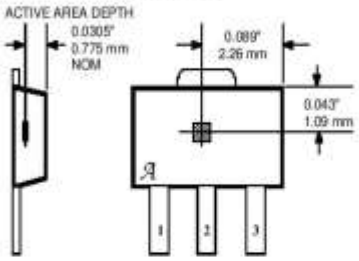


* Complete part number includes a suffix denoting operating temperature range (E- or L-) and package type (-LT, -U, or -UA).

3141 THRU 3144
SENSITIVE HALL-EFFECT SWITCHES FOR HIGH-TEMP. OPERATION

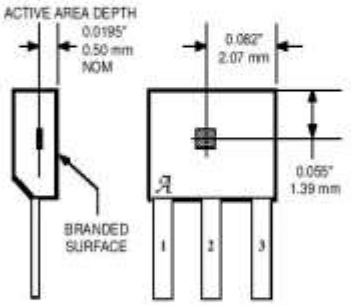
SENSOR LOCATIONS
(±0.005" [0.13 mm] die placement)

Suffix "LT"



Dwg. MH-008-2D

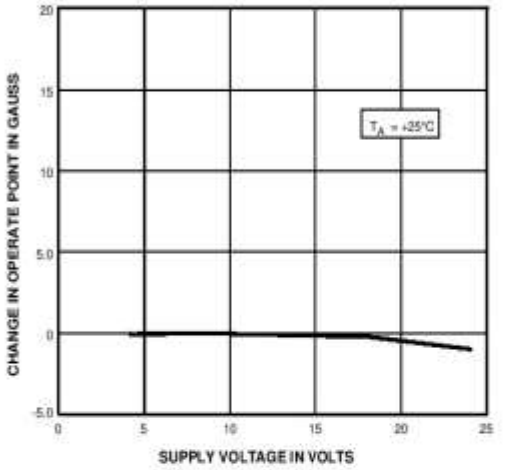
Suffix "UA"



Dwg. MH-011-10A

TYPICAL OPERATING CHARACTERISTICS (cont.)

CHANGE IN OPERATE POINT



Dwg. GH-042-1

OPERATION

The output of these devices (pin 3) switches low when the magnetic field at the Hall sensor exceeds the operate point threshold (B_{OP}). At this point, the output voltage is $V_{OUT(SAT)}$. When the magnetic field is reduced to below the release point threshold (B_{RP}), the device output goes high. The difference in the magnetic operate and release points is called the hysteresis (B_{hys}) of the device. This built-in hysteresis allows clean switching of the output even in the presence of external mechanical vibration and electrical noise.

Extensive applications information for Hall-effect sensors is available in:
- *Hall-Effect IC Applications Guide*, Application Note 27701;
- *Hall-Effect Devices: Soldering, Gluing, Potting, Encapsulating, and Lead Forming*, Application Note 27703.1;
- *Soldering of Through-Hole Hall-Sensor Devices*, Application Note 27703; and
- *Soldering of Surface-Mount Hall-Sensor Devices*, Application Note 27703.2.

All are provided in *Allegro Electronic Data Book*, AMS-702. or at
www.allegromicro.com

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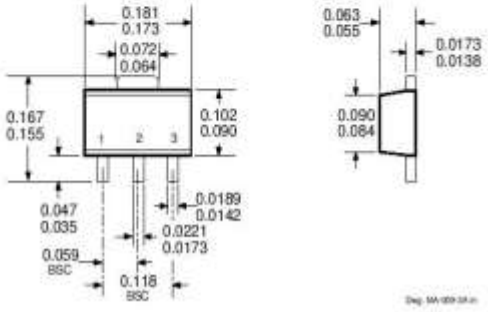
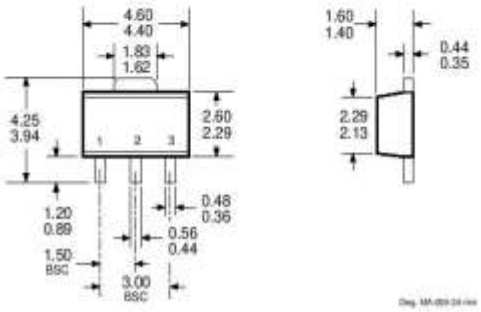
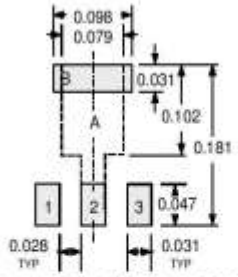
PACKAGE DESIGNATOR 'LT'
(SOT89/TO-243AA)

Dimensions in Inches
(for reference only)



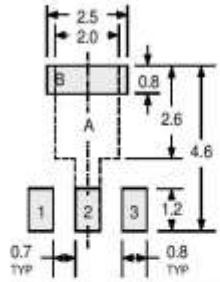
Dimensions in Millimeters
(controlling dimensions)





Pads 1, 2, 3, and A — Standard SOT89 Layout
Pads 1, 2, 3, and B — Low-Stress Version
Pads 1, 2, and 3 only — Lowest Stress, But Not Self Aligning

Dwg. MA-012-3 in



Pads 1, 2, 3, and A — Standard SOT89 Layout
Pads 1, 2, 3, and B — Low-Stress Version
Pads 1, 2, and 3 only — Lowest Stress, But Not Self Aligning

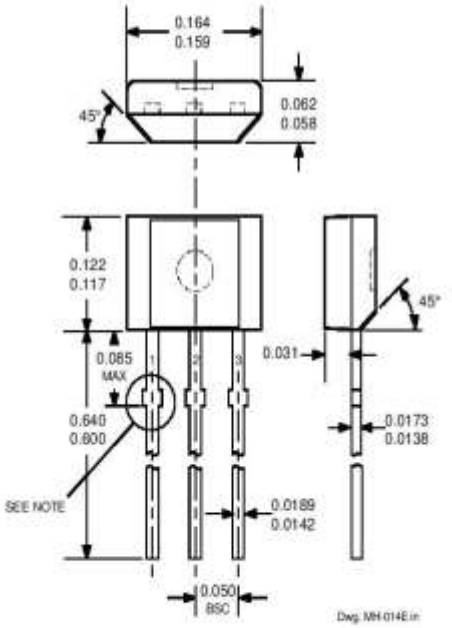
Dwg. MA-012-3 mm

NOTES: 1. Exact body and lead configuration at vendor's option within limits shown.
2. Supplied in bulk pack (500 pieces per bag) or add "TR" to part number for tape and reel.
3. Only low-temperature (≤240°C) reflow-soldering techniques are recommended for SOT89 devices.

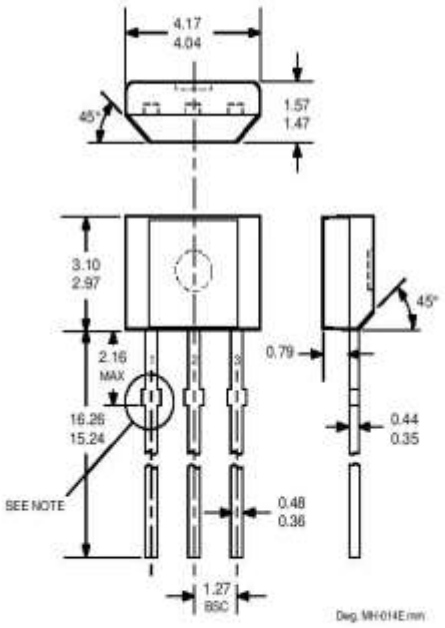
3141 THRU 3144
SENSITIVE HALL-EFFECT SWITCHES FOR HIGH-TEMP. OPERATION

PACKAGE DESIGNATOR 'UA'

Dimensions in Inches
(controlling dimensions)

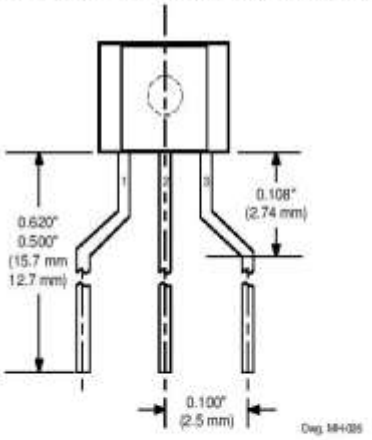


Dimensions in Millimeters
(for reference only)



NOTES:
1. Tolerances on package height and width represent allowable mold offsets. Dimensions given are measured at the widest point (parting line).
2. Exact body and lead configuration at vendor's option within limits shown.
3. Height does not include mold gate flash.
4. Recommended minimum PWB hole diameter to clear transition area is 0.035" (0.89 mm).
5. Where no tolerance is specified, dimension is nominal.
6. Supplied in bulk pack (500 pieces per bag).

Radial Lead Form (order A314xxUA-LC)



NOTE: Lead-form dimensions are the nominals produced on the forming equipment. No dimensional tolerance is implied or guaranteed for bulk packaging (500 pieces per bag).

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3141 THRU 3144
SENSITIVE HALL-EFFECT SWITCHES FOR HIGH-TEMP. OPERATION

HALL-EFFECT SENSORS

UNIPOLAR HALL-EFFECT DIGITAL SWITCHES

Partial Part Number	Operate Point (G) Over Oper. Voltage & Temp. Range	Release Point (G)	Hysteresis (G)	Oper. Temp.	Packages	Replaces and Comments
A3121x	220 to 500	80 to 410	60 to 150	E, L	LT, UA	3019, 3113, 3119
A3122x	260 to 430	120 to 360	70 to 140	E, L	LT, UA	
A3123x	230 to 470	160 to 330	70 to 140	E, L	LT, UA	
A3141x	30 to 175	10 to 145	20 to 80	E, L	LT, UA	3040, 3140
A3142x	115 to 245	60 to 190	30 to 80	E, L	LT, UA	
A3143x	205 to 355	150 to 300	30 to 80	E, L	LT, UA	
A3144x	35 to 450	25 to 430	>20	E, L	LT, UA	3020, 3120
A3161E	<160 (Typ 130)	>30 (Typ 110)	5 to 80	E	LT, UA	2-wire operation
A3163E	<160 (Typ 98)	>30 (Typ 79)	5 to 40	E	LT, UA	2-wire
A3240x	<50 (Typ 35)	>5 (Typ 25)	Typ 10	E, L	LH, LT, UA	chopper stabilized
A3250x	<50 to >350	–	5 to 35	J, L	UA	programmable, chopper stabilized
A3251x	<50 to >350	–	5 to 35	J, L	UA	programmable, chopper stabilized
A3361E	<125	>40	5 to 30	E	LH, LT, UA	2-wire, chopper stabilized, output normally high
A3362E	<125	>40	5 to 30	E	LH, LT, UA	2-wire, chopper stabilized, output normally low

MICROPOWER OMNIPOLAR HALL-EFFECT DIGITAL SWITCHES

Partial Part Number	Operate Points (G) Over Oper. Voltage & Temp. Range	Release Points (G)	Hysteresis (G)	Oper. Temp.	Packages	Average Supply Current (μA)
A3209E	>-60, <60	<-5, >5	Typ 7.7	E	LH, UA	<425 (Typ 145)
A3210E	>-60, <60	<-5, >5	Typ 7.7	E	LH, UA	<60 (Typ 8.8)
A3212E	>-55, <55	<-10, >10	Typ. 8	E	LH, UA	<10 (Typ 4.2)

BIPOLAR HALL-EFFECT DIGITAL SWITCHES

Partial Part Number	Operate Point (G) Over Oper. Voltage & Temp. Range	Release Point (G)	Hysteresis (G)	Oper. Temp.	Packages	Replaces and Comments
UGx3132	<95 (Typ 32)	>-95 (Typ -20)	>30 (Typ 52)	K, L, S	LT, UA	3030, 3130, 3131
UGx3133	<75 (Typ 32)	>-75 (Typ -20)	>30 (Typ 52)	K, L, S	LT, UA	
UGx3134	-40 to 50	-50 to 40	5 to 55	E, L	LT, UA	
A3260x	<30 (Typ 10)	>-30 (Typ -10)	Typ 20	E, L	LH, LT, UA	2 wire, chopper stabilized

Notes: 1) Typical data is at T_A = +25°C and nominal operating voltage.
2) "x" = Operating Temperature Range [suffix letter or (prefix)]: S (UGN) = -20°C to +85°C, E = -40°C to +85°C, J = -40°C to +115°C, K (UGS) = -40°C to +125°C, L (UGL) = -40°C to +150°C.

3141 THRU 3144
SENSITIVE HALL-EFFECT SWITCHES FOR HIGH-TEMP. OPERATION

Allegro MicroSystems, Inc.

115 Northeast Cutoff, Box 15036
Worcester, Massachusetts 01615-0036 (508) 853-5000

Datasheet Sensor **Ultrasonik HC-SR04**

Tech Support: services@elecfreaks.com

Ultrasonic Ranging Module HC - SR04

Product features:

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:
(1) Using IO trigger for at least 10us high level signal,
(2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
(3) IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.
Test distance = (high level time×velocity of sound (340M/S) / 2,

Wire connecting direct as following:

- 5V Supply
- Trigger Pulse Input
- Echo Pulse Output
- 0V Ground

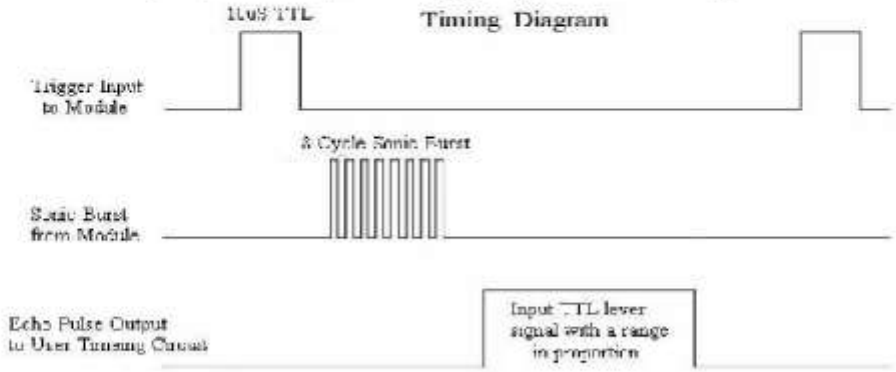
Electric Parameter

Working Voltage	**DC 5 V**
Working Current	**15mA**
Working Frequency	**40Hz**
Max Range	**4m**
Min Range	**2cm**
MeasuringAngle	**15 degree**
Trigger Input Signal	**10uS TTL pulse**
Echo Output Signal	**Input TTL lever signal and the range in proportion**
Dimension	**45*20*15mm**

Vcc Trig Echo GND

Timing diagram

The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: uS / 58 = centimeters or uS / 148 =inch; or: the range = high level time * velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.



Attention:

- The module is not suggested to connect directly to electric, if connected electric, the GND terminal should be connected the module first, otherwise, it will affect the normal work of the module.
- When tested objects, the range of area is not less than 0.5 square meters and the plane requests as smooth as possible, otherwise ,it will affect the results of measuring.

www.Elecfreaks.com

Datasheet nRF24L01+

1 Introduction

The nRF24L01 is a single chip 2.4GHz transceiver with an embedded baseband protocol engine (Enhanced ShockBurst™), designed for ultra low power wireless applications. The nRF24L01 is designed for operation in the world wide ISM frequency band at 2.400 - 2.4835GHz. An MCU (microcontroller) and very few external passive components are needed to design a radio system with the nRF24L01.

The nRF24L01 is configured and operated through a Serial Peripheral Interface (SPI.) Through this interface the register map is available. The register map contains all configuration registers in the nRF24L01 and is accessible in all operation modes of the chip.

The embedded baseband protocol engine (Enhanced ShockBurst™) is based on packet communication and supports various modes from manual operation to advanced autonomous protocol operation. Internal FIFOs ensure a smooth data flow between the radio front end and the system's MCU. Enhanced ShockBurst™ reduces system cost by handling all the high-speed link layer operations.

The radio front end uses GFSK modulation. It has user configurable parameters like frequency channel, output power and air data rate.

The air data rate supported by the nRF24L01 is configurable to 2Mbps. The high air data rate combined with two power saving modes makes the nRF24L01 very suitable for ultra low power designs.

Internal voltage regulators ensure a high Power Supply Rejection Ratio (PSRR) and a wide power supply range.

1.1 Features

Features of the nRF24L01 include:

- Radio
  - Worldwide 2.4GHz ISM band operation
  - 126 RF channels
  - Common RX and TX pins
  - GFSK modulation
  - 1 and 2Mbps air data rate
  - 1MHz non-overlapping channel spacing at 1Mbps
  - 2MHz non-overlapping channel spacing at 2Mbps
- Transmitter
  - Programmable output power: 0, -6, -12 or -18dBm
  - 11.3mA at 0dBm output power
- Receiver
  - Integrated channel filters
  - 12.3mA at 2Mbps
  - -82dBm sensitivity at 2Mbps
  - -85dBm sensitivity at 1Mbps
  - Programmable LNA gain
- RF Synthesizer
  - Fully integrated synthesizer
  - No external loop filer, VCO varactor diode or resonator
  - Accepts low cost ±60ppm 16MHz crystal
- Enhanced ShockBurst™
  - 1 to 32 bytes dynamic payload length
  - Automatic packet handling
  - Auto packet transaction handling
  - 6 data pipe MultiCeiver™ for 1:6 star networks
- Power Management
  - Integrated voltage regulator
  - 1.9 to 3.6V supply range
  - Idle modes with fast start-up times for advanced power management
  - 22uA Standby-I mode, 900nA power down mode
  - Max 1.5ms start-up from power down mode
  - Max 130us start-up from standby-I mode
- Host Interface
  - 4-pin hardware SPI
  - Max 8Mbps
  - 3 separate 32 bytes TX and RX FIFOs
  - 5V tolerant inputs
- Compact 20-pin 4x4mm QFN package

1.2 Block diagram

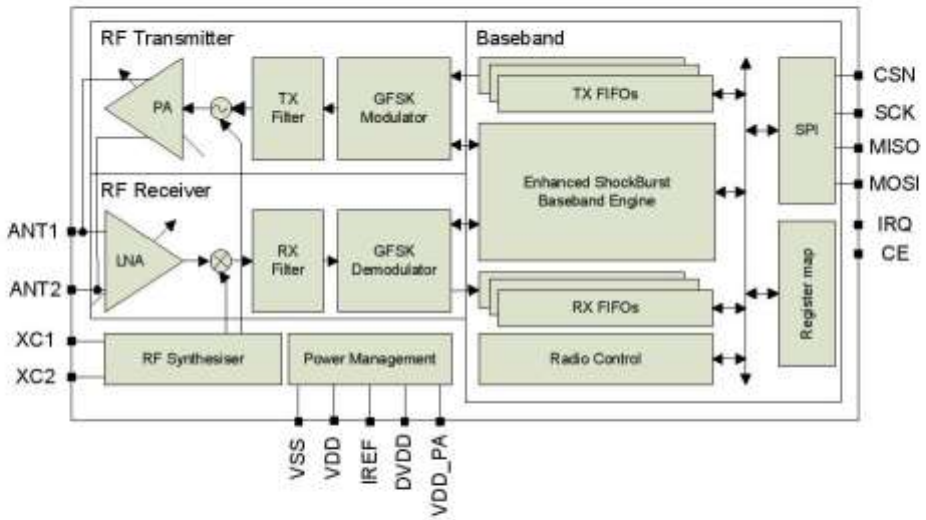


Figure 1. nRF24L01 block diagram

2.2 Pin functions

Pin	Name	Pin function	Description
1	CE	Digital Input	Chip Enable Activates RX or TX mode
2	CSN	Digital Input	SPI Chip Select
3	SCK	Digital Input	SPI Clock
4	MOSI	Digital Input	SPI Slave Data Input
5	MISO	Digital Output	SPI Slave Data Output, with tri-state option
6	IRQ	Digital Output	Maskable interrupt pin. Active low
7	VDD	Power	Power Supply (+1.9V - +3.6V DC)
8	VSS	Power	Ground (0V)
9	XC2	Analog Output	Crystal Pin 2
10	XC1	Analog Input	Crystal Pin 1
11	VDD_PA	Power Output	Power Supply Output(+1.8V) for the internal nRF24L01 Power Amplifier. Must be connected to ANT1 and ANT2 as shown in Figure 30.
12	ANT1	RF	Antenna interface 1
13	ANT2	RF	Antenna interface 2
14	VSS	Power	Ground (0V)
15	VDD	Power	Power Supply (+1.9V - +3.6V DC)
16	IREF	Analog Input	Reference current. Connect a 22kΩ resistor to ground. See: Figure 30.
17	VSS	Power	Ground (0V)
18	VDD	Power	Power Supply (+1.9V - +3.6V DC)
19	DVDD	Power Output	Internal digital supply output for de-coupling purposes. See: Figure 30.
20	VSS	Power	Ground (0V)

Table 1. nRF24L01 pin function

5 Electrical specifications

Conditions: V_{DD} = +3V, V_{SS} = 0V, T_A = - 40°C to + 85°C

5.1 Power consumption

Symbol	Parameter (condition)	Notes	Min.	Typ.	Max.	Units
	Idle modes					
I_{VDD_PD}	Supply current in power down			900		nA
I_{VDD_ST1}	Supply current in standby-I mode	a		22		µA
I_{VDD_ST2}	Supply current in standby-II mode			320		µA
I_{VDD_SU}	Average current during 1.5ms crystal oscillator startup			285		µA
	Transmit					
I_{VDD_TX0}	Supply current @ 0dBm output power	b		11.3		mA
I_{VDD_TX6}	Supply current @ -6dBm output power	b		9.0		mA
I_{VDD_TX12}	Supply current @ -12dBm output power	b		7.5		mA
I_{VDD_TX18}	Supply current @ -18dBm output power	b		7.0		mA
I_{VDD_AVG}	Average Supply current @ -6dBm output power, Enhanced ShockBurst™	c		0.12		mA
I_{VDD_TXS}	Average current during TX settling	d		8.0		mA
	Receive					
I_{VDD_2M}	Supply current 2Mbps			12.3		mA
I_{VDD_LC}	Supply current 2Mbps LNA low current			11.5		mA
I_{VDD_1M}	Supply current 1Mbps			11.8		mA
I_{VDD_LC}	Supply current 1Mbps LNA low current			11.1		mA
I_{VDD_RXS}	Average current during RX settling	e		8.4		mA

a. Current is given for a 12pF crystal. Current when using external clock is dependent on signal swing.
b. Antenna load impedance = 15Ω+j88Ω.
c. Antenna load impedance = 15Ω+j88Ω. Average data rate 10kbps and full packets
d. Average current consumption for TX startup (130µs) and when changing mode from RX to TX (130µs).
e. Average current consumption for RX startup (130µs) and when changing mode from TX to RX (130µs).

Table 4.Power consumption

5.2 General RF conditions

Symbol	Parameter (condition)	Notes	Min.	Typ.	Max.	Units
f_{OP}	Operating frequency	a	2400		2525	MHz
PLL_{res}	PLL Programming resolution			1		MHz
f_{XTAL}	Crystal frequency			16		MHz
Δf_{1M}	Frequency deviation @ 1Mbps			±160		kHz
Δf_{2M}	Frequency deviation @ 2Mbps			±320		kHz
R_{GFSK}	Air Data rate	b	1000		2000	kbps
$F_{CHANNEL\ 1M}$	Non-overlapping channel spacing @ 1Mbps	c		1		MHz
$F_{CHANNEL\ 2M}$	Non-overlapping channel spacing @ 2Mbps	c		2		MHz

a. Usable band is determined by local regulations
b. Data rate in each burst on-air
c. The minimum channel spacing is 1Mhz

Table 5. General RF conditions

5.3 Transmitter operation

Symbol	Parameter (condition)	Notes	Min.	Typ.	Max.	Units
P_{RF}	Maximum Output Power	a		0	+4	dBm
P_{RFC}	RF Power Control Range		16	18	20	dB
P_{RFCR}	RF Power Accuracy				±4	dB
P_{BW2}	20dB Bandwidth for Modulated Carrier (2Mbps)			1800	2000	kHz
P_{BW1}	20dB Bandwidth for Modulated Carrier (1Mbps)			900	1000	kHz
P_{RF1}	1^{st} Adjacent Channel Transmit Power 2MHz				-20	dBm
P_{RF2}	2^{nd} Adjacent Channel Transmit Power 4MHz				-50	dBm

a. Antenna load impedance = 15Ω+j88Ω

Table 6.Transmitter operation

5.4 Receiver operation

Symbol	Parameter (condition)	Notes	Min.	Typ.	Max.	Units
RX_{max}	Maximum received signal at <0.1% BER			0		dBm
RX_{SENS}	Sensitivity (0.1%BER) @2Mbps			-82		dBm
RX_{SENS}	Sensitivity at (0.1%BER) @1Mbps			-85		dBm
RX selectivity according to ETSI EN 300 440-1 V1.3.1 (2001-09) page 27						
C/I_{CO}	C/I Co-channel (@2Mbps)	a		7		dB
C/I_{1ST}	1st Adjacent Channel Selectivity C/I 2MHz			1		dB
C/I_{2ND}	2nd Adjacent Channel Selectivity C/I 4MHz			-21		dB
C/I_{3RD}	3rd Adjacent Channel Selectivity C/I 6MHz			-27		dB
C/I_{CO}	C/I Co-channel (@1Mbps)	b		9		dB
C/I_{1ST}	1st Adjacent Channel Selectivity C/I 1MHz			8		dB
C/I_{2ND}	2nd Adjacent Channel Selectivity C/I 2MHz			-22		dB
C/I_{3RD}	3rd Adjacent Channel Selectivity C/I 3MHz			-30		dB
RX selectivity with nRF24L01 equal modulation on interfering signal						
C/I_{CO}	C/I Co-channel (@2Mbps) (Modulated carrier)	a		11		dB
C/I_{1ST}	1st Adjacent Channel Selectivity C/I 2MHz			4		dB
C/I_{2ND}	2nd Adjacent Channel Selectivity C/I 4MHz			-20		dB
C/I_{3RD}	3rd Adjacent Channel Selectivity C/I 6MHz			-27		dB
C/I_{CO}	C/I Co-channel (@1Mbps)	b		12		dB
C/I_{1ST}	1st Adjacent Channel Selectivity C/I 1MHz			8		dB
C/I_{2ND}	2nd Adjacent Channel Selectivity C/I 2MHz			-21		dB
C/I_{3RD}	3rd Adjacent Channel Selectivity C/I 3MHz			-30		dB

a. Data rate is 2Mbps for the following C/I measurements
b. Data rate is 1Mbps for the following C/I measurements

Table 7. Receiver operation

Appendix D - Application example

nRF24L01 with single ended matching network crystal, bias resistor, and decoupling capacitors.

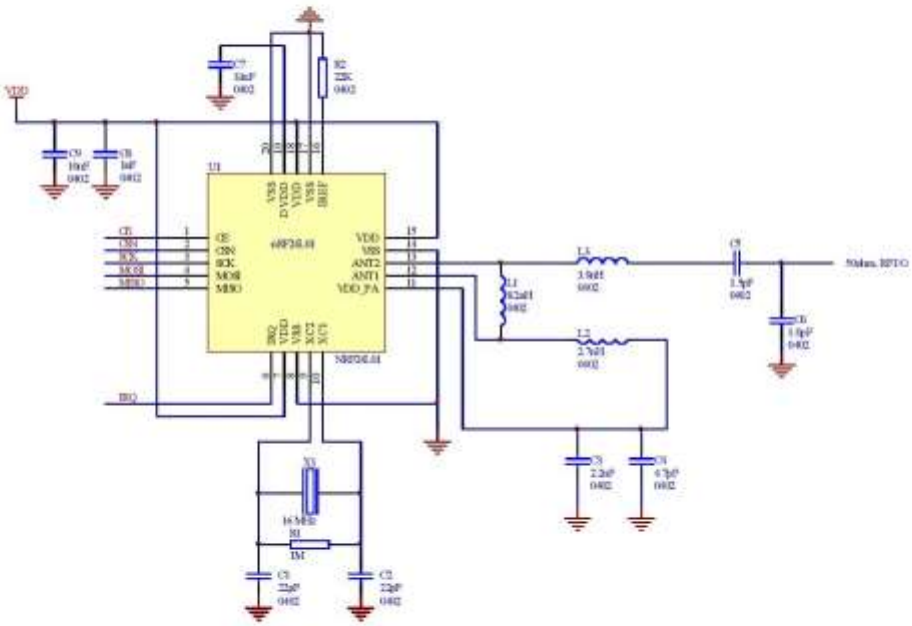


Figure 30. nRF24L01 schematic for RF layouts with single ended 50Ω RF output

Part	Designator	Footprint	Description
22pF[a]	C1	0402	NPO, +/- 2%
22pF[a]	C2	0402	NPO, +/- 2%
2.2nF	C3	0402	X7R, +/- 10%
4.7pF	C4	0402	NPO, +/- 0.25pF
1.5pF	C5	0402	NPO, +/- 0.1pF
1,0pF	C6	0402	NPO, +/- 0.1pF
33nF	C7	0402	X7R, +/- 10%
1nF	C8	0402	X7R, +/- 10%
10nF	C9	0402	X7R, +/- 10%
8,2nH	L1	0402	chip inductor +/- 5%
2.7nH	L2	0402	chip inductor +/- 5%
3,9nH	L3	0402	chip inductor +/- 5%
1MΩ	R1	0402	+/-10%
22kΩ	R2	0402	+/-1%
nRF24L01	U1	QFN20 4x4	
16MHz	X1		+/-60ppm, C_L=12pF

a. C1 and C2 must have values that match the crystals load capacitance, C_L

Table 26. Recommended components (BOM) in nRF24L01 with antenna matching network

Datasheet Atmega 328

Features

- High Performance, Low Power AVR® 8-Bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 20 MIPS Throughput at 20 MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
  - 4/8/16/32K Bytes of In-System Self-Programmable Flash program memory
  - 256/512/512/1K Bytes EEPROM
  - 512/1K/1K/2K Bytes Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/100 years at 25°C[1]
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by On-chip Boot Program
    - True Read-While-Write Operation
  - Programming Lock for Software Security
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Six PWM Channels
  - 8-channel 10-bit ADC in TQFP and QFN/MLF package
    - Temperature Measurement
  - 6-channel 10-bit ADC in PDIP Package
    - Temperature Measurement
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Byte-oriented 2-wire Serial Interface (Philips I²C compatible)
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated 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
  - 23 Programmable I/O Lines
  - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
  - 1.8 - 5.5V
- Temperature Range:
  - -40°C to 85°C
- Speed Grade:
  - 0 - 4 MHz@1.8 - 5.5V, 0 - 10 MHz@2.7 - 5.5.V, 0 - 20 MHz @ 4.5 - 5.5V
- Power Consumption at 1 MHz, 1.8V, 25°C
  - Active Mode: 0.2 mA
  - Power-down Mode: 0.1 µA
  - Power-save Mode: 0.75 µA (Including 32 kHz RTC)

8-bit AVR® Microcontroller with 4/8/16/32K Bytes In-System Programmable Flash

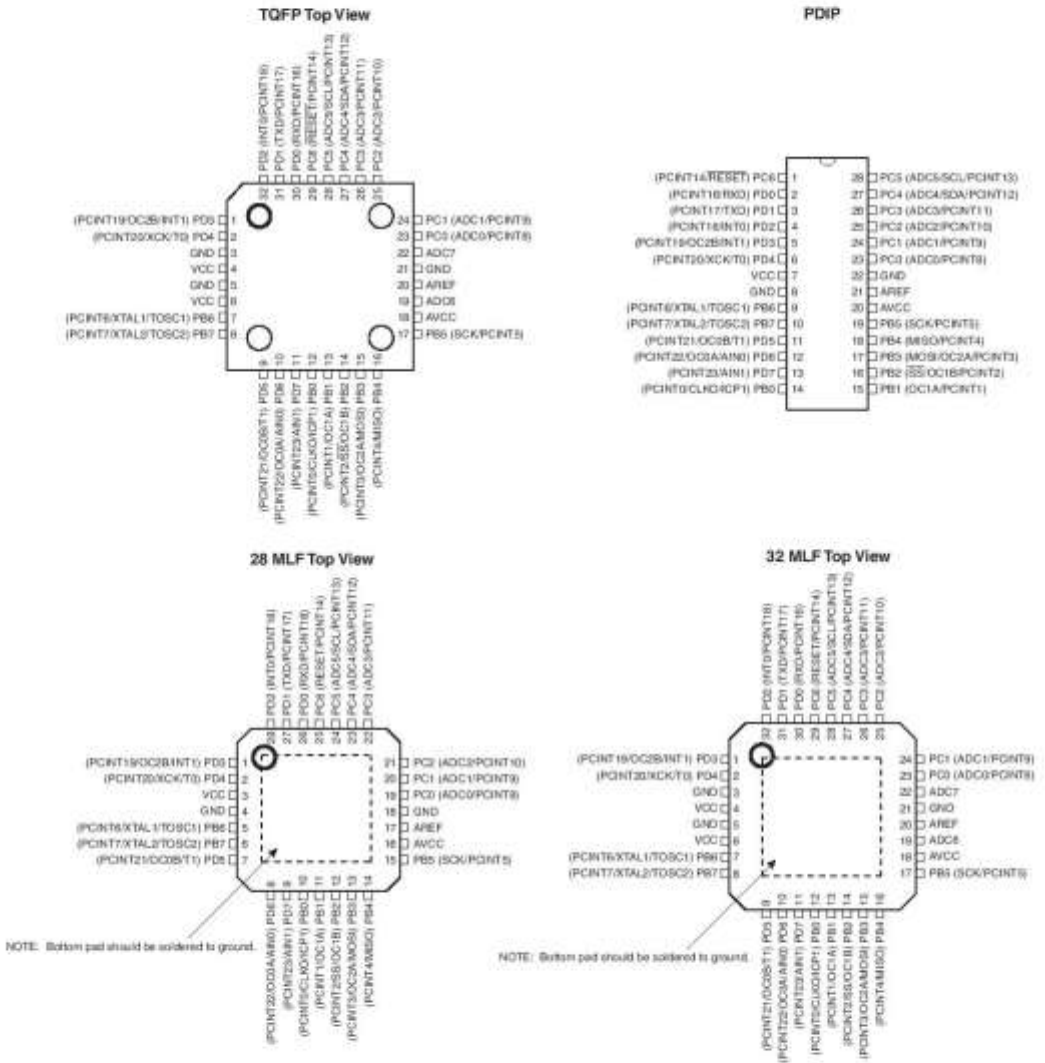
ATmega48A
ATmega48PA
ATmega88A
ATmega88PA
ATmega168A
ATmega168PA
ATmega328
ATmega328P

Summary

Rev. 8271BS–AVR–04/10

1. Pin Configurations

Figure 1-1. Pinout ATmega48A/48PA/88A/88PA/168A/168PA/328/328P



4. Register Summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0xFF)	Reserved	–	–	–	–	–	–	–	–	
(0xFE)	Reserved	–	–	–	–	–	–	–	–	
(0xFD)	Reserved	–	–	–	–	–	–	–	–	
(0xFC)	Reserved	–	–	–	–	–	–	–	–	
(0xFB)	Reserved	–	–	–	–	–	–	–	–	
(0xFA)	Reserved	–	–	–	–	–	–	–	–	
(0xF9)	Reserved	–	–	–	–	–	–	–	–	
(0xF8)	Reserved	–	–	–	–	–	–	–	–	
(0xF7)	Reserved	–	–	–	–	–	–	–	–	
(0xF6)	Reserved	–	–	–	–	–	–	–	–	
(0xF5)	Reserved	–	–	–	–	–	–	–	–	
(0xF4)	Reserved	–	–	–	–	–	–	–	–	
(0xF3)	Reserved	–	–	–	–	–	–	–	–	
(0xF2)	Reserved	–	–	–	–	–	–	–	–	
(0xF1)	Reserved	–	–	–	–	–	–	–	–	
(0xF0)	Reserved	–	–	–	–	–	–	–	–	
(0xEF)	Reserved	–	–	–	–	–	–	–	–	
(0xEE)	Reserved	–	–	–	–	–	–	–	–	
(0xED)	Reserved	–	–	–	–	–	–	–	–	
(0xEC)	Reserved	–	–	–	–	–	–	–	–	
(0xEB)	Reserved	–	–	–	–	–	–	–	–	
(0xEA)	Reserved	–	–	–	–	–	–	–	–	
(0xE9)	Reserved	–	–	–	–	–	–	–	–	
(0xE8)	Reserved	–	–	–	–	–	–	–	–	
(0xE7)	Reserved	–	–	–	–	–	–	–	–	
(0xE6)	Reserved	–	–	–	–	–	–	–	–	
(0xE5)	Reserved	–	–	–	–	–	–	–	–	
(0xE4)	Reserved	–	–	–	–	–	–	–	–	
(0xE3)	Reserved	–	–	–	–	–	–	–	–	
(0xE2)	Reserved	–	–	–	–	–	–	–	–	
(0xE1)	Reserved	–	–	–	–	–	–	–	–	
(0xE0)	Reserved	–	–	–	–	–	–	–	–	
(0xDF)	Reserved	–	–	–	–	–	–	–	–	
(0xDE)	Reserved	–	–	–	–	–	–	–	–	
(0xDD)	Reserved	–	–	–	–	–	–	–	–	
(0xDC)	Reserved	–	–	–	–	–	–	–	–	
(0xDB)	Reserved	–	–	–	–	–	–	–	–	
(0xDA)	Reserved	–	–	–	–	–	–	–	–	
(0xD9)	Reserved	–	–	–	–	–	–	–	–	
(0xD8)	Reserved	–	–	–	–	–	–	–	–	
(0xD7)	Reserved	–	–	–	–	–	–	–	–	
(0xD6)	Reserved	–	–	–	–	–	–	–	–	
(0xD5)	Reserved	–	–	–	–	–	–	–	–	
(0xD4)	Reserved	–	–	–	–	–	–	–	–	
(0xD3)	Reserved	–	–	–	–	–	–	–	–	
(0xD2)	Reserved	–	–	–	–	–	–	–	–	
(0xD1)	Reserved	–	–	–	–	–	–	–	–	
(0xD0)	Reserved	–	–	–	–	–	–	–	–	
(0xCF)	Reserved	–	–	–	–	–	–	–	–	
(0xCE)	Reserved	–	–	–	–	–	–	–	–	
(0xCD)	Reserved	–	–	–	–	–	–	–	–	
(0xCC)	Reserved	–	–	–	–	–	–	–	–	
(0xCB)	Reserved	–	–	–	–	–	–	–	–	
(0xCA)	Reserved	–	–	–	–	–	–	–	–	
(0xC9)	Reserved	–	–	–	–	–	–	–	–	
(0xC8)	Reserved	–	–	–	–	–	–	–	–	
(0xC7)	Reserved	–	–	–	–	–	–	–	–	
(0xC6)	UDR0	USART I/O Data Register								196
(0xC5)	UBRR0H						USART Baud Rate Register High			200
(0xC4)	UBRR0L	USART Baud Rate Register Low								200
(0xC3)	Reserved	–	–	–	–	–	–	–	–	
(0xC2)	UCSR0C	UMSEL01	UMSEL00	UPM01	UPM00	USBS0	[illegible]	[illegible]	UCPOL0	198/213

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0xC1)	UCSR0B	RXCIE0	TXCIE0	UDRIE0	RXEN0	TXEN0	UCSZ02	RXB80	TXB80	197
(0xC0)	UCSR0A	RXC0	TXC0	UDRE0	FE0	DOR0	UPE0	U2X0	MPCM0	196
(0xBF)	Reserved	–	–	–	–	–	–	–	–	
(0xBE)	Reserved	–	–	–	–	–	–	–	–	
(0xBD)	TWAMR	TWAM6	TWAM5	TWAM4	TWAM3	TWAM2	TWAM1	TWAM0	–	245
(0xBC)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	–	TWIE	242
(0xBB)	TWDR	2-wire Serial Interface Data Register								244
(0xBA)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE	245
(0xB9)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	–	TWPS1	TWPS0	244
(0xB8)	TWBR	2-wire Serial Interface Bit Rate Register								242
(0xB7)	Reserved	–		–	–	–	–	–	–	
(0xB6)	ASSR	–	EXCLK	AS2	TCN2UB	OCR2AUB	OCR2BUB	TCR2AUB	TCR2BUB	165
(0xB5)	Reserved	–	–	–	–	–	–	–	–	
(0xB4)	OCR2B	Timer/Counter2 Output Compare Register B								163
(0xB3)	OCR2A	Timer/Counter2 Output Compare Register A								163
(0xB2)	TCNT2	Timer/Counter2 (8-bit)								163
(0xB1)	TCCR2B	FOC2A	FOC2B	–	–	WGM22	CS22	CS21	CS20	162
(0xB0)	TCCR2A	COM2A1	COM2A0	COM2B1	COM2B0	–	–	WGM21	WGM20	159
(0xAF)	Reserved	–	–	–	–	–	–	–	–	
(0xAE)	Reserved	–	–	–	–	–	–	–	–	
(0xAD)	Reserved	–	–	–	–	–	–	–	–	
(0xAC)	Reserved	–	–	–	–	–	–	–	–	
(0xAB)	Reserved	–	–	–	–	–	–	–	–	
(0xAA)	Reserved	–	–	–	–	–	–	–	–	
(0xA9)	Reserved	–	–	–	–	–	–	–	–	
(0xA8)	Reserved	–	–	–	–	–	–	–	–	
(0xA7)	Reserved	–	–	–	–	–	–	–	–	
(0xA6)	Reserved	–	–	–	–	–	–	–	–	
(0xA5)	Reserved	–	–	–	–	–	–	–	–	
(0xA4)	Reserved	–	–	–	–	–	–	–	–	
(0xA3)	Reserved	–	–	–	–	–	–	–	–	
(0xA2)	Reserved	–	–	–	–	–	–	–	–	
(0xA1)	Reserved	–	–	–	–	–	–	–	–	
(0xA0)	Reserved	–	–	–	–	–	–	–	–	
(0x9F)	Reserved	–	–	–	–	–	–	–	–	
(0x9E)	Reserved	–	–	–	–	–	–	–	–	
(0x9D)	Reserved	–	–	–	–	–	–	–	–	
(0x9C)	Reserved	–	–	–	–	–	–	–	–	
(0x9B)	Reserved	–	–	–	–	–	–	–	–	
(0x9A)	Reserved	–	–	–	–	–	–	–	–	
(0x99)	Reserved	–	–	–	–	–	–	–	–	
(0x98)	Reserved	–	–	–	–	–	–	–	–	
(0x97)	Reserved	–	–	–	–	–	–	–	–	
(0x96)	Reserved	–	–	–	–	–	–	–	–	
(0x95)	Reserved	–	–	–	–	–	–	–	–	
(0x94)	Reserved	–	–	–	–	–	–	–	–	
(0x93)	Reserved	–	–	–	–	–	–	–	–	
(0x92)	Reserved	–	–	–	–	–	–	–	–	
(0x91)	Reserved	–	–	–	–	–	–	–	–	
(0x90)	Reserved	–	–	–	–	–	–	–	–	
(0x8F)	Reserved	–	–	–	–	–	–	–	–	
(0x8E)	Reserved	–	–	–	–	–	–	–	–	
(0x8D)	Reserved	–	–	–	–	–	–	–	–	
(0x8C)	Reserved	–	–	–	–	–	–	–	–	
(0x8B)	OCR1BH	Timer/Counter1 - Output Compare Register B High Byte								139
(0x8A)	OCR1BL	Timer/Counter1 - Output Compare Register B Low Byte								139
(0x89)	OCR1AH	Timer/Counter1 - Output Compare Register A High Byte								139
(0x88)	OCR1AL	Timer/Counter1 - Output Compare Register A Low Byte								139
(0x87)	ICR1H	Timer/Counter1 - Input Capture Register High Byte								139
(0x86)	ICR1L	Timer/Counter1 - Input Capture Register Low Byte								139
(0x85)	TCNT1H	Timer/Counter1 - Counter Register High Byte								139
(0x84)	TCNT1L	Timer/Counter1 - Counter Register Low Byte								139
(0x83)	Reserved	–	–	–	–	–	–	–	–	
(0x82)	TCCR1C	FOC1A	FOC1B	–	–	–	–	–	–	138
(0x81)	TCCR1B	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10	137
(0x80)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	–	–	WGM11	WGM10	135

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0x7F)	DIDR1	–	–	–	–	–	–	AIN1D	AIN0D	250
(0x7E)	DIDR0	–	–	ADC5D	ADC4D	ADC3D	ADC2D	ADC1D	ADC0D	267
(0x7D)	Reserved	–	–	–	–	–	–	–	–	
(0x7C)	ADMUX	REFS1	REFS0	ADLAR	–	MUX3	MUX2	MUX1	MUX0	263
(0x7B)	ADCSRB	–	ACME	–	–	–	ADTS2	ADTS1	ADTS0	266
(0x7A)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	264
(0x79)	ADCH	ADC Data Register High byte								268
(0x78)	ADCL	ADC Data Register Low byte								268
(0x77)	Reserved	–	–	–	–	–	–	–	–	
(0x76)	Reserved	–	–	–	–	–	–	–	–	
(0x75)	Reserved	–	–	–	–	–	–	–	–	
(0x74)	Reserved	–	–	–	–	–	–	–	–	
(0x73)	Reserved	–	–	–	–	–	–	–	–	
(0x72)	Reserved	–	–	–	–	–	–	–	–	
(0x71)	Reserved	–	–	–	–	–	–	–	–	
(0x70)	TIMSK2	–	–	–	–	–	OCIE2B	OCIE2A	TOIE2	164
(0x6F)	TIMSK1	–	–	ICIE1	–	–	OCIE1B	OCIE1A	TOIE1	140
(0x6E)	TIMSK0	–	–	–	–	–	OCIE0B	OCIE0A	TOIE0	112
(0x6D)	PCMSK2	PCINT23	PCINT22	PCINT21	PCINT20	PCINT19	PCINT18	PCINT17	PCINT16	75
(0x6C)	PCMSK1	–	PCINT14	PCINT13	PCINT12	PCINT11	PCINT10	PCINT9	PCINT8	75
(0x6B)	PCMSK0	PCINT7	PCINT6	PCINT5	PCINT4	PCINT3	PCINT2	PCINT1	PCINT0	75
(0x6A)	Reserved	–	–	–	–	–	–	–	–	
(0x69)	EICRA	–	–	–	–	ISC11	ISC10	ISC01	ISC00	72
(0x68)	PCICR	–	–	–	–	–	PCIE2	PCIE1	PCIE0	
(0x67)	Reserved	–	–	–	–	–	–	–	–	
(0x66)	OSCCAL	Oscillator Calibration Register								37
(0x65)	Reserved	–	–	–	–	–	–	–	–	
(0x64)	PRR	PRTWI	PRTIM2	PRTIM0	–	PRTIM1	PRSPI	PRUSART0	PRADC	42
(0x63)	Reserved	–	–	–	–	–	–	–	–	
(0x62)	Reserved	–	–	–	–	–	–	–	–	
(0x61)	CLKPR	CLKPCE	–	–	–	CLKPS3	CLKPS2	CLKPS1	CLKPS0	37
(0x60)	WDTCSR	WDIF	WDIE	WDP3	WDCE	WDE	WDP2	WDP1	WDP0	55
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C	8
0x3E (0x5E)	SPH	–	–	–	–	–	(SP10) [1]	SP9	SP8	12
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	12
0x3C (0x5C)	Reserved	–	–	–	–	–	–	–	–	
0x3B (0x5B)	Reserved	–	–	–	–	–	–	–	–	
0x3A (0x5A)	Reserved	–	–	–	–	–	–	–	–	
0x39 (0x59)	Reserved	–	–	–	–	–	–	–	–	
0x38 (0x58)	Reserved	–	–	–	–	–	–	–	–	
0x37 (0x57)	SPMCSR	SPMIE	(RWWSB) [2]	–	(RWWSRE) [3]	BLBSET	PGWRT	PGERS	SELFPRGEN	294
0x36 (0x56)	Reserved	–	–	–	–	–	–	–	–	
0x35 (0x55)	MCUCR	–	BODS [4]	BODSE [4]	PUD	–	–	IVSEL	IVCE	45/59/93
0x34 (0x54)	MCUSR	–	–	–	–	WDRF	BORF	EXTRF	PORF	55
0x33 (0x53)	SMCR	–	–	–	–	SM2	SM1	SM0	SE	40
0x32 (0x52)	Reserved	–	–	–	–	–	–	–	–	
0x31 (0x51)	Reserved	–	–	–	–	–	–	–	–	
0x30 (0x50)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	248
0x2F (0x4F)	Reserved	–	–	–	–	–	–	–	–	
0x2E (0x4E)	SPDR	SPI Data Register								176
0x2D (0x4D)	SPSR	SPIF	WCOL	–	–	–	–	–	SPI2X	175
0x2C (0x4C)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	174
0x2B (0x4B)	GPIOR2	General Purpose I/O Register 2								25
0x2A (0x4A)	GPIOR1	General Purpose I/O Register 1								25
0x29 (0x49)	Reserved	–	–	–	–	–	–	–	–	
0x28 (0x48)	OCR0B	Timer/Counter0 Output Compare Register B								
0x27 (0x47)	OCR0A	Timer/Counter0 Output Compare Register A								
0x26 (0x46)	TCNT0	Timer/Counter0 (8-bit)								
0x25 (0x45)	TCCR0B	FOC0A	FOC0B	–	–	WGM02	CS02	CS01	CS00	
0x24 (0x44)	TCCR0A	COM0A1	COM0A0	COM0B1	COM0B0	–	–	WGM01	WGM00	
0x23 (0x43)	GTCCR	TSM	–	–	–	–	–	PSRASY	PSRSYNC	144/166
0x22 (0x42)	EEARH	(EEPROM Address Register High Byte) [1]								21
0x21 (0x41)	EEARL	EEPROM Address Register Low Byte								21
0x20 (0x40)	EEDR	EEPROM Data Register								21
0x1F (0x3F)	EECR	–	–	EEPM1	EEPM0	EERIE	EEMPE	EEPE	EERE	21
0x1E (0x3E)	GPIOR0	General Purpose I/O Register 0								25

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
0x1D (0x3D)	EIMSK	–	–	–	–	–	–	INT1	INT0	73
0x1C (0x3C)	EIFR	–	–	–	–	–	–	INTF1	INTF0	73
0x1B (0x3B)	PCIFR	–	–	–	–	–	PCIF2	PCIF1	PCIF0	
0x1A (0x3A)	Reserved	–	–	–	–	–	–	–	–	
0x19 (0x39)	Reserved	–	–	–	–	–	–	–	–	
0x18 (0x38)	Reserved	–	–	–	–	–	–	–	–	
0x17 (0x37)	TIFR2	–	–	–	–	–	OCF2B	OCF2A	TOV2	164
0x16 (0x36)	TIFR1	–	–	ICF1	–	–	OCF1B	OCF1A	TOV1	140
0x15 (0x35)	TIFR0	–	–	–	–	–	OCF0B	OCF0A	TOV0	
0x14 (0x34)	Reserved	–	–	–	–	–	–	–	–	
0x13 (0x33)	Reserved	–	–	–	–	–	–	–	–	
0x12 (0x32)	Reserved	–	–	–	–	–	–	–	–	
0x11 (0x31)	Reserved	–	–	–	–	–	–	–	–	
0x10 (0x30)	Reserved	–	–	–	–	–	–	–	–	
0x0F (0x2F)	Reserved	–	–	–	–	–	–	–	–	
0x0E (0x2E)	Reserved	–	–	–	–	–	–	–	–	
0x0D (0x2D)	Reserved	–	–	–	–	–	–	–	–	
0x0C (0x2C)	Reserved	–	–	–	–	–	–	–	–	
0x0B (0x2B)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	94
0x0A (0x2A)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	94
0x09 (0x29)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	94
0x08 (0x28)	PORTC	–	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	93
0x07 (0x27)	DDRC	–	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	93
0x06 (0x26)	PINC	–	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0	93
0x05 (0x25)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	93
0x04 (0x24)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	93
0x03 (0x23)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	93
0x02 (0x22)	Reserved	–	–	–	–	–	–	–	–	
0x01 (0x21)	Reserved	–	–	–	–	–	–	–	–	
0x0 (0x20)	Reserved	–	–	–	–	–	–	–	–	

Note:
1. For compatibility with future devices, reserved bits should be written to zero if accessed. Reserved I/O memory addresses should never be written.
2. I/O Registers within the address range 0x00 - 0x1F are directly bit-accessible using the SBI and CBI instructions. In these registers, the value of single bits can be checked by using the SBIS and SBIC instructions.
3. Some of the Status Flags are cleared by writing a logical one to them. Note that, unlike most other AVRs, the CBI and SBI instructions will only operate on the specified bit, and can therefore be used on registers containing such Status Flags. The CBI and SBI instructions work with registers 0x00 to 0x1F only.
4. When using the I/O specific commands IN and OUT, the I/O addresses 0x00 - 0x3F must be used. When addressing I/O Registers as data space using LD and ST instructions, 0x20 must be added to these addresses. The ATmega48A/48PA/88A/88PA/168A/168PA/328/328P is a complex microcontroller with more peripheral units than can be supported within the 64 location reserved in Opcode for the IN and OUT instructions. For the Extended I/O space from 0x60 - 0xFF in SRAM, only the ST/STS/STD and LD/LDS/LDD instructions can be used.
5. Only valid for ATmega88A/88PA/168A/168PA/328/328P.
6. BODS and BODSE only available for picoPower devices ATmega48PA/88PA/168PA/328P