United Monolithic Semiconductors is deeply involved since more than 10 years in the development and production of sensors for the automotive market. This leads to a huge knowledge of the sensor and radars functionalities and production in the millimetre wave range, in particular for the 5.8GHz, 24GHz and 77GHz ISM frequency bands. The UMS offer for such function is very large, and covers nearly all applications in those ISM frequency bands, such as positioning sensors, level sensors, identification sensors, automation sensors in various fields: agricultural, water management, storage, logistics, and transportation.

The typical architecture of radar is based on the frequency generation (VCO) often use also as the transmitter, and local oscillator for the receiver (homodyne), and a mixer for the receiver. Other circuits such as multipliers and amplifiers can be used in high frequency and/or more complex systems.

A typical high complexity level radar sensor is shown on the following figure. This architecture is multi-mode, multi beam, multi channel, basically used for high end automotive sensors.
The high production volume for such MMIC’s in automotive market leads to a mature industrial process, taking all advantages of integrated GaAs function versus the discrete counterpart, such as reliability, easy to use, low cost, reproducibility and so on. United Monolithic Semiconductors is now offering this knowhow through its product portfolio for a wide range of application from the simplest one to the more complex one, for the full benefit to the millimetre wave sensors industry. In particular, all the basic building blocks are available to simplify the realisation of all kind of sensors for the ISM frequency bands. Let’s review a sampling of UMS product offer for ISM sensors:

First of all, the most basic need is the frequency generation. The UMS offer is based on a family of dedicated VCO’s. Thanks to the integrated approach, it is possible to offer the full function in one component, as shown on Figure 2, feathering the frequency generation, the times two multiplier, the output buffer amplifier, and the first level of the feedback loop with a times eight frequency divider that provides a signal fully compatible with low cost standard PLL device. Bias is fully integrated, and the part is offered in a standard SMT package (QFN4x4).

![VCO dedicated to the 24GHz ISM frequency band.](image)

**Figure 2**: VCO dedicated to the 24GHz ISM frequency band.

For the 77GHz ISM frequency band, the UMS offer is also based on fully integrated VCO’s, such as the ones describes on the Figure 3. In order to achieve performances and produce ability, those VCO’s are set at a low frequency compared to the 77GHz. A complementary part is then needed to achieve the right output frequency and power describe in the Figure 4 as the Transmit multifunction (Tx). This last part includes the multipliers and buffer amplifiers that are required to operate in the 77GHz ISM frequency band.

![Main Features](image)

**Main Features**
- K-band VCO+K-band buffers+Prescaler/8
- Fully integrated VCO (no need for external Resonator
- Low phase noise
- High temperature range
- High frequency stability
- On chip self biased devices
- Standard SMD package : 24L-QFN4x4

![Main Characteristics in QFN package](image)

**Main Characteristics in QFN package**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>F_out</td>
<td>Specified output frequency range</td>
<td>24</td>
<td>24.125</td>
<td>24.25</td>
<td>GHz</td>
</tr>
<tr>
<td>F_vco</td>
<td>Oscillator frequency</td>
<td>F_vco/2</td>
<td>GHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F_i</td>
<td>Output Intermediate frequency</td>
<td>F_out/16</td>
<td>GHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P_out</td>
<td>Output power at F_out</td>
<td>13</td>
<td>16</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>PIF</td>
<td>Output power at Intermediate frequency (IF)</td>
<td>3</td>
<td>0</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>PN</td>
<td>SSB Phase Noise @ F_out @ 100 kHz</td>
<td>-90</td>
<td>-80</td>
<td>dBc/Hz</td>
<td></td>
</tr>
</tbody>
</table>

For the ISM sensors for the ISM frequency bands. Let's review a sampling of UMS product offer all the basic building blocks are available to simplify the realisation of all kind of complex one, for the full benefit to the millimetre wave sensors industry. In particular, the high production volume for such MMIC’s in automotive market leads to a mature industrial process, taking all advantages of integrated GaAs function versus the discrete counterpart, such as reliability, easy to use, low cost, reproducibility and so on. United Monolithic Semiconductors is now offering this knowhow through its product portfolio for a wide range of application from the simplest one to the more complex one, for the full benefit to the millimetre wave sensors industry. In particular, all the basic building blocks are available to simplify the realisation of all kind of sensors for the ISM frequency bands. Let’s review a sampling of UMS product offer for ISM sensors:

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Figure 3: Fully integrated VCO dedicated to the 77GHz ISM frequency band.

Due to the very high frequency (77GHz) it was found optimum to share the function in a set of two parts, each one fabricated on the best process to insure at the same time performances and yield, leading to low cost and easy to use components. For the VCO’s, as the frequency is kept low enough, a standard SMT plastic packaging can be done, and then those parts are offered both in bare die, and QFN package.

CHU2277

CHU3277

CHU3377

Figure 4: Transmit multifunction dedicated to the 77GHz ISM frequency band.
The second basic function that is required for sensor development is the receiver. Here also UMS offer a family of products dedicated to each ISM frequency band. The first example is the 24GHz fully integrated receiver, as shown on figure 5.

**Main Features**
- Typical Noise figure: 7 dB
- Stable gain vs temperature: \(23 \pm 2.5\) dB
- Single supply Voltage: +5V
- Devices self biased on chip
- Standard SMD package: QFN 24L 4x4

**Main Characteristics**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameters</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX_RF</td>
<td>Frequency range</td>
<td>22</td>
<td>24.5</td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>Conversion Gain</td>
<td></td>
<td>19</td>
<td>23</td>
<td>27</td>
<td>dB</td>
</tr>
<tr>
<td>SSB Noise figure (IF=1MHz)</td>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>RX_LO / RX_RF</td>
<td>Input / Output Return Loss</td>
<td>8</td>
<td>15</td>
<td></td>
<td>dB</td>
</tr>
</tbody>
</table>

![Conversion Gain vs Frequency](image)

Figure 5: Fully integrated Receiver dedicated to the 24GHz ISM frequency band.

This particular part feature a low noise amplifier, a mixer and a local oscillator buffer amplifier that makes it fully compatible of the CHV2411 describe earlier, and is also offered in the same standard SMT package (QFN4x4).

**CHM2179b / CHM2378a**
- BES
- Single or dual mixer
- CL: 7dB
- NF=18dB @ 100kHz IF

**CHA1077a**
- pHEMT
- G=18dB
- NF=4dB

Figure 6: Fully integrated Receiver and low noise amplifier dedicated to the 77GHz ISM frequency band.
Those two parts used together helps to build a very simple and performing sensor in the 24GHz ISM frequency band.

For the 77GHz ISM frequency band, receivers are also available, as shown on Figure 6, together with an optional low noise amplifier at 77GHz. In some occasion it could be necessary to add such low noise amplifier in front of the receiver, to improve the performances such as range or sensitivity increase. The same kind of option is also provided for the 24GHz ISM frequency band, with a specific low noise amplifier (CHA2411-QDG) offered in the same SMT package (QDN4x4). In addition UMS propose also a family of switch that can be used for complex multi beam system for these ISM frequency bands (CHS2411-QDG).

For the 77GHz ISM frequency band, the parts are mainly offered in die form, due to the very high frequency and the limitations of the standard QFN. So UMS developed a different packaging approach in order to offer also the 77GHz parts in a SMT package, described in Figure 7 for the transmitter. The same kind of package is also available for the receiver.

Figure 7: UMS SMT packaging approach for 77GHz ISM applications.

This packaging demonstrates the feasibility of a surface mount approach for high millimetre wave application, compatible with production. Now, for high volume production, typically for the automotive long range radar (LRR), it was mandatory to develop a low cost version of this package. UMS is currently in development phase for such a package, based on a modified version of the QFN in order to make it low cost and compatible with high volume product, maintaining the performances at the required level.
The other UMS approach is to offer full chip-set for a dedicated application, and three examples are given in the following. On Figure 8, a full chip-set for a local oscillator distribution chain at 77GHz is described.

Figure 8: UMS typical chip-set for 77GHz local oscillator distribution chain for ISM applications: CHX1094, CHU2277 & CHA1077a.

Figure 9 gives a typical 24GHz sensor architecture based on a four chip chip-set. It is a complex multi beam approach that can be tailored to simpler needs.

Figure 9: UMS typical chip-set for 24GHz for sensor: CHV2411a, CHR2411, CHA2411 & CHS2411.
Figure 10 show a family a product that can be used in typical 5.8GHz sensor.

<table>
<thead>
<tr>
<th>EC2612</th>
<th>CHS5100</th>
<th>CHA3666</th>
<th>CHA3664</th>
<th>CHA4664</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transistor</td>
<td>Switch 0-20GHz</td>
<td>LNA 5.8-16GHz</td>
<td>MPA 5-21GHz</td>
<td>VGA 5.5-16GHz</td>
</tr>
<tr>
<td>G = 14dB</td>
<td>L = 1.2dB</td>
<td>G = 20dB</td>
<td>G = 15dB</td>
<td>G = 23dB</td>
</tr>
<tr>
<td>NF = 0.5dB</td>
<td>Pin1dB = 20dBm</td>
<td>NF = 2.1dB</td>
<td>Psat = 20dBm</td>
<td>23dB range Gctrl</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pout1dB=16dBm</td>
<td>Pout1dB = 23dBm</td>
<td></td>
</tr>
</tbody>
</table>

Figure 10: UMS typical products for 5.8GHz for sensor: EC2612, CHS5100, CHA3666, CHA3664 & CHA4664.
United Monolithic Semiconductors is fully ISO 9001, ISO 14001, ISO TS 16949 certified. With fully in-house GaAs manufacturing and offering space evaluated process, United Monolithic Semiconductors products meet highest quality standard as required by Space and Automotive productions.

You can choose from our catalogue your MMIC or ask UMS to advise the MMIC suiting best to your application with the possibility to adjust the design to meet specifically your requirements or for any specific needs.

All UMS team looks forward to give you the benefit of our MMIC performance.