Pira.cz

PIRA32 Microcontroller

FM Broadcast Radio Data System Encoder MCU with single communication port

DESCRIPTION

The PIRA32 Microcontroller forms a fully digital Radio Data System encoder that has been developed especially for FM broadcasting. It implements physical and data-link layers and supports extended set of RDS services.

All functions are controlled by the RS-232 interface. The device supports optional I^2C slave peripherals such as EEPROM memory, RTC, LCD display or digital potentiometer.

FEATURES

- Single supply
- Typical operating current: 9 mA @ 5 V
- Minimum external parts
- I^2C bus for external peripherals like EEPROM, real time clock, LCD or digital potentiometer
- External TA and Program switch
- Two indication LED outputs
- Both stereo and mono operation possible
- Built-in digital 19 kHz pilot tone PLL with software phase shift adjustment
- Parallel 8-bit D/A converter, 361 kHz sampling rate (over-sampled)
- Broadcast quality output signal
- Only simple output filter required
- RDS/RBDS signal:
  conforms to CENELEC EN50067 / EN 62106
- Continuous RDS transmission during all operations
- Firmware update capability
- Communication bus:
  RS-232, bidirectional
- Baud rate: 1200 to 19200 Bd
- Packages available: 28-Pin PDIP
  28-Pin SOIC

R·D·S RADIO DATA SYSTEM

TYPICAL APPLICATIONS

- FM broadcast RDS encoders with single communication port
- RDS testing, research and development

Important Note:

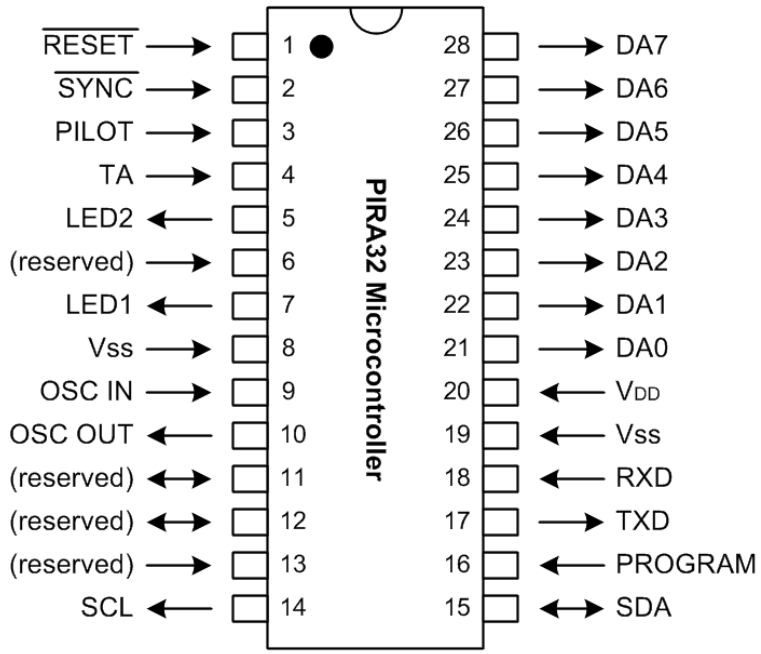
This datasheet is not intended to be a complete PIRA32 system designer's reference source.
For more information on the features, characteristics, control and use refer to these documents:
"PIRA32 RDS Encoder Technical Manual" (available online)
"PIRA32 LCD Display" (available online)
"PIRA32 Device Configuration" (optional, available on request)
"PIRA32 LCD Display Multiplexing" (optional, available on request)

Revision 2017-06-09

TABLE OF CONTENTS

1 PIN DIAGRAMS AND DESCRIPTION

1.1 28-pin PDIP, 28-pin SOIC

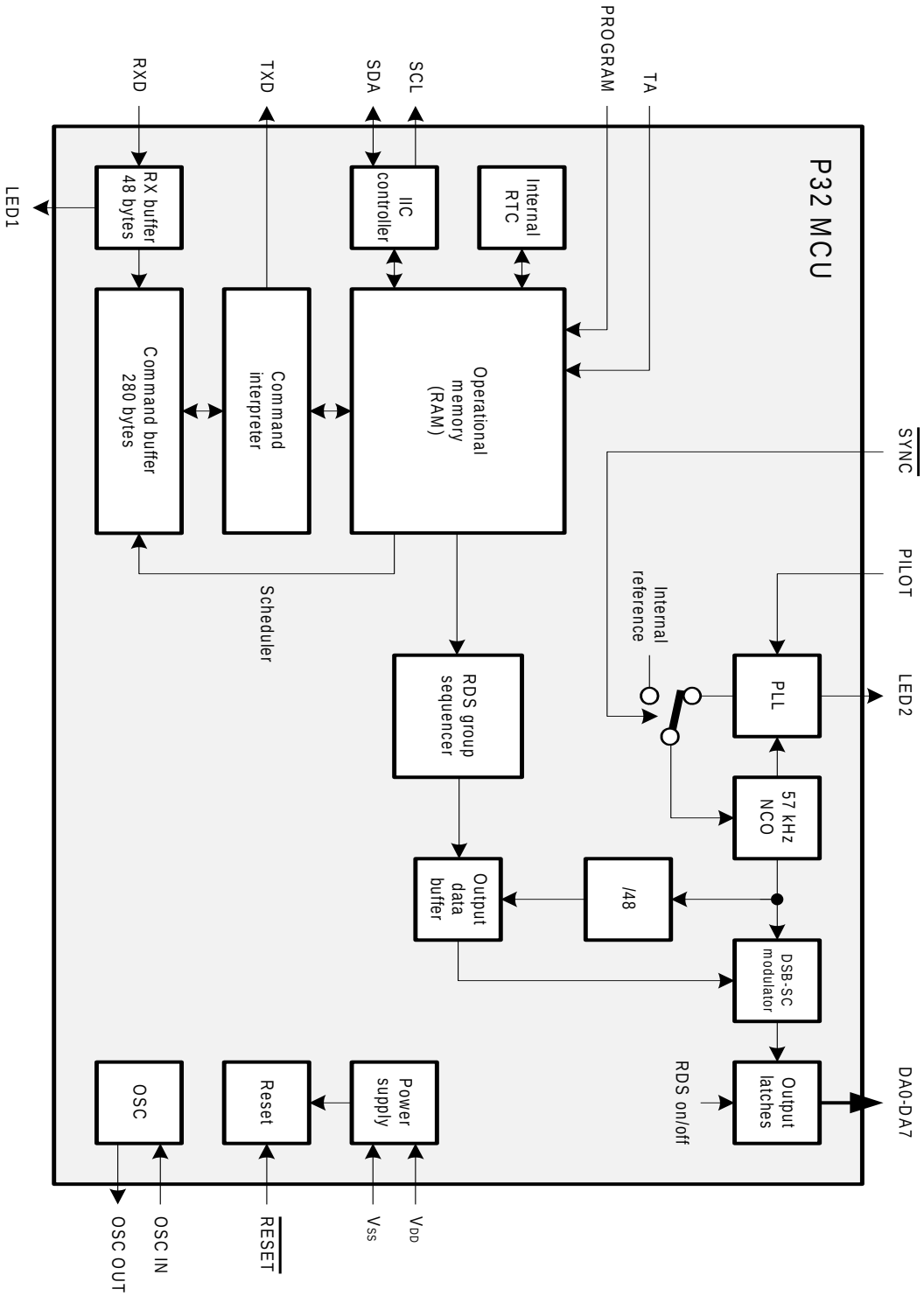


Pin name	Description
/RESET	**Device reset** Logical low on this pin holds the device in reset state. If the reset function is not required, connect this pin to V_{DD} through a resistor.
/SYNC	**Pilot sync. switch** Drive this pin low to confirm the pilot tone validity and to enable internal pilot PLL assuring stable phase relation between pilot tone and RDS sub-carrier. If the pilot sync. function is not required (mono transmission), connect this pin to V_{DD} through a resistor so internal clock reference will be used.
PILOT	**Pilot tone input** The pilot tone must comply with TTL levels. If pilot tone is not available or does not meet the specifications required, the /SYNC pin should be driven high.
PROGRAM	**Program select** Selects between two different RDS data sets (program 1 or program 2). If the program external switching function is not required, connect this pin to V_{DD} through a resistor.
TA	**TA switch** RDS Traffic Announcement (TA) flag control. If the TA external switching function is not required, connect this pin to VDD through a resistor.

V_{DD}	**Positive supply** Apply V_{DD} power supply voltage to this pin. Decoupling capacitor is required on V_{DD} and V_{SS} pins. A 100 nF 10-50V ceramic capacitor is recommended. The decoupling capacitor should be placed as close to the pins as possible.
V_{SS}	**Ground reference** All V_{SS} pins must be connected.
OSC IN	**Crystal oscillator input** Tie to 4.332 MHz crystal pin.
OSC OUT	**Crystal oscillator output** Tie to 4.332 MHz crystal pin. Can be used for clocking another device on the board.
LED1	**Operation LED** Connect an indication LED (+) through a resistor or leave unconnected.
LED2	**Pilot LED** Connect an indication LED (+) through a resistor or leave unconnected.
SCL	**I^2C serial clock output** Open-drain terminal, external 2k pull-up resistor is required.
SDA	**I^2C serial data input/output** Open-drain terminal, external 2k pull-up resistor is required.
TXD	**Serial port transmit data** Serial RS-232 port transmit data output (software selectable 1200 to 19200 bps). Logical high = idle. This pin is required for proper software configuration of the device.
RXD	**Serial port receive data** Serial RS-232 port receive data input (software selectable 1200 to 19200 bps). Logical high = idle. This pin is required for proper software configuration of the device.
DA0-DA7	**D/A Converter bit 0 to 7** These pins together form driving signal for parallel D/A converter. A simple low-cost R/2R resistor network can serve the D/A converter function. The R value should be 1k.

All pins marked as “reserved” should be left unconnected or tied to V_{DD} through a 10k resistor.

1.1. Internal logical structure (simplified)



2 ELECTRICAL CHARACTERISTICS

Maximum Ratings

Ambient temperature under bias ..... -40 °C to +125 °C
Storage temperature ..... -65 °C to +150 °C
Voltage on V_{DD} with respect to V_{SS} ..... -0.3 V to +7.5 V
Voltage on any I/O pin with respect to V_{SS} ..... -0.3 V to (V_{DD} + 0.3 V)
Maximum current sourced by any output pin ..... 25 mA
Maximum current sunk by any output pin ..... 25 mA

Stresses above those listed under “Maximum Ratings” may cause permanent damage to the device.

Symbol	Parameter	Min.	Typ.	Max.	Unit	Conditions
V_{DD}	Supply voltage	4.2	-	5.5	V	
F_{OSC}	Oscillator Frequency	-0.01 %	4.332	+0.01 %	MHz	
F_S	D/A Converter sampling rate	-	361	-	kHz	
B_{PLL}	PLL capture range	-	8	-	Hz	Stereo broadcast
T_{PU}	Power-up delay	-	-	1100	ms	
F_{CLK}	I^2C clock frequency	-	400	-	kHz	

3 DESIGN NOTES

3.1 Device reset

A reset is generated by holding the /RESET pin low. The device has a noise filter in the reset path which detects and ignores small pulses.

A reset pulse is generated on-chip whenever V_{DD} rises above a certain threshold. This allows the device to start in the initialized state when V_{DD} is adequate for operation.

To take advantage of this feature, tie the /RESET pin through a resistor (1k to 10k) to V_{DD}. This will eliminate external RC components usually needed to create a reset delay.

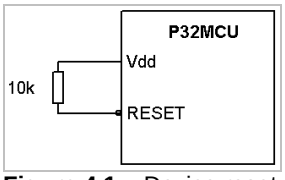


Figure 4.1 – Device reset.

When the device starts normal operation (i.e., exits the reset condition), device operating parameters (voltage, temperature, etc.) must be met to ensure operation. If these conditions are not met, the device must be held in reset until the operating conditions are met.

3.2 Crystal oscillator

The oscillator circuit should be placed on the same side of the board as the device. The load capacitors should be placed next to the oscillator itself.

The load capacitor value depends on the crystal characteristics. Optimal value ensures the F_{OSC} to lie in the tolerance range given in section Electrical characteristics. A good starting value is 22 pF for the load capacitors.

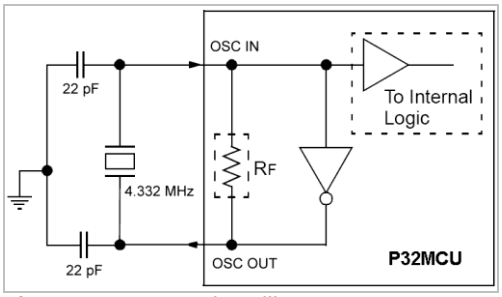


Figure 4.2 – Crystal oscillator.

Recommended crystal type is
Auris **Q- 4,332000M-HC49US-F-30-30-D-16**
or equivalent.

3.3 Power supply

The power supply must be bypassed close to the device with a 100 nF ceramic capacitor. The output RDS level varies proportionally to the supply voltage.

3.4 Internal PLL

The PIRA32 Microcontroller includes an internal phase locked loop, which synchronises the RDS subcarrier with 19 kHz pilot tone in case of stereo broadcast. Parameters of the PLL are controlled by software.

Pilot tone is tied to the PILOT input pin and must comply with TTL levels.

The PLL is active if the /SYNC pin is driven low. This configuration makes easy to connect commonly available clock recovery circuits (LM567) if the pilot tone needs to be filtered from MPX signal.

The PLL should be disabled in case of mono broadcast by driving the /SYNC pin high or by the command `EXTSYNC`.

3.5 External TA switch

The external TA switch can set the Traffic Announcement flag to 1. The TA flag is set to 1 if the TA input is driven low. This can be done using simple mechanical switch or any logic circuit.

Where the external TA switch feature is not required, the TA pin must be tied to V_{DD} through a resistor.

3.6 RS-232 interface

The RS-232 interface is used for the device configuration and data transfers. The RXD and TXD pin levels are compatible with TTL. For connection to external equipment an inverter and level converter is required (for example MAX232).

The serial data format is given in the RDS Encoder Technical manual (available online).

3.7 Digital-to-Analog converter

The Microcontroller uses parallel 8-bit D/A converter with over-sampling technique. Digital data provided on DA pins can be directly formed into final analogue RDS output signal using low-cost resistor network.

Figure 4.3 shows accurate 8-bit DAC using R/2R resistor network. It's a binary weighted DAC that creates each value with a repeating structure of 2 resistor values, R and R times two. This is an optimal DAC for this device. The resistor value tolerance must not exceed 2 %.

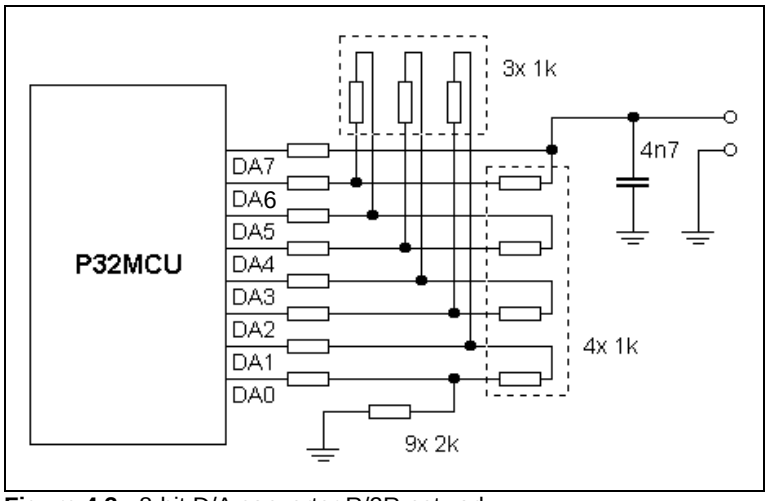


Figure 4.3 - 8-bit D/A converter R/2R network

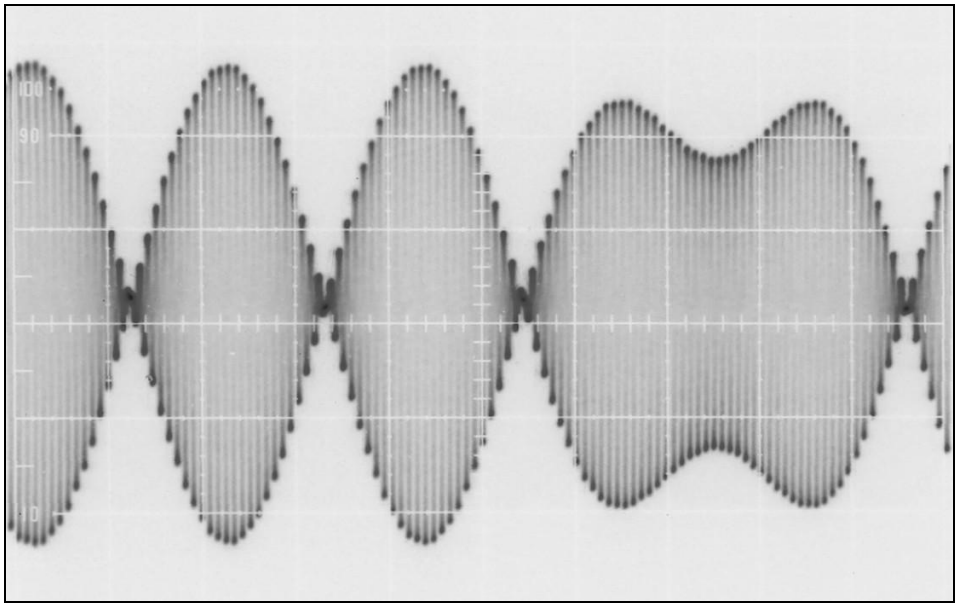


Figure 4.4 – Output RDS signal on oscilloscope (horizontal: 200 µs/div, vertical: 500 mV/div).

3.8 Output low-pass filter

The output RDS signal modulated at 57 kHz subcarrier requires no special filtering. Spurious products are kept below -70 dB broadcast limit and the D/A conversion residues around the sampling frequency can be cut-off using any simple low-pass filter. This may be based either on active filter or a simple LC element. For FM broadcast purposes the low-pass filter rejection should be at least 20 dBc on the sampling frequency. It is recommended for high quality FM broadcasting that the output filter characteristics interpolate at least these values:

15 kHz	57 kHz	360 kHz
-20 dB	0 dB	**-30 dB**

3.9 Expansion I²C bus

The PIRA32 Microcontroller supports several external devices that extend its functions and features. All of these devices are optional, i.e. the final design is highly customizable. The devices are recognized automatically on power-up or device reset.

The I²C devices supported are listed in following table:

Device name	Manufacturer	Description
24LC256	Microchip	Serial EEPROM. Non-volatile memory for storing RDS and configuration data. Recommended for proper function.
PCF8563	NXP	Battery powered backup real-time clock (RTC).
MCP23008	Microchip	Parallel port for 16×2 LCD display based on HD44780 driver.
MCP4551-103	Microchip	Digital potentiometer for software control of RDS output level.

3.10 Operation without EEPROM on I²C bus

Operation without EEPROM is possible. If EEPROM is not detected on the I²C bus after power-up or reset, the RAM memory is filled with blank data. The RDS generator is turned off. The user may fill the RAM with valid values using RS-232 ASCII commands and then turn on the RDS generator by the command `RDSGEN=1`.

4 CONNECTION DIAGRAMS

4.1 Basic connection diagram

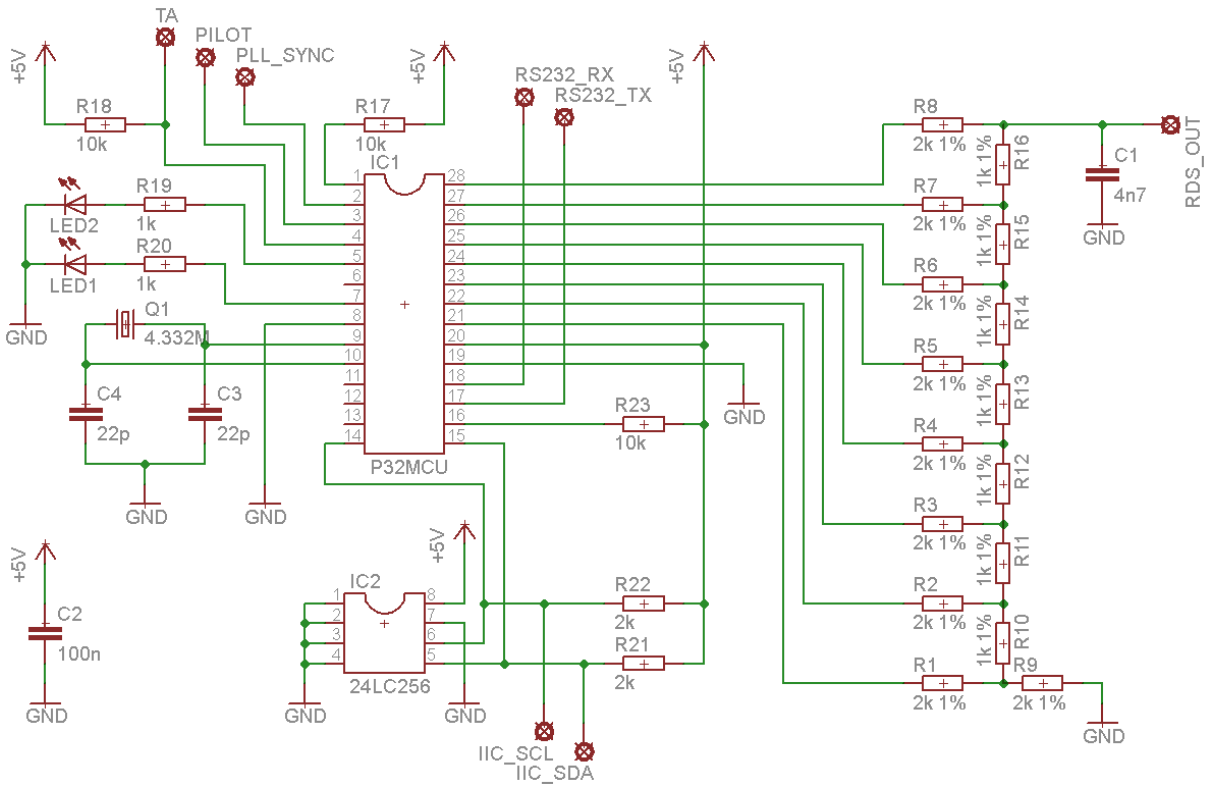


Figure 4.1.1 - Sample application circuit - schematic diagram

The figure above effectively represents minimum required connection for proper operation. It is a default circuit for further extensions and development purposes.

Notes to the basic connection diagram:

TA	Traffic announcement switch. Driving this pin low will activate the RDS TA flag. **(Optional)**
PILOT	Pilot input (19 kHz TTL) from stereo encoder or pilot recovery circuit. **(Optional)**
RS232	RS232 interface in TTL levels for connection to a PC or any data provider through a level converter, USB adapter or Ethernet adapter.
PLL_SYNC	Synchronization source selection: 0 – External pilot, 1 – Internal clock.
IIC	Expansion I^2C bus.
RDS_OUT	Final RDS output (already modulated at 57 kHz sub-carrier, signal level 5 Vpp). For direct FM broadcasting, additional 57 kHz bandpass filter is recommended: -20 dB (15 kHz), 0 dB (57 kHz), -30 dB (360 kHz).

4.2 Reference connection diagram

The reference connection diagram represents typical application for the PIRA32 Microcontroller.
The application includes:

- Real time circuit with back-up battery
- Pilot tone recovery circuit for enabling RDS and pilot tone synchronization using MPX input signal
- RDS level set by onboard trimmer (either single- or multi-turn)
- Single RS-232 interface for setup and control purposes
- Mixing RDS and MPX to enable 'loopthrough' mode of operation for FM transmitters with no dedicated RDS/SCA input

4.2.1 Setting up

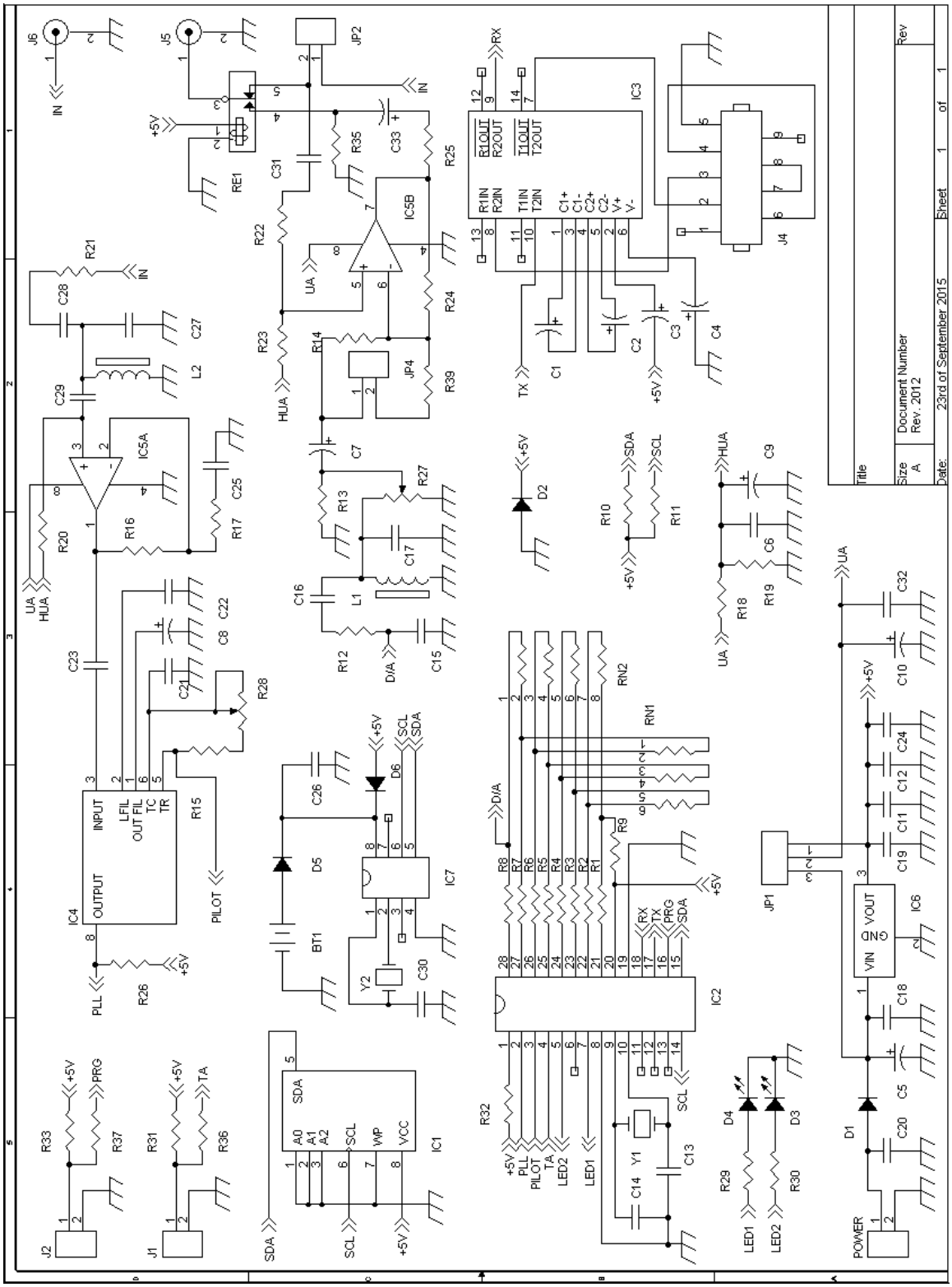
After assembly, the setting up can be made in a few steps:

- Without any input signal connected, adjust 19 kHz (± 100 Hz) on pin 3 of the IC2
- Initialize the EEPROM memory (in the Windows control software, select RDS Encoder - Special - Initialize, or follow the Technical manual)

4.2.2 I/O connectors and control items

J5	Output
J6	Optional pilot/MPX input
JP2	Loopthrough mode enabling jumper
R27	RDS level adjust (0 to 1.4 V peak to peak)
JP4	RDS level boost enabling jumper (RDS level ×2)
POWER	DC power supply input (8 to 16 V)
JP1	Analog section power supply jumper. See the Technical manual for details. Can be replaced by a permanent connection.
J1	Optional TA switch input (short to enable RDS TA)
J2	Optional Program switch input
LED1	Operational LED
LED2	Pilot sync. LED

4.2.3 Schematic diagram

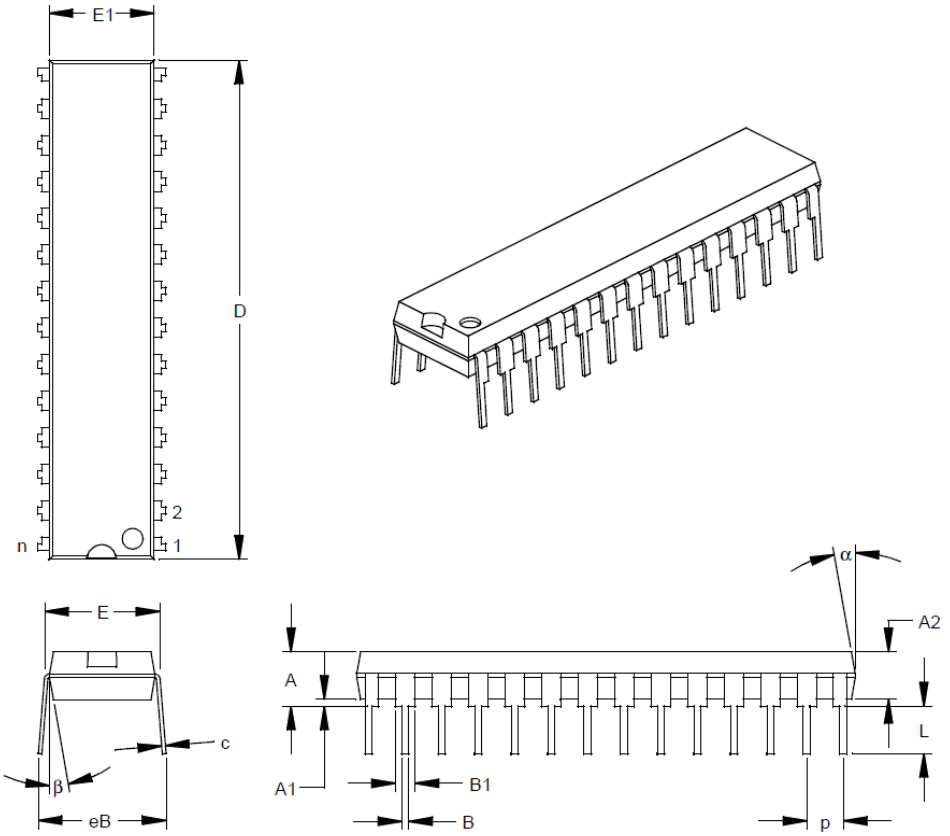


4.2.4 Part list

Part	Value
IC1	24LC256-I/P
IC2	PIRA32 Microcontroller
IC3	MAX232
IC4	LM567
IC5	TLC272
IC6	7805
IC7	PCF8563
D1, D2	1N4007
D3, D4	LED 5mm
D5, D6	1N4148
Y1	4.332 MHz crystal
Y2	32.768 kHz crystal
L1	09P-331K (330 uH)
L2	09P-152J (1.5 mH)
RE1	signal relay
J4	CANON 9F connector
J5, J6	BNC connector
C1, C2, C3, C4	1u (min. 50V, electrolytic)
C5, C10	100u (min. 25V, electrolytic)
C6, C11, C12, C18, C19, C20, C24, C26, C32	100n (ceramic)
C7, C8	10u (min. 35V, electrolytic)
C9, C33	100u (min. 16V, electrolytic)
C13, C14, C30	22p (ceramic)
C15, C16, C25	4n7 (foil)
C17	22n (5%, foil)
C21	3n3 (foil)
C22	220n (foil)
C23, C29	1n (ceramic)
C27	47n (5%, foil)
C28	330p (ceramic)
C31	4u7 (foil)
BT1	CR2032 battery in vertical socket
POWER	DC power connector
R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R17, R29, R30, R36, R37	2k
R14, R19, R26, R31, R32, R33, R39	10k
R15, R18, R22	15k
R16, R20, R21, R24	33k
R23	4k7
R25	91R
R27	trimmer 1k
R28	trimmer 5k
R35	150k
RN1	3x 1k resistor network
RN2	4x 1k resistor network

5 PACKAGE DETAILS

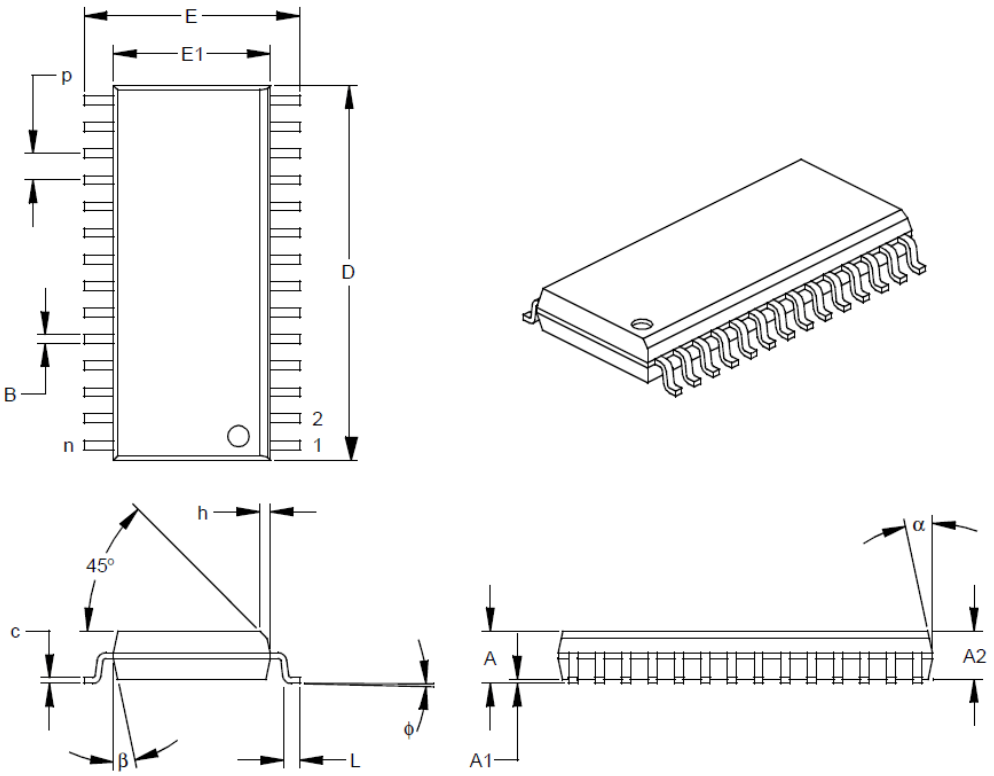
5.1 28-Lead Skinny Plastic Dual In-Line – 300 mil Body (PDIP)



Units		INCHES		
Dimension Limits		MIN	TYP	MAX
Number of Pins	n		28	
Pitch	p		.100	
Top to Seating Plane	A	.140	.150	.160
Molded Package Thickness	A2	.125	.130	.135
Base to Seating Plane	A1	.015	-	-
Shoulder to Shoulder Width	E	.300	.310	.325
Molded Package Width	E1	.275	.285	.295
Overall Length	D	1.345	1.365	1.385
Tip to Seating Plane	L	.125	.130	.135
Lead Thickness	c	.008	.012	.015
Upper Lead Width	B1	.040	.053	.065
Lower Lead Width	B	.016	.019	.022
Overall Row Spacing §	eB	.320	.350	.430
Mold Draft Angle Top	α	5°	10°	15°
Mold Draft Angle Bottom	β	5°	10°	15°

Notes:
§ Significant Characteristic
Dimension D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010” (0.254 mm) per side.

5.2 28-Lead Plastic Small Outline – Wide, 300 mil Body (SOIC)



Units		MILLIMETERS		
Dimension Limits		MIN	TYP	MAX
Number of Pins	n		28	
Pitch	p		1.27	
Overall Height	A	2.36	2.50	2.64
Molded Package Thickness	A2	2.24	2.31	2.39
Standoff §	A1	0.10	0.20	0.30
Overall Width	E	10.01	10.34	10.67
Molded Package Width	E1	7.32	7.49	7.59
Overall Length	D	17.65	17.87	18.08
Chamfer Distance	h	0.25	0.50	0.74
Foot Length	L	0.41	0.84	1.27
Foot Angle Top	ϕ	0°	4°	8°
Lead Thickness	c	0.23	0.28	0.33
Lead Width	B	0.36	0.42	0.51
Mold Draft Angle Top	α	0°	12°	15°
Mold Draft Angle Bottom	β	0°	12°	15°

Notes:
§ Significant Characteristic
Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010” (0.254mm) per side.