

AS3901

**ISM 433/315 MHz
FSK/ASK Transmitter**

**Data Sheet
Rev. 06, August 2000**

Key Features

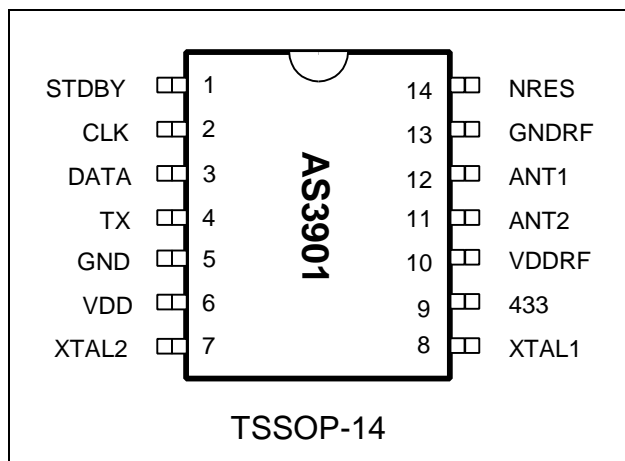
- Supports the European 433 MHz ISM band.
- No frequency pulling by (antenna) load variation due to PLL synthesizer.
- Designed to be conform to EN 300 220-1 requirements.
- Supports FSK (data rates 0...32 kb/s) or ASK modulation (data rates 0...20kb/s)
- No data synchronization for FSK or ASK needed.
- Supports clock and reset signals for the external μ C.
- Supports different power down modes, one without any running XTAL oscillator.
- Wide supply range between 2.7 V to 5 V.
- Only one XTAL and very few external elements required.
- Wide operating temperature range from -40 C to $+85$ C.
- Low TX current, typical 7 mA.

General Description

The AS3901 is a low power FSK/ (ASK) transmitter intended for the European 433 MHz and the US 315 MHz ISM band application. It uses a PLL stabilized oscillator which avoids frequency pulling by approaching the antenna with objects as it occurs at SAW resonator based transmitters.

FSK modulation is performed by an I/Q-based continuous phase FSK modulator with a well defined frequency deviation of 16 kHz. The FSK modulator is operating completely asynchronous to the TX data stream and therefore needs no data clock or other possible by switching the driving amplifier and FSK modulator on and off by an applied transmit data stream.

The μ C clock frequency and the FSK frequency deviation can be kept almost constant for both frequency bands by selecting the correct scaling factors by the 433/315 pin. As external components the AS3901 needs only a reference XTAL and 5 capacitors.



Applications

- Short range radio data transmission.
- Remote keyless entry systems.
- Security applications and alarm systems.
- Domestic and consumer remote control units.
- Remote metering.
- Low power telemetry.

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1 Functional Description

The AS3901 consists of a reference XTAL oscillator, a single channel RF- synthesizer, an I/Q based asynchronous continuous phase FSK modulator, a driving amplifier and a μ C interface, including μ C clock divider, and a power management circuitry.

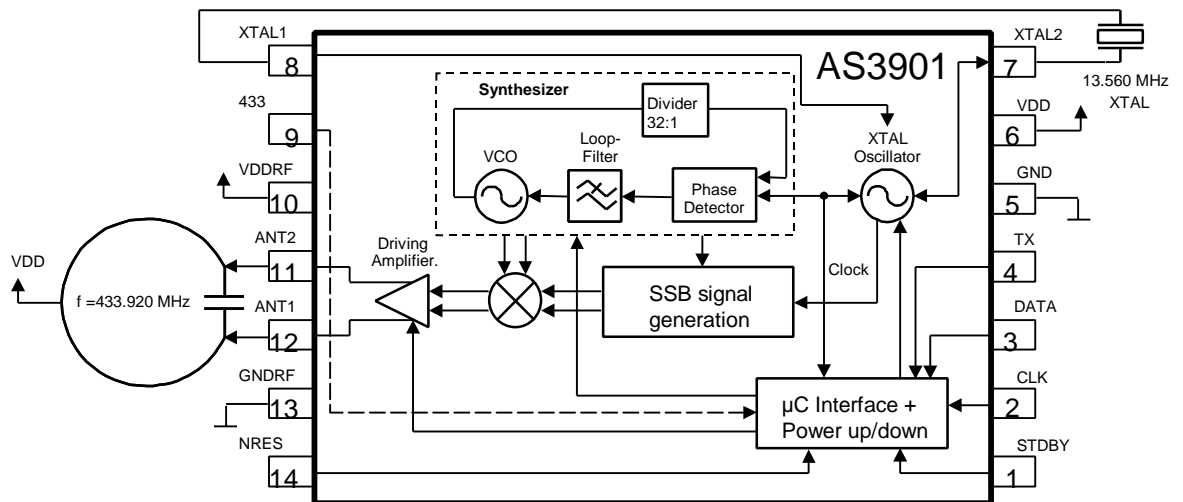


Figure 1: Block diagram of the AS3901.

1.1 RF Synthesizer

The RF synthesizer is a fully integrated single channel device with internal loop filter, generating the 433 MHz or 315 MHz transmit carrier frequency f_{RF} by a fix, 32 times, multiplication of the reference XTAL frequency f_{XTAL} .

1.2 Microprocessor Clock

The microprocesor clock frequency f_{CLK} is generated by dividing the XTAL frequency f_{XTAL} by 3 or 4, dependent on the 433/315 MHz selection pin to keep the μ C clock frequency f_{CLK} almost constant for European and US applications.

1.3 Modulation

The FSK modulator is an I/Q modulator based continuous phase FSK modulator. The modulating NRZ data may be in the range of 0 up to 32 kbit/s. The FSK frequency deviation Δf is ≈ 16 kHz, independent of the data rate. It is also kept almost constant for both transmit frequency bands by selecting proper frequency deviation multiplication factors of the XTAL reference frequency by the 433/315 MHz selection pin.

The processing clock of the data source can be different from the AS3901 reference XTAL or μ C clock f_{CLK} and no data synchronization of the FSK modulator is required.

1.4 Driving Amplifier

The driving amplifier has a differential open collector output optimized for driving of small, symmetrical high-impedance loop antennas. The amplifier drives a nominal RF current of 0.7 mA_{rms}. The maximal differential voltage swing is about 4 V_{PP}. Therefore the output power is a function of the connected load impedance. With a 2 kΩ differential load a nominal peak output power (to the antenna) of ≈1 mW is obtained. Please note that the finally radiated power (from antenna) is lower and strongly dependent on the efficiency (function of the size) of the antenna to be used.

1.5 ASK Modulation

ASK modulation with a data rate up to 20 kbits/s can be achieved by turning the driving amplifier and the FSK modulator by the TX/ASK pin on and off, where a TX/ASK = „H“ means a turned on state.

1.6 Power Management and Operation Modes

For normal operation the switching between different operation modes follows a Grey-coded scheme to avoid unwanted switching between operation modes due to inaccurate occurrence of edges of STDBY and TX/ASK.

Mode	STDBY	TX/ASK	Function
Standby	1	1	All Off
Clock generator operation	1	0	XTAL oscillator on and CLOCK output active.
Transmit operation	0	1	XTAL oscillator, PLL, FSK modulator running, (FSK operation or „H“ transmitted at ASK).
Turned off power	0	0	XTAL oscillator and PLL running, output amplifier and FSK modulator off, („L“ transmitted at ASK).

1.7 μC Interface and Timing

The AS3901 contains a direct interface to a microcontroller (μC). The μC interface of the AS3901 consists of three input and two outputs pins:

- „Standby input“ (STDBY).
- „Transmit / ASK input“ (TX/ASK).
- „μC reset output (Active „L“)“ (NRES).
- „μC clock output“ (CLK).
- „FSK data input“ (DATA).

These lines support the μC with the required reset, clock and data signals. Lines 1 to 4 control the AS3901 internal power on/off circuit which wakes up and shuts down the whole transmitter consisting of the AS3901 and the μC.

Figure 2 shows a typical interconnection of the AS3901 with a typical μC. Figure 3 presents a related timing for power up and down of the transmitter.

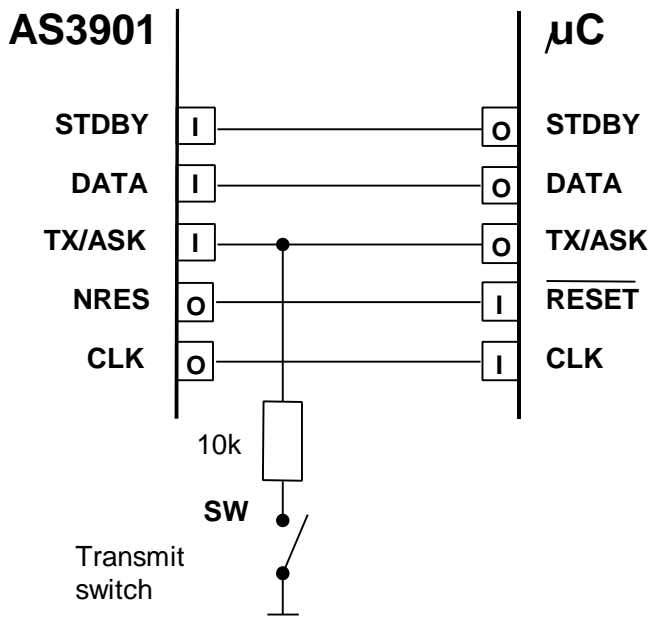


Figure 2: Interconnection of the AS3901 with a typical µC.

Note: At room temperature, resistor values of $\approx 10\text{ k}\Omega$ are suggested for the µC interface. For other temperatures to be calculated from figure 5.

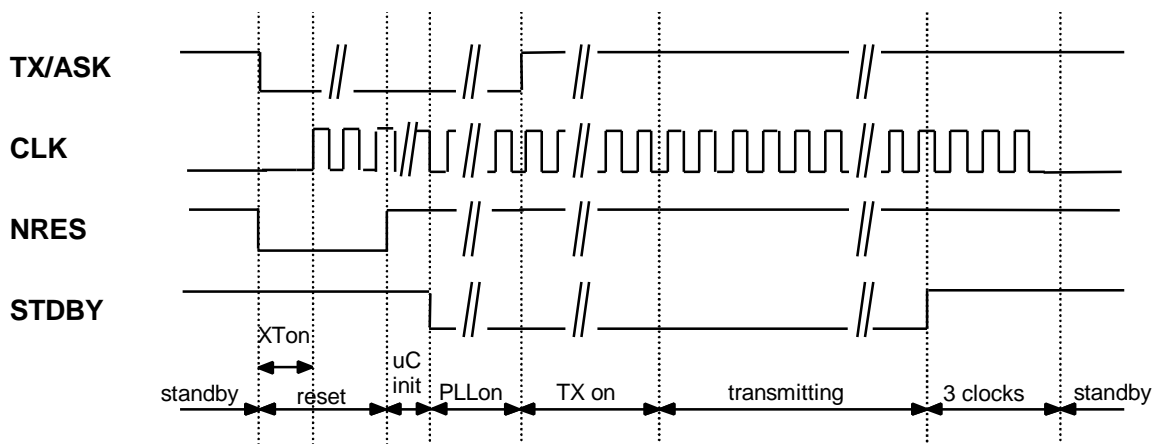


Figure 3: µC interface timing for a transmission cycle.

Note: Activating the transmit switch results in a „weak L state“ at TX/ASK. It can be overridden by the microcontroller so that the transmission cycle remains unaffected by the duration the switch is pressed. The STDBY and TX/ASK inputs have internal pullup resistors of $\sim 100\text{ k}\Omega$

1.7.1 Interface Description

Wake-up sequence:

TX/ASK=H, STDBY=H: Standby. All off low current state.

TX/ASK→L, STDBY=H; → XTAL oscillator starts up. NRES goes L, resetting (starting) the μC for t_{XTON} plus 3 clock cycles.

NRES returns to H, μC initializes.

After μC is initialized, it sets STDBY→L; PLL is turned on, after t_{PLLon} a stable RF carrier is generated.

TX/ASK→H, STDBY=L; →TX is turned on, t_{TXON} later the RF signal is available and data can be transmitted.

To switch the AS3901 „on“ a „push button“ with series resistance $\sim 10\text{-}20\text{ k}\Omega$ can be used to make TX/ASK = „L“. The „push-button“ must be pushed long enough (typ. $> 3\text{ms}$) for the μC to reset and sustain the TX/ASK „L“ state.

Standby procedure (for sleep-mode ($I_{\text{DD1}} < 1\mu\text{A}$):

The μC outputs a „H“ to TX/ASK and STDBY. After minimal 3 CLK cycles the XTAL oscillator will be switched off. The pull-up resistors at the AS3901 TX/ASK and STDBY inputs will sustain the sleep mode.

Note: Multiple „push buttons“ for different functions can be used.

2 Electrical Characteristics

2.1 Absolute Maximum Ratings (non operating)

Symbol	Parameter	Min	Max	Units	Note
VDD	Positive supply voltage	-0.5	7	V	
GND	Negative supply voltage	0	0	V	
V _{IN}	Voltage on input pins	-0.5	VDD+0.5	V	
ESD	Electrostatic discharge		1000	V	1)
T _{STG}	Storage temperature	-55	125	°C	
T _{LEAD}	Lead temperature		260	°C	2)

Note:

- 1) HBM: R = 1.5 kΩ, C = 100 pF. The pins ANT1, ANT2, XTAL1 and XTAL2 have 500 V ESD protection.
- 2) 260°C for 10 s (reflow and wave soldering), 360 °C for 3 s (manual soldering).

2.2 Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit	Note
VDD	Positive supply voltage	2.7	3.0	5.0	V	
GND	Negative supply voltage	0	0	0	V	
IDD1	Supply current, STDBY = "H", TX/ASK = "H"			1	μA	1)
IDD2	Supply current, STDBY = "H", TX/ASK = "L"		350	850	μA	2)
IDD3	Supply current, STDBY = "L", TX/ASK = "H"		7	9	mA	3)
IDD4	Supply current, STDBY = "L", TX/ASK = "L"		3.5	4.5	mA	4)
T _{AMB}	Ambient temperature range	-40		+85	°C	

Note:

- 1) Standby: T_{AMB} = 23 °C, Synthesizer and driving amplifier are turned off.
- 2) Clock generator operation: T_{AMB} = 23 °C XTAL oscillator and μC clock divider on. RF driving amplifier and PLL off, no external load connected to CLK pin.
- 3) Transmit operation: T_{AMB} = 23 °C, Synthesizer and driving amplifier are turned on.
- 4) Turned off TX power: T_{AMB} = 23 °C, XTAL oscillator and μC clock divider and PLL on RF driving amplifier off.

2.3 Transmit Operation

$T_{AMB} = 23\text{ °C}$, $VDD = 3.0\text{ V}$, unless specified otherwise.

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Note
$f_{RF, EU}$	Transmit frequency (Europe)	$f_{XTAL} = 13.560\text{ MHz}$		433.920		MHz	1)
$f_{RF, US}$	Transmit frequency (US)	$f_{XTAL} = 9.84375\text{ MHz}$		315.000		MHz	1)
f_{offset}	Frequency tolerance	After t_{TXON} , no XTAL tolerance.			2	kHz	
$f_{CLK, EU}$	μC clock frequency (Europe)	$f_{XTAL} = 13.560\text{ MHz}$		3.390		MHz	
$f_{CLK, US}$	μC clock frequency (US)	$f_{XTAL} = 9.84375\text{ MHz}$		3.28125		MHz	
t_{TXon}	Transmitter turn on time	FSK modulator and driver amplifier		20		μs	
t_{PLLon}	PLL turn on time			t.b.d.		ms	
T_{XTon}	XTAL oscillator turn on time			5		ms	

Note:

- 1) XTAL tolerances will slightly change the typical transmit frequency.

2.3.1 ASK Operation

$T_{AMB} = 23\text{ °C}$, $VDD = 3.0\text{ V}$, unless specified otherwise.

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Note
$P_{OUT,H}$	Available peak output power	In $2\text{ k}\Omega$, STDBY = "L", TX/ASK = "H"	-1.5	0	1.5	dB_m	1) 3)
$P_{OUT,L}$	Leakage peak output power	In $2\text{ k}\Omega$, STDBY = "L", TX/ASK = "L"			-50	dB_m	
$P_{OUT\ 3rd}$	Radiated third harmonic output power	Antenna attenuation > 20 dB			-39	dB_m	2)
P_{SP}	Spurious power	In distance of f_{CLK} or f_{XTAL} from carrier. No antenna selectivity assumed.		-45	-25	dB_C	2) 3)
R_{ASK}	ASK data rate range	For a RF packet duty cycle $\geq 25\%$.	0		20	Kb/s	

Note:

- 1) Output power depends on load impedance, differential output current is typical 0.7 mA_{rms} . Maximum differential voltage swing is typical 4 V_{PP} .
- 2) Measurement bandwidth (close to EN 300 220-1) see also figure 10.
- 3) Actual E.R.P. depends on antenna efficiency

2.3.2 FSK Operation

T_{AMB} = 23 °C, VDD = 3.0 V, unless specified otherwise.

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Note
P _{OUT,FSK}	Available peak output power	In 2 kΩ, STDBY = "L", TX/ASK = "H"	-1.5	0	1.5	dB _m	1) 3)
P _{OUT 3rd}	Radiated third harmonic output power	Antenna and band pass filter attenuation > 20 dB			-36	dB _m	2)
P _{SP}	Spurious power	In distance of f _{CLK} or f _{XTAL} from carrier. No antenna selectivity assumed.		-45	-25	dB _C	2) 3)
R _{FSK}	FSK data rate range		0		32	kb/s	4)
Δf	FSK frequency deviation			16		kHz	

Note:

- 1) Output power depends on load impedance, differential output current is typical 0.7 mA_{ms}. Maximum differential voltage swing is typical 4 V_{PP}.
- 2) Measurement bandwidth (close to EN 300 220-1) see also figure 10.
- 3) Actual E.R.P. depends on antenna efficiency
- 4) Guaranteed by design

2.4 Digital Pin Characteristics

$T_{AMB} = 23\text{ }^{\circ}\text{C}$, $V_{DD} = 3.0\text{ V}$, unless specified otherwise. GND is the 0 V reference.

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Note
CLK (μC clock output)							
VOH	High level output voltage	$I_{OH} = -1\text{ mA}$	VDD-0.7	-	VDD	V	
VOL	Low level output voltage	$I_{OL} = 1\text{ mA}$	GND	-	1.2	V	
tr	Rise time	$C_{Load} = 10\text{ pF}$		20		ns	
td	Fall time	$C_{Load} = 10\text{ pF}$		20		ns	
jcc	Cycle to cycle jitter				+/-5	%	1)
NRES (Inverted reset output)							
VOH	High level output voltage	$I_{OH} = -1\text{ mA}$	VDD-0.3	-	VDD	V	
VOL	Low level output voltage	$I_{OL} = 1\text{ mA}$	GND	-	0.2	V	
tr	Rise time	$C_{Load} = 10\text{ pF}$		20		ns	
td	Fall time	$C_{Load} = 10\text{ pF}$		20		ns	
TX/ASK (Driving amplifier and FSK modulator on/off (ASK) input)							
VIH	High level input voltage		VDD-0.5	-	VDD	V	
VIL	Low level input voltage		GND	-	0.3	V	
IIH	High level input current	$V_{IH} = V_{DD}$			1		
IIL	Low level input current	$V_{IL} = 0\text{ V}$. internal pull-up	-40			μA	
DATA (FSK data input)							
VIH	High level input voltage		VDD-0.5	-	VDD	V	
VIL	Low level input voltage		GND	-	0.3	V	
IIH	High level input current	$V_{IH} = V_{DD}$			1	μA	
IIL	Low level input current	$V_{IL} = 0\text{ V}$	-1			μA	

433/315 (Band selection (division ratio))

VIH	High level input voltage		VDD-0.5	-	VDD	V	
VIL	Low level input voltage		GND	-	0.3	V	
IIH	High level input current	VIH = VDD			1	μA	
IIL	Low level input current	VIL = 0 V.	-1			μA	

STANDBY (Standby input)

VIH	High level input voltage		VDD-0.5		VDD	V	
VIL	Low level input voltage		GND	-	0.3	V	
IIH	High level input current	VIH = VDD			1	μA	
1IIL	Low level input current	VIL = 0 V. internal pull-up	-40			μA	

Notes

1) Guaranteed by design

3 Pin-out Information

Pin #	Pin Name	Input / Output	Description
1	STDBY	Dig. Input, 100 k Ω pull up	Power down for all functions
2	CLK	Dig. Output	Clock output (CMOS level)
3	DATA	Dig. Input	Transmit data input (CMOS level)
4	TX/ASK on/off ASK	Dig. Input, 100 k Ω pull up	Power off for TX (PLL and XTAL working) ASK modulation
5	GND	Power	Ground
6	VDD	Power	Positive supply (2.7 V-5.0 V)
7	XTAL2	Analog	XTAL pin2
8	XTAL1	Analog	XTAL pin1
9	433/315	Dig. Input	Selects division factors for constant μ C Clock frequency and deviation
10	VDDRF	Power	Positive supply (2.7 V-5.0 V)
11	ANT2	Analog open collector output	To loop antenna
12	ANT1	Analog open collector output	To loop antenna
13	GNDRF	Power	Ground
14	NRESET	Dig. Output	Reset, „L“ state resets a microcontroller

4 Application Schematic

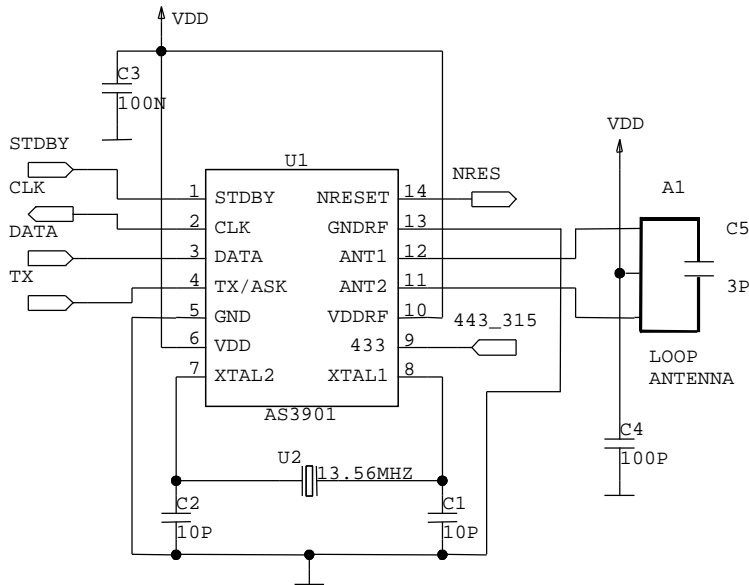


Figure 4: Basic application schematic of the AS3901.

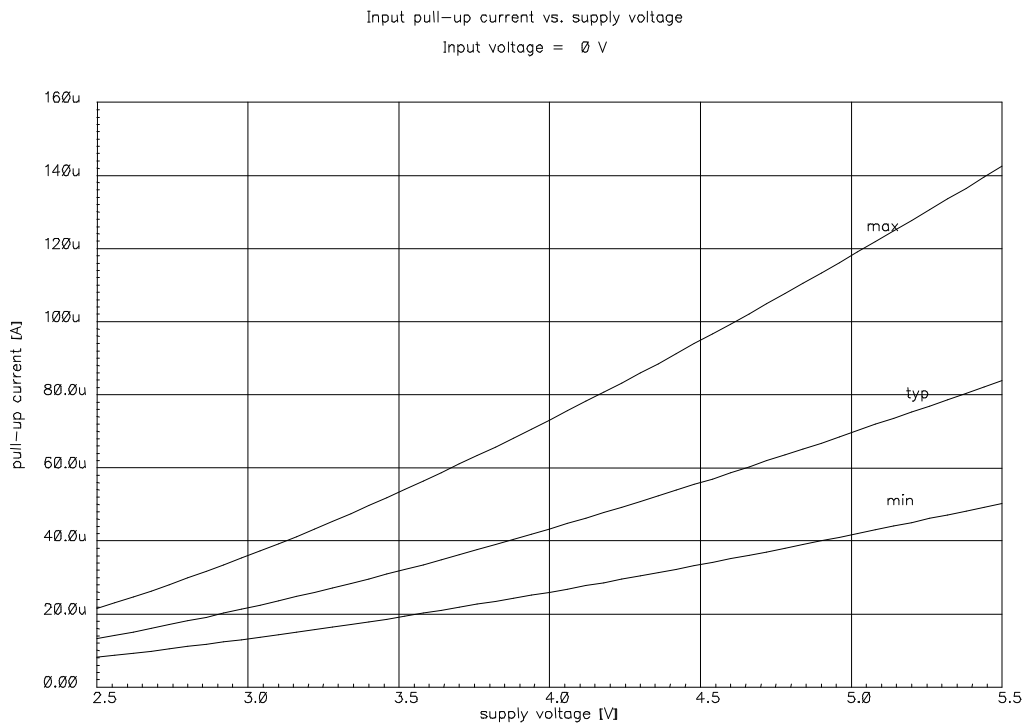


Figure 5: Pull Up characteristics for the TX/ASK pin.

5 Typical Measurements

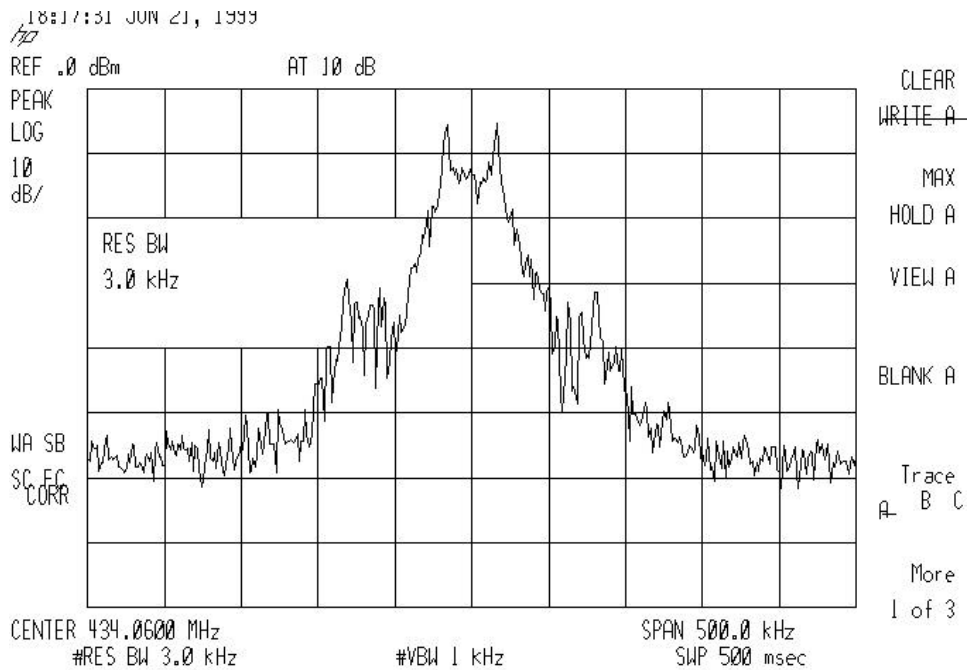


Figure 6: Narrow band output spectrum of the AS3901 FSK modulated with pseudo random data at 32 kbit/s.

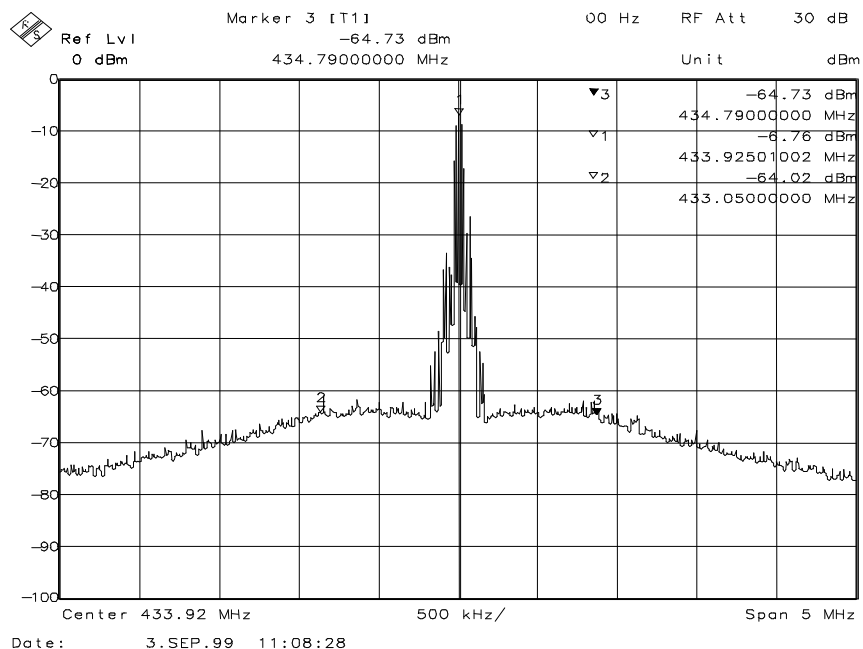


Figure 7: Modulation bandwidth of the AS3901 in FSK operation at 32.6 kbit/s, measured close to the EN 300-220-1 recommendation for wide-band equipment, clause 8.6. Instead of 5 kHz video bandwidth (VBW) 10 kHz was used. The markers were set up to the band edges. (433.050 MHz, 434.790 MHz) The recommendation says that the spectrum should be observed at least 1MHz from the ISM band edges, but it was measured with larger frequency span.

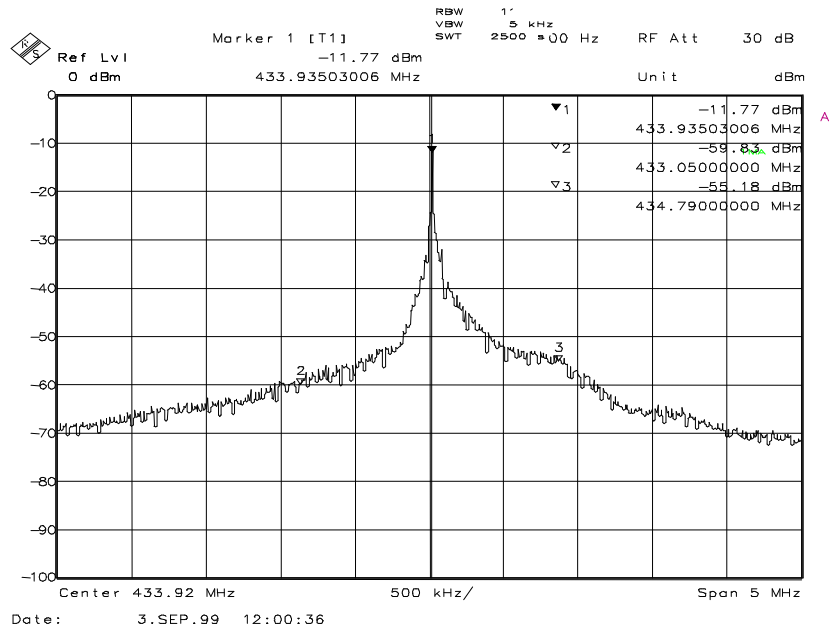


Figure 8: Modulation bandwidth of the AS3901 in AKS operation at 9.2 kbit/s, measured close to the EN 300-220-1 recommendation for wide-band equipment, clause 8.6. Instead of 5 kHz video bandwidth (VBW) 10 kHz was used. The markers were set up to the band edges. (433.050 MHz, 434.790 MHz) The recommendation says that the spectrum should be observed at least 1 MHz from the ISM band edges, but it was measured with larger frequency span.

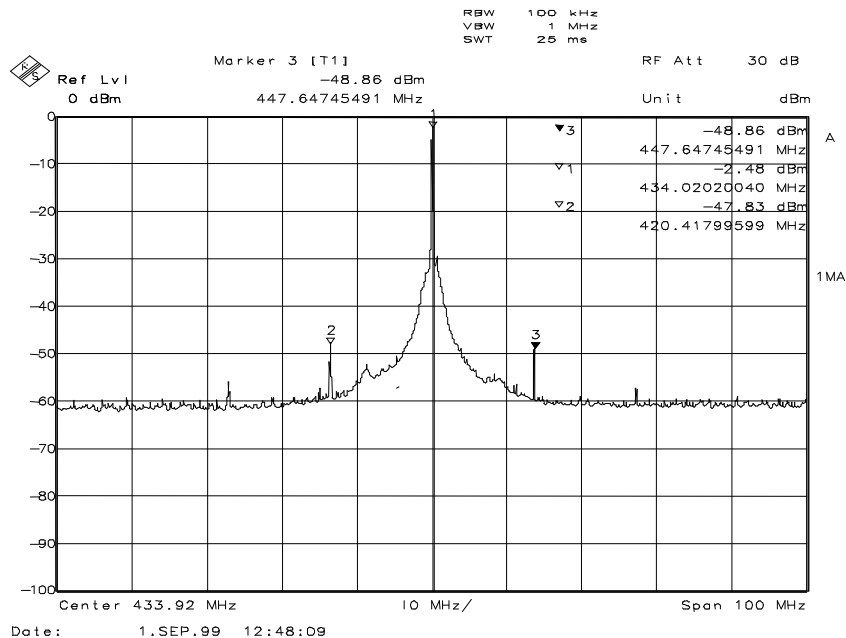


Figure 9: Spurious emissions of the AS3901 in FSK operation, measured close to the EN 300-220-1 Recommendation for wide-band equipment, clause 8.7, without modulation. (Only difference: 100 kHz RBW was used instead of 120 kHz). From the measurement it can be seen that the main critical spurious emission is generated by the 13.56 MHz clock frequency. The level of CLK spurious is near -48 dBm so the suppression is 45 dB for this component.

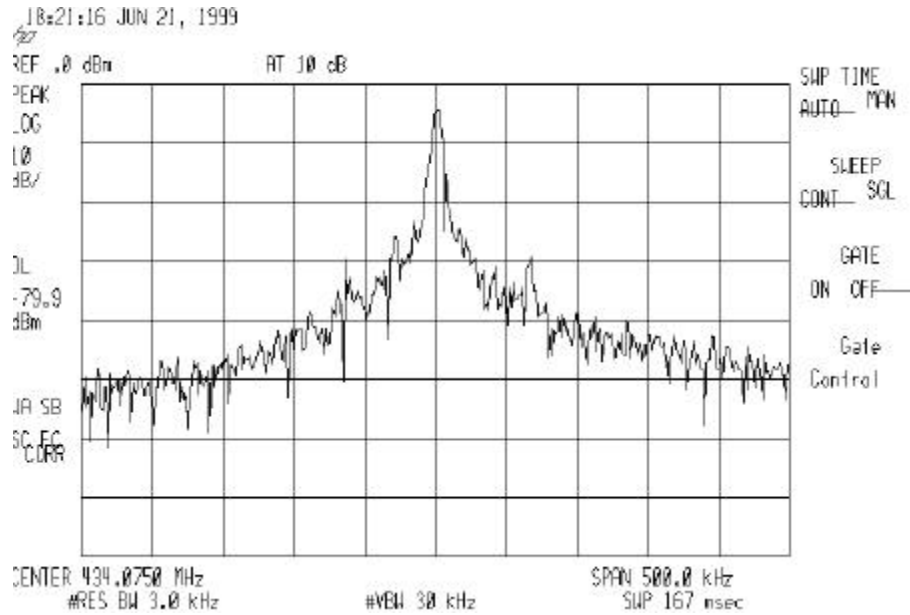


Figure 10: Typical out spectrum in ASK 9.2 kb/s PRN modulation.

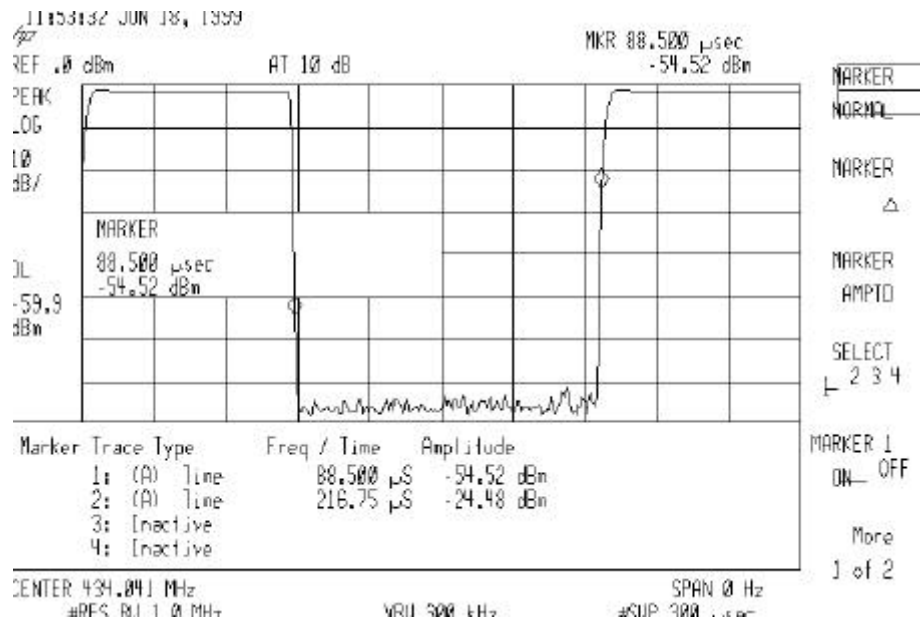


Figure 11: Transmission power as function of time at ASK modulation with an 9.2 kbit/s 0101.. data pattern.

6 Package Information

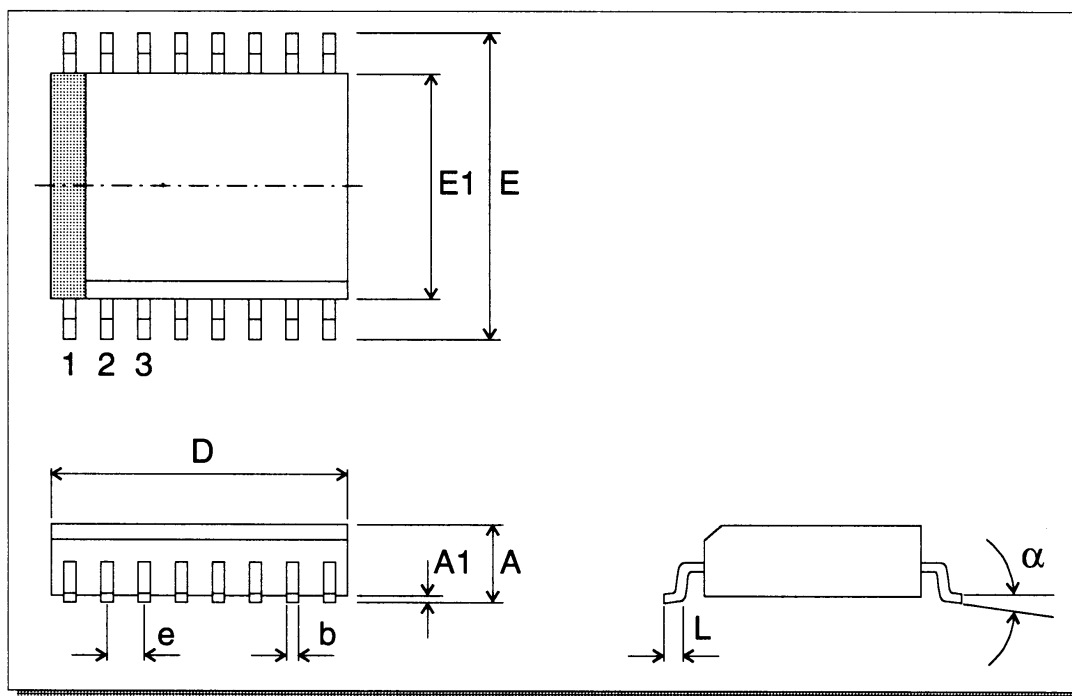


Figure 12: Physical dimensions of TSSOP-14.

Symbol	Common Dimensions		
	Minimal (mm)	Nominal (mm)	Maximal (mm)
A	-	-	1.20
A1	0.05	-	0.15
b	0.19	-	0.30
D	4.90	-	5.10
e	0.65 BSC		
E	-	6.40	-
E1	4.30	-	4.50
L	0.45	-	0.75
α	0°	-	8°

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