# A COMPACT SDH/SUPERPDH ODU PLATFORM

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Abstract: A new family of OutDoor Units (ODU) for point to point radio links in the 6 to 38 GHz microwave bands has been designed, able to transport high digital rates with high complexity modulation formats, up to 2+2xSTM-1in polarization diversity on a 55 MHz radio channel. Besides their natural use in SDH systems, a challenging target for the new outdoor units is their use in "Super PDH systems ": low data rates with modulation formats up to 128 TCM. The paper will deal with a short description of main targets for the design of the new ODU Platform and with a detailed analysis of 7 and 8 GHz band transceivers, already developed. A short description of 18 GHz band transceiver will be also given as an example of upper band transceivers. 

## 1. DESIGN TARGETS AND TECHNICAL SOLUTIONS FOR THE NEW ODU PLATFORM

The aim for this next generation of digital microwave radio transceivers is to match the market and the manufacturing requirements in terms of performances, reliability and easiness of assembly and testing.

Next generation ODU have to be fully compatible with existing indoor units and must guarantee the same, or a better, link budget which is guaranteed by present generation systems (ref.1). They must satisfy the requirements for all system types, including hot stand-by protected systems and co-channel systems. Their use as Super PDH transceivers asks for good phase noise local oscillators, well insensitive to mechanical vibrations and thermal variations.

The key solution is a single board design approach: the microwave transceiver, the intermediate frequency parts, the RF and IF VCOs, the cable interface and the microcontroller are housed on the same PC board. Only the power supply is housed on a second PC board and is placed under the main RF/IF unit, in good thermal contact with the heat sink .

This leads to a simple mechanical design which can be optimized for light weight and good heat dissipation performances. It has also a positive impact on the mounting and test times. Two different sized mechanics have been designed: one larger for 7 to 13 GHz bands and one smaller for the upper bands transceivers.

The availability of packaged MMIC devices for all microwave frequencies allows the use of standard SMT processes for assembly and reduces costs and lead time.

The power supply unit specifications have been conceived to satisfy the requirements for all transceivers of the family, from 6 to 38 GHz bands.

## 2. DESCRIPTION OF 7 AND 8 GHZ BAND OUTDOOR UNITS

The two transceivers which have been developed for 7 & 8 GHz bands are fully realized on a standard lead free compatible 8 layers 1.8 mm thick PCB. They cover from 7.1 to 7.9 GHz (7 GHz version) and from 7.7 to 8.5 GHz for the (8 GHz version), without changing anything more than the diplexer filters.

Their main performances are resumed in Table 1 and a simplified transceiver block diagram is shown in Fig. 1.

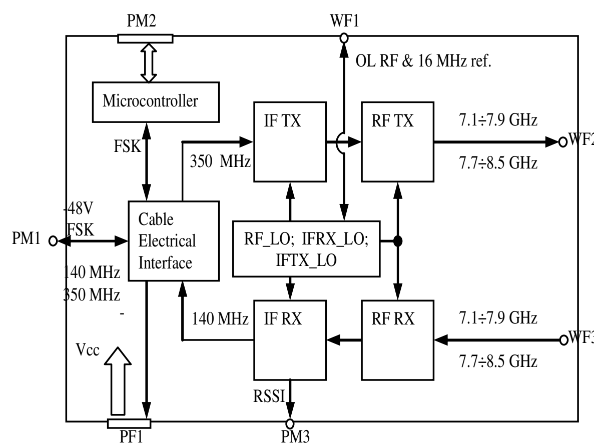


Fig. 1. Simplified 7&8 GHz transceivers block diagram

The ODU is connected to indoor unit by means of a coaxial cable which carries the transmitter and receiver intermediate frequencies (respectively 350 MHz and 140 MHz), a FSK up-down telemetry channel for remote control and the battery voltage (PM1connector in the block diagram).

Table 1 : 7&8 GHz ODU main electrical parameters.

| | |
|---|---|
| Frequency range (GHz) | 7.1÷ 7.9 / 7.7÷8.5 GHz |
| Nominal Transmitted output power | 23 dBm |
| Transmitter output power control range | 15 dB |
| Nominal Receiver noise figure | 5 dB |

One solution, which contributes to reduce costs, is the use of a single synthesized 10GHz VCO, common to receiver and transmitter sides and based on a plastic packaged HBT VCO. The transmitter second intermediate frequency is fixed and the receiver first intermediate frequency is variable and depends on the particular frequency shift.
In co-channel systems, the transceiver which is master for synchronization (V or H) sends its RF LO signal and its TCXO reference frequency to the other transceiver (WF1 connector in the block diagram), in order to match the requirements for the XPIC function (indoor unit) which needs that all the oscillators on receiver side (first and second conversions) must be synchronized. One coaxial cable interconnects the two transceivers in a co-channel system.
The transmitter uses surface mounting devices, only the power amplifier, an internally matched C band power FET, is a flanged device. Particular care has been devoted to the study of thermal dissipation structure for the TX driver SMD MMIC, which dissipates 5 Watt: a dense array of 32 microvias is placed under this devices and the PCB thickness is locally reduced to 0.5 millimeter in order to keep the thermal resistance to a very low value. The optimization of thermal dissipation structures on standard PCB is a very important matter for the future, in order to make possible the use of SMD devices with higher power dissipated, instead of flanged devices.
The TX IF signal is pre-distorted with a feed forward analog solution which guarantees the compliance of transmitted signal at nominal power with ETSI EN 300 234 class 5b limits for emission at maximum output power.
The receiver LNA uses FET devices, a very cheap and effective solution. The linearity is very good also in upfading condition. A second image rejection mixer was needed because the variable first RX IF allows only a very broad filtering. The 140 MHz second intermediate IF channel makes use of a VGA monolithic amplifier. All microwave filters are printed on the PC board, their optimization for 7 or 8 GHz bands make the relevant differences between the transceivers for the two bands.
Two SMA surface mount connectors are used as receiver input and transmitter output.
ODU power consumption is about 40 W.
The fully assembled 7 GHz transceiver is shown in fig.2. The PC board is directly screwed to the mechanical base block, the power supply subunit is under the RF/IF board and is connected by means of a multipin connector.
The aluminium die cast base block has dissipation fins for thermal management.
The first temperature tests in thermo regulated chamber showed the good thermal performances of the design: the maximum internal temperature is under the 85 degrees limit, with 60 degrees of ambient temperature.
A lid covers transmitter and receiver sections, niches are provided to separate different functions in order to avoid electromagnetic interference. The layout has been designed with particular care to the isolation between receiver and transmitter subsections.

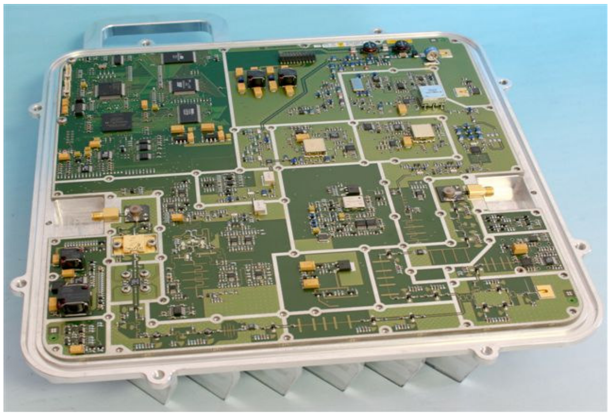

Fig.2. 7 GHz transceiver assembled with its base block

Figures 3 to 5 show ODU mechanical structure, internal and external.
The duplexer filter is on the top of the structure, it is easily accessible and can be easily disassembled or it can be mounted after the ODU final testing in order to reduce the lead time of the production process.
The external cover is screwed to the base block, a rubber gasket guarantees watertight.
The ODU outer dimensions are: 277 x 277 x 125 mm.
No cable connections to the external ODU connectors are needed during final assembly: PM1, PM3 and WF1 connectors (see fig.1) on RF/IF board interface directly the respective external connector with a snap-in solution. Only Transmitter output (WF2) and Receiver input (WF3) SMA interfaces need short coaxial cables to be connected to the diplexer filter.
The 7 and 8 GHz ODU weight is about 8.5 Kg.

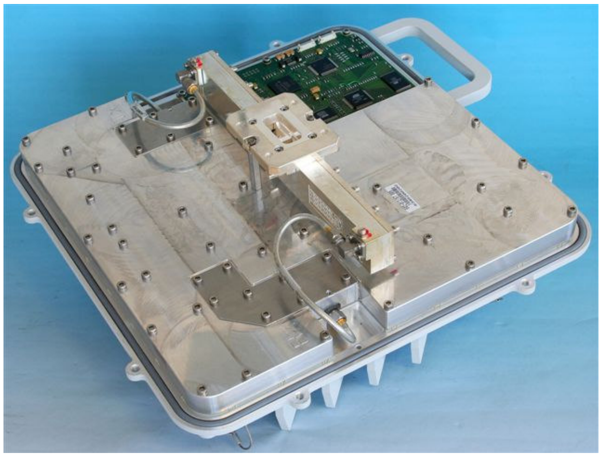

Fig.3. 7 & 8 GHz ODU internal structure: the diplexer filter is easily accessible.

Fig.4. 7 & 8 GHz ODU external structure: the dissipation fins and the IDU-ODU, RSSI and cochannel connectors.

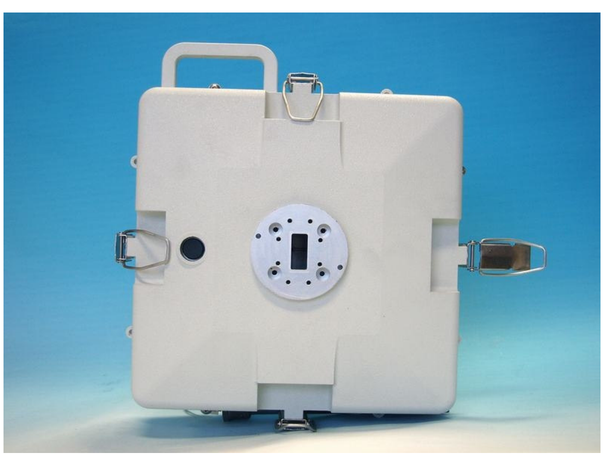

Fig.5. 7 & 8 GHz ODU external structure: the input/output wave
guide and the clamps for quick pole mounting.

## 3. TEST RESULTS FOR 7 GHZ BAND TRANSCEIVERS

A group of twenty 7 GHz ODU prototypes has been tested and fully characterized with very good results.
The RF synthesizer, based on a monolithic VCO as described, is enough insensitive to mechanical vibrations ( ETSI EN300 019-1-4) even if it is not elastically suspended.
Fig. 6 shows transmitter output with a 256 QAM modulated signal, at nominal power, with and without IF pre distortion.

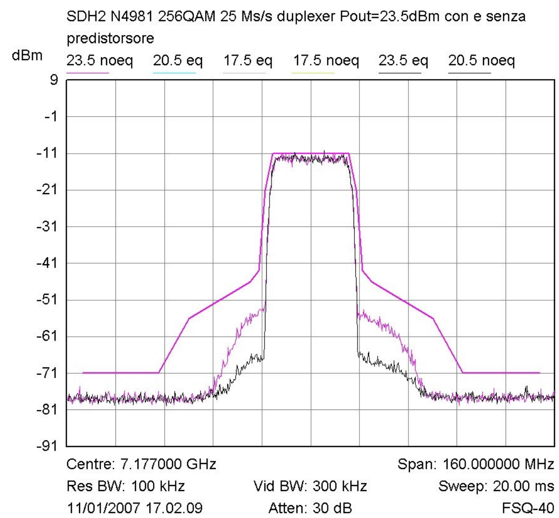


Fig.6. Transmitter output signal with and without IF pre distortion

The design target of -43dBc of intermodulation products is satisfied even without signal predistorsion, but the predistortion linearizer guarantees the larger margins needed for a mass production.
The possibility offered by microcontroller to change with temperature the level of the signal at the input of the linearizer guarantees its good efficiency in the whole operating temperature range of -30 to +55 degrees centigrade (ref. 2).

## 4. NEW ODU FAMILY FURTHER DEVELOPMENTS

The already developed and tested 7 and 8 GHz ODU are the first two of the new SDH/SUPERPDH family, ODU for the other planned frequency bands are under development.
ODU for frequency bands up to 13 GHz will have the same outer dimensions of 7 and 8 GHz ODU and a similar electrical structure, with only one RF VCO. Upper bands ODU will be housed in a smaller mechanic, with outer dimensions 234x234 mm, in agreement with family design targets. All these transceivers have a waveguide receiver input and transmitter output, the microstrip to waveguide

transitions are directly realized on the PC board and the shorts under the transitions are machined in the base block.
The 18 GHz band transceiver deserve attention because it is fully SMD, without flanged RF devices, and will be shortly described as an example of upper band transceivers.

## 5. 18 GHZ TRANSCEIVER SHORT DESCRIPTION

Figure 7 shows the 18 GHz transceiver assembled with its base block.

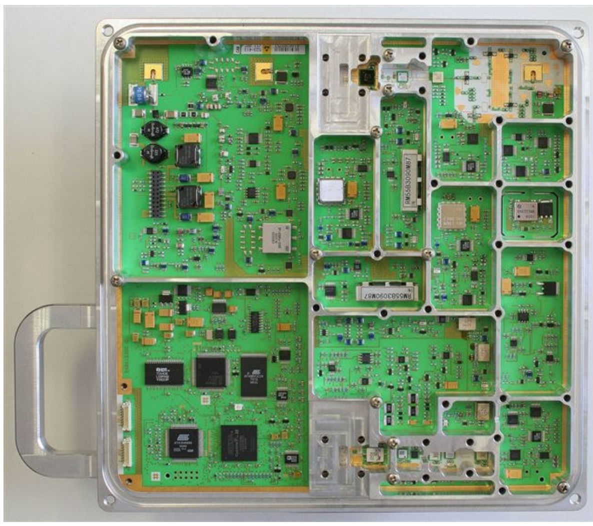

Fig.7. 18 GHz transceiver assembled with its base block

The single PC board consists of a 8 layer structure, the first layer layer is made of Rogers material RO4350, for its low loss at microwave frequencies, the other layers are standard lead free compatible epoxy resin materials. All microwave filters are printed on the first layer.
Table 2 resumes the main electrical parameters.

Table 2 : 18 GHz ODU main electrical parameters.

| | |
|---|---|
| Frequency range (GHz) | 17.5 – 19.5 GHz |
| Nominal Transmitted output power | 17 dBm |
| Transmitter output power control range | 15 dB |
| Nominal Receiver noise figure | ≤ 6 dB |

The microwave transceiver has two RF synthesizers, based on monolithic VCOs, and uses a full SMD chipset. The power amplifier is a K band MMIC, which dissipates 5.2W to give +17 dBm at the ODU's output, with less than 43 dBc of intermodulation products.
Other functions are similar to those described for 7 and 8 GHz ODU, in particular the syncronization scheme for local oscillators on receiver side is common to all ODU of the family. One external cable interconnects the two ODU in a cochannel system.
18 GHz ODU power consumption is about 32W.

## 6. CONCLUSIONS

A new family of OutDoor Units (ODU) for point to point SHD and Super PDH radio links in the 7 to 38 GHz microwave bands has been designed and is under development in Siemens Networks S.p.A., Cassina de' Pecchi.
The ODU for 7 & 8 GHz bands has been already developed and fully tested. Their architecture, based on a single RF VCO and variable intermediate frequencies scheme, is attractive for its low cost, easy tuning and low spurious signals generation. A short description of 18 GHz band Outdoor unit, whose tests on first prototypes are in progress, has been given.

## REFERENCES


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