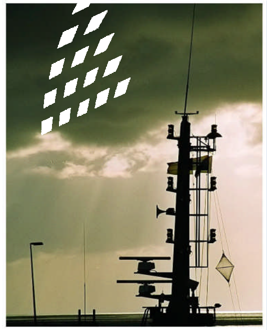
AXSEM

AXSEM

The wireless company!



Trends in ISM bands

06/2010

Thom‘s Bio

- Born, school, matura in Hamburg
- National service in the German navy as radio technician
- Diploma studies of physics at the University of Hamburg
- PhD studies at ETH in R. Eichlers research team (PSI)
- Development manager at Martignoni Electronics ZH
- Improvement of communication skills Cambridge UK
- Philips Semiconductors ZH
  - Analog design engineer for BB and audio interfaces
  - Project manager for BB and audio interfaces
  - Development manager for GSM BB and audio chip sets.
- Founding e-vision/*AXSEM Dübendorf on the idea of CMOS-RF*
  - Focus on company management and sales (hate marketing)
  - First 6 years as design service company / last 4.5 years fab-less semi-con
- Growing AXSEM to be one of the largest suppliers of sub 1G ISM IC

AXSEM Introduction

We are…

A fab-less semiconductor manufacturer with in-house test facility

Wafer production China and Taiwan

In house test capacity ~2.5 m IC/month

Expanding in house to 5m IC/month at the moment

Fully privately owned, not VC based, founded in 2000

What do we do?

We develop, produce and market: high performance, low cost RF ICs

Focused on high volume markets

What are ISM bands?

The industrial, scientific and medical (ISM) radio bands were originally reserved internationally for the use of RF electromagnetic fields for industrial, scientific and medical purposes other than communications. In general, communications equipment must accept any interference generated by ISM equipment.

The ISM bands are defined by the ITU-R in 5.138, 5.150, and 5.280 (International Telecommunication Union, body of the United Nations) of the Radio Regulations. Individual countries' use of the bands designated in these sections may differ due to variations in national radio regulations. **Because communication devices using the ISM bands must tolerate any interference from ISM equipment, these bands are typically given over to uses intended for unlicensed operation, since unlicensed operation typically needs to be tolerant of interference from other devices anyway.** In the United States of America, uses of the ISM bands are governed by Part 18 of the FCC rules, while Part 15 Subpart B contains the rules for unlicensed communication devices, even those that use the ISM frequencies. Part 18 ISM rules prohibit using ISM for communications.

Source Wikipedia

ISM frequencies

Start frequency [MHz]	End frequency [MHz]		Availability
6.77	6.80	A	SRD
13'553.00	13.57	B	SRD
26.96	27.28	B	SRD
40.66	40.70	B	SRD
433.05	434.79	A	SRD, Region 1 only (Europe, Africa)
868.00	870.00	A	SRD, Region 1 only (Europe, Africa)
902.00	928.00	B	Region 2 only (North and South America)
2'400.00	2'500.00	B	
5'725.00	5'875.00	B	
24'000.00	24'250.00	B	
61'000.00	61'500.00	A	Subject to local acceptance
122'000.00	123'000.00	A	Subject to local acceptance
244'000.00	246'000.00	A	Subject to local acceptance
			A = License required
			B = License free

Source Wikipedia

Available Global Frequencies

Range of RF systems

What are the dominant factors?

- Maximum output power of transmitter
- Sensitivity of receiver
- Selectivity of the receiver
- Frequency used
- Interference with other RF system
- Pass loss
- Antenna gain

Range estimation at the example of AX5042 transceiver

AX5042	Module 7.3				Line of sight 1)	Plane Earth: Egli model 2)	Plane Earth: Hata model urban 3)	Plane Earth: Hata model sub urban 4)	Plane Earth: Hata model open country 5)
Modulation	**Datarate**	**Sensitivity**	**TX power**	**F [MHz]**	**d [m]**	**d [m]**	**d [m]**	**d [m]**	**d [m]**
ASK	1.2	-113	10	868.0	38590	1783	332	1093	1474
ASK	**10**	**-109**	**10**	**868.0**	**24349**	**1416**	**269**	**886**	**1195**
ASK	100	-99	10	868.0	7700	796	159	523	706
ASK	600	-91	10	868.0	3065	502	104	344	463
FSK	1.2	-121	10	868.0	96935	2825	505	1666	2246
FSK	**10**	**-114**	**10**	**868.0**	**43299**	**1888**	**350**	**1152**	**1554**
FSK	100	-104	10	868.0	13692	1062	207	681	918
FSK	200	-98	10	868.0	6862	752	151	497	670
PSK	2	-120	10	868.0	86393	2667	479	1580	2131
PSK	**10**	**-118**	**10**	**868.0**	**68625**	**2377**	**431**	**1422**	**1918**
PSK	100	-107	10	868.0	19341	1262	242	797	1075
PSK	600	-99	10	868.0	7700	796	159	523	706

1.5 m above ground for TX and RX

No noise of interferers is taken into account

Range of different systems in different markets

AXSEM

	Modulation	Datarate	Sensitivity	TX power	F [MHz]	Line of sight 1)	Plane Earth: Egli model 2)	Plane Earth: Hata model urban 3)	Plane Earth: Hata model sub urban 4)	Plane Earth: Hata model open country 5)
						d [m]	d [m]	d [m]	d [m]	d [m]
RKE/GDO	FSK	1.2	-123	0	433.0	77359	1189	426	1147	1603
Meter reading long range	**4-FSK**	**4.8**	**-118**	**30**	**433.0**	**1375663**	**35439**	**8722**	**32414**	**50562**
RKE/GDO	**FSK**	**10**	**-116**	**10**	**433.0**	**109273**	**1413**	**497**	**1337**	**1870**
	FSK	100	-106	0	433.0	10927	447	178	480	671
	PSK	600	-101	0	433.0	6145	335	138	371	519
Modules	FSK	1.2	-121	0	868.0	30654	1059	255	814	1090
Sensors	**FSK**	**10**	**-114**	**0**	**868.0**	**13692**	**708**	**178**	**569**	**761**
Sensors	FSK	100	-104	10	868.0	13692	708	178	569	761
Zigbee 900	**PSK**	**600**	**-95**	**10**	**868.0**	**4858**	**422**	**112**	**358**	**480**
	FSK	2	-115	10	2450.0	17212	1334	169	724	953
	FSK	**10**	**-108**	**10**	**2450.0**	**7688**	**891**	**118**	**506**	**665**
	FSK	100	-102	10	2450.0	3853	631	87	372	489
ZigBee 2.4G	**PSK**	**2000**	**-90**	**10**	**2450.0**	**968**	**316**	**47**	**201**	**264**
BlueTooth	PSK	2000	-90	0	2450.0	306	178	28	120	158
WLAN	PSK	2000	-90	24	2450.0	4851	708	96	412	542

1.5 m above ground for TX and RX
Except for metering long range. 30 m and 1.5 m for that case.

No noise of interferers is taken into account

Different Antennas

What are typical antennas and gains?

- Dish: 20 dBi
- Yagi Uda: 10 dBi
- Dipole/folded dipole/monopole $\lambda/4$: 2 dBi
- Helical: 0 dBi
- Chip -5 dBi
- Small helical: -5 dBi
- Small loop: -10 dBi

						Plane Earth			
					Line of sight 1)	Egli model 2)	Hata model urban 3)	Hata model sub urban 4)	Hata model open country 5)
Modulation	Datarate	Sensitivity	TX power + Ant Gain	F [MHz]	d [m]	d [m]	d [m]	d [m]	d [m]
FSK	10	-114	-30	868.0	433	189	43	140	189
FSK	10	-114	-20	868.0	1369	336	72	238	321
FSK	10	-114	-10	868.0	4330	597	122	402	542
FSK	**10**	**-114**	**0**	**868.0**	**13692**	**1062**	**207**	**681**	**918**
FSK	10	-114	10	868.0	43299	1888	350	1152	1554
FSK	10	-114	20	868.0	136924	3358	592	1951	2630
PSK	2000	-90	-30	2450.0	10	*47*	6	*29*	*38*
PSK	2000	-90	-20	2450.0	31	*84*	11	*49*	*65*
PSK	2000	-90	-10	2450.0	97	150	19	83	110
PSK	**2000**	**-90**	**0**	**2450.0**	**306**	**267**	**31**	**140**	**186**
PSK	2000	-90	10	2450.0	968	474	53	237	314
PSK	2000	-90	20	2450.0	3061	844	90	401	532

RF Absorbtion

What is the absorbtion of materials

- Plasterboard wall 3dB
- Glass wall with metal frame 6dB
- Office window 3dB
- Single house window 6 dB
- Double glas window 12-20 dB
- Metal door 6dB
- Metal door in brick wall 15 dB

							Plane Earth			
						Line of sight 1)	Egli model 2)	Hata model urban 3)	Hata model sub urban 4)	Hata model open country 5)
	Modulation	Datarate	Sensitivity	TX power + Ant Gain + Loss	F [MHz]	d [m]	d [m]	d [m]	d [m]	d [m]
Outdoors	FSK	10	-114	10	868.0	43299	1888	350	1152	1554
1 wall	FSK	10	-114	-5	868.0	7700	796	159	523	706
2 walls	**FSK**	**10**	**-114**	**-20**	**868.0**	**1369**	**336**	**72**	**238**	**321**
3 walls	FSK	10	-114	-35	868.0	243	142	33	108	146
4 walls	FSK	10	-114	-50	868.0	43	60	15	49	66
5 walls	FSK	10	-114	-65	868.0	8	25	7	22	30
Outdoors	FSK	2000	-90	10	2450.0	968	474	53	237	314
1 wall	FSK	2000	-90	-5	2450.0	172	200	24	108	143
2 walls	**FSK**	**2000**	**-90**	**-20**	**2450.0**	**31**	**84**	**11**	**49**	**65**
3 walls	FSK	2000	-90	-35	2450.0	5	36	5	22	29
4 walls	FSK	2000	-90	-50	2450.0	1	15	2	10	13
5 walls	FSK	2000	-90	-65	2450.0	0	6	1	5	6

Selectivity helps

What is the selectivity of receiver?

- **The capability of rejecting unwanted signals in the neighborhood of the channel.**
- **What happens is that the receiver integrates over a smaller bandwidth**

- **Narrow-band devices 6.25 kHz, 12.5 kHz and 25 kHz channel filter (**This requires a TCXO in general**)**
- **General purpose devices use typical 150 kHz or larger (**This works easy with a XTAL**)**
- **We define the cross over at 40 kHz**

- **Selectivity does not help for in channel emissions from interferers !!!**

Regulators start forcing spectral efficiency !!!

What does that mean?

- There is trend that a given channel bandwidth has to be filled with a certain data rate. E.g. 4.8 kbps in a 6.25 kHz channel not violating a spectral mask (FCC)

- Spectral masks for transmitter become stricter

What are the consequences?

- Narrow-band will become more popular for low data rate applications
- Higher modulation types have to be used

Power consumption

Integrated transmitter have at the moment about 20-50% PAE, the rest is physics. For a 10 mW transmitter the typical demand is 40 mW + offset of PLL = 55 mW, resulting in 30 mA. The PAE for low power is typically worse than for higher power.

Receivers work duty cycled with typical average RX currents of less than 10µA. As an example AX5051 with 1s DC and 100 kbps takes 5µA including a PIC16F886 micro controller.

Integration

Is there a trend to integrate a MCU with RF

- For high end systems it is very difficult without performance loss
- Every customer needs a different MCU, different requirements in memory (FLASH, RAM, EEPROM) and peripherals (e.g. LCD driver, low power features)

Therefore

- For simpler system I'd expect to see some integration and also for space constraint systems.

Conclusions

- ISM gets crowded!
- 2.4 GHz is heavily loaded though 100 (54) MHz BW
- 868/915 MHz load is increasing
- 433 MHz becomes needs big antennas
- Range always matters

Thanks !!!