

# MAS9178

## AM Receiver IC

- High Sensitivity
- Very Low Power Consumption
- Wide Supply Voltage Range
- Power Down Control
- Control for AGC On
- High Selectivity by Crystal Filter
- Fast Startup Feature

### DESCRIPTION

The MAS9178 AM-Receiver chip is a highly sensitive, simple to use AM receiver specially intended to receive time signals in the frequency range from 40 kHz to 100 kHz. Only a few external components are required for time signal receiver. The circuit has preamplifier, wide range automatic gain control, demodulator and output comparator built in. The output signal can be processed directly by an additional digital circuitry to extract the data from the received signal. The control for AGC (automatic gain control) can be used to switch AGC on or off if necessary. Unlike MAS1016A and

MAS1016B, MAS9178 does not require AGC control procedure in WWVB and JJY systems.

MAS9178A1 has differential input and internal 0.875 pF compensation capacitor for crystal shunt capacitance compensation.

MAS9178A5 requires external compensation capacitor for crystal shunt capacitance compensation.

It can be used with crystals that do not match with fixed 0.875 pF compensation capacitance of MAS9178A1.

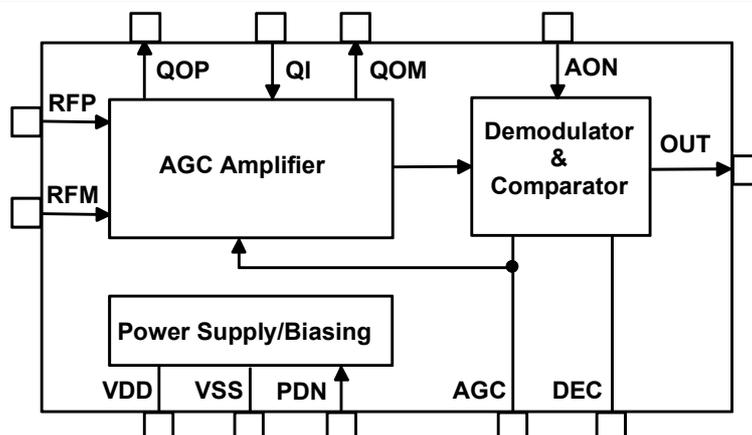
### FEATURES

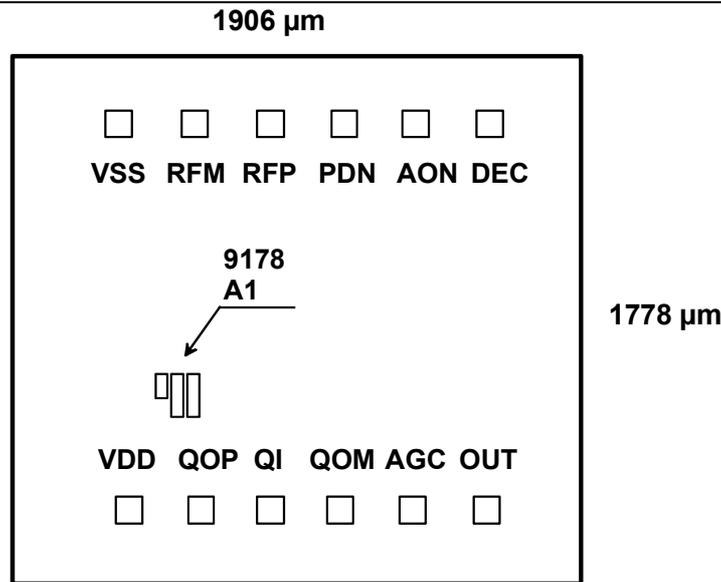
- Highly Sensitive AM Receiver, 0.4  $\mu\text{V}_{\text{RMS}}$  typ.
- Wide Supply Voltage Range from 1.1 V to 3.6 V
- Very Low Power Consumption
- Power Down Control
- Fast Startup
- Only a Few External Components Necessary
- Control for AGC On
- Wide Frequency Range from 40 kHz to 100 kHz
- High Selectivity by Quartz Crystal Filter

### APPLICATIONS

- Time Signal Receiver WWVB (USA), JJY (Japan), DCF77 (Germany) and MSF (UK)
- Receiver for ASK Modulated Data Signals

### BLOCK DIAGRAM



**PAD LAYOUT**


DIE size = 1.91 x 1.78 mm; PAD size = 100 x 100 µm except for VSS PAD size 104 x 112 µm

**Note:** Because the substrate of the die is internally connected to VDD, the die has to be connected to VDD or left floating. Please make sure that VDD is the first pad to be bonded. Pick-and-place and all component assembly are recommended to be performed in ESD protected area.

**Note:** Coordinates are pad center points where origin has been located in the center of VDD pad

| Pad Identification  | Name | X-coordinate | Y-coordinate | Note |
|---|------|--------------|--------------|------|
| Power Supply Voltage  | VDD  | 0 µm         | 0 µm         |      |
| Quartz Filter Output for Crystal                                    | QOP  | 306 µm       | 19 µm        |      |
| Quartz Filter Input for Crystal and External Compensation Capacitor | QI   | 549 µm       | 19 µm        |      |
| Quartz Filter Output for External Compensation Capacitor            | QOM  | 866 µm       | 19 µm        |      |
| AGC Capacitor   | AGC  | 1146 µm      | 19 µm        |      |
| Receiver Output   | OUT  | 1389 µm      | 19 µm        | 1    |
| Demodulator Capacitor   | DEC  | 1389 µm      | 1428 µm      |      |
| AGC On Control  | AON  | 1146 µm      | 1428 µm      | 2    |
| Power Down Input  | PDN  | 829 µm       | 1428 µm      | 3    |
| Positive Receiver Input   | RFP  | 586 µm       | 1428 µm      |      |
| Negative Receiver Input   | RFM  | 269 µm       | 1428 µm      |      |
| Power Supply Ground   | VSS  | 16 µm        | 1407 µm      |      |

**Notes:**

- 1) OUT = VSS when carrier amplitude at maximum; OUT = VDD when carrier amplitude is reduced (modulated)
  - the output is a current source/sink with  $|I_{OUT}| > 5 \mu A$
  - at power down the output is pulled to VSS (pull down switch)
- 2) AON = VSS means AGC off (hold current gain level); AON = VDD means AGC on (working)
  - Internal pull-up with current  $< 1 \mu A$  which is switched off at power down
- 3) PDN = VSS means receiver on; PDN = VDD means receiver off
  - Fast start-up is triggered when the receiver is after power down (PDN=VDD) controlled to power up (PDN=VSS) i.e. at the falling edge of PDN signal.

## ABSOLUTE MAXIMUM RATINGS

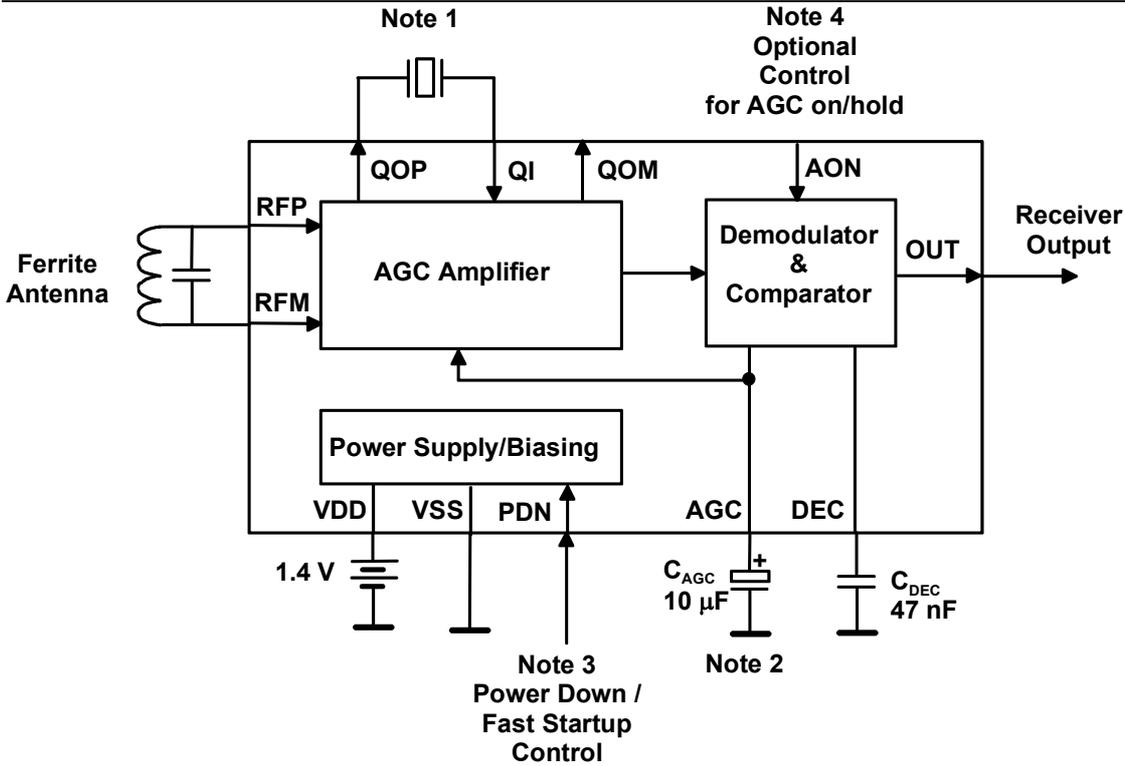
| Parameter             | Symbol          | Conditions | Min          | Max          | Unit |
|-----------------------|-----------------|------------|--------------|--------------|------|
| Supply Voltage        | $V_{DD}-V_{SS}$ |            | -0.3         | 5.0          | V    |
| Input Voltage         | $V_{IN}$        |            | $V_{SS}-0.3$ | $V_{DD}+0.3$ | V    |
| Power Dissipation     | $P_{MAX}$       |            |              | 100          | mW   |
| Operating Temperature | $T_{OP}$        |            | -20          | 70           | °C   |
| Storage Temperature   | $T_{ST}$        |            | -40          | 120          | °C   |

## ELECTRICAL CHARACTERISTICS

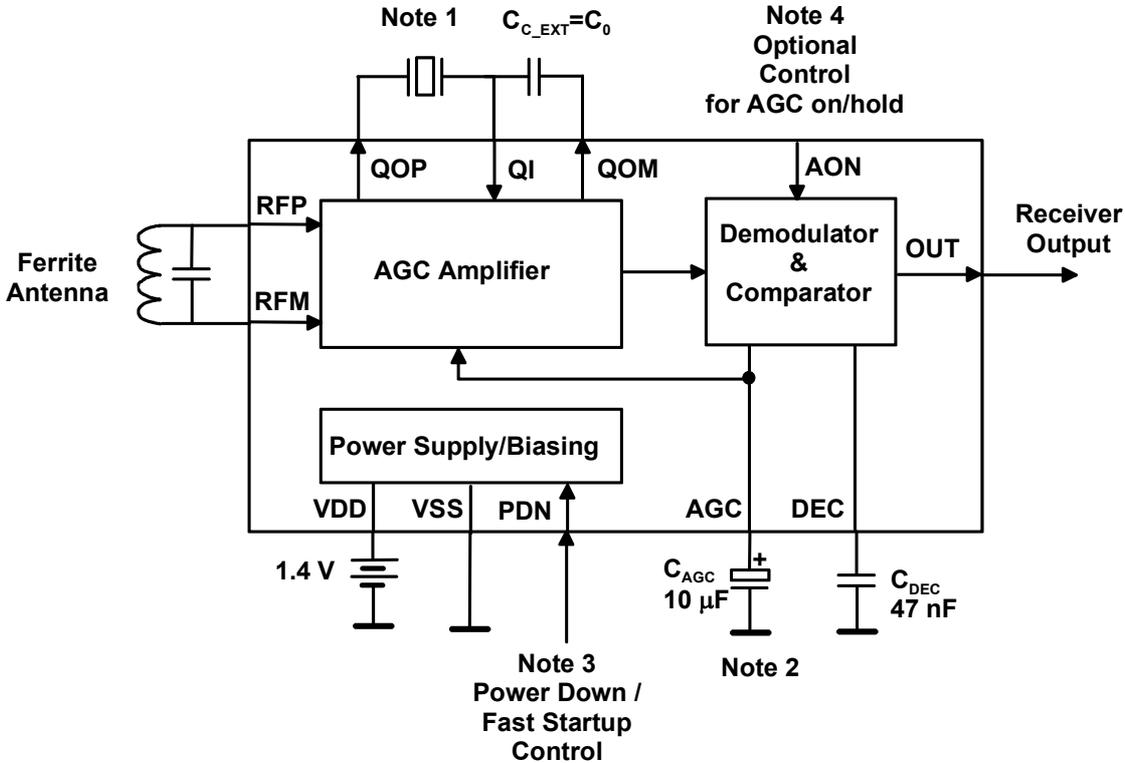
 Operating Conditions:  $V_{DD} = 1.4V$ , Temperature = 25°C

| Parameter  | Symbol               | Conditions   | Min         | Typ      | Max         | Unit          |
|--|----------------------|--|-------------|----------|-------------|---------------|
| Operating Voltage  | $V_{DD}$             |  | 1.10        |          | 3.60        | V             |
| Current Consumption  | $I_{DD}$             | $V_{DD}=3.6V, V_{in}=0\mu V$<br>$V_{DD}=1.4V, V_{in}=0\mu V$ | 56          | 76<br>66 | 95          | $\mu A$       |
| Stand-By Current   | $I_{DDoff}$          |  |             |          | 0.1         | $\mu A$       |
| Input Frequency Range                                      | $f_{IN}$             |  | 40          |          | 100         | kHz           |
| Minimum Input Voltage                                      | $V_{INmin}$          |  |             | 0.4      | 1           | $\mu V_{rms}$ |
| Maximum Input Voltage                                      | $V_{INmax}$          |  | 20          |          |             | mVrms         |
| Input Levels $ I_{IN}  < 0.5\mu A$                         | $V_{IL}$<br>$V_{IH}$ |  | $0.8V_{DD}$ |          | $0.2V_{DD}$ | V             |
| Output Current<br>$V_{OL} < 0.2V_{DD}; V_{OH} > 0.8V_{DD}$ | $ I_{OUT} $          |  | 5           |          |             | $\mu A$       |
| Output Pulse   | $T_{100ms}$          | $1\mu V_{rms} \leq V_{IN} \leq 20mV_{rms}$                   | 50          |          | 140         | ms            |
|  | $T_{200ms}$          | $1\mu V_{rms} \leq V_{IN} \leq 20mV_{rms}$                   | 150         |          | 230         | ms            |
|  | $T_{500ms}$          | $1\mu V_{rms} \leq V_{IN} \leq 20mV_{rms}$                   | 400         | 500      | 600         | ms            |
|  | $T_{800ms}$          | $1\mu V_{rms} \leq V_{IN} \leq 20mV_{rms}$                   | 700         | 800      | 900         | ms            |
| Startup Time   | $T_{Start}$          | Fast Start-up  |             | 12       |             | s             |
|  |                      | Without Fast Start-up  |             | 3        |             | min           |
| Output Delay Time  | $T_{Delay}$          |  |             | 50       | 100         | ms            |

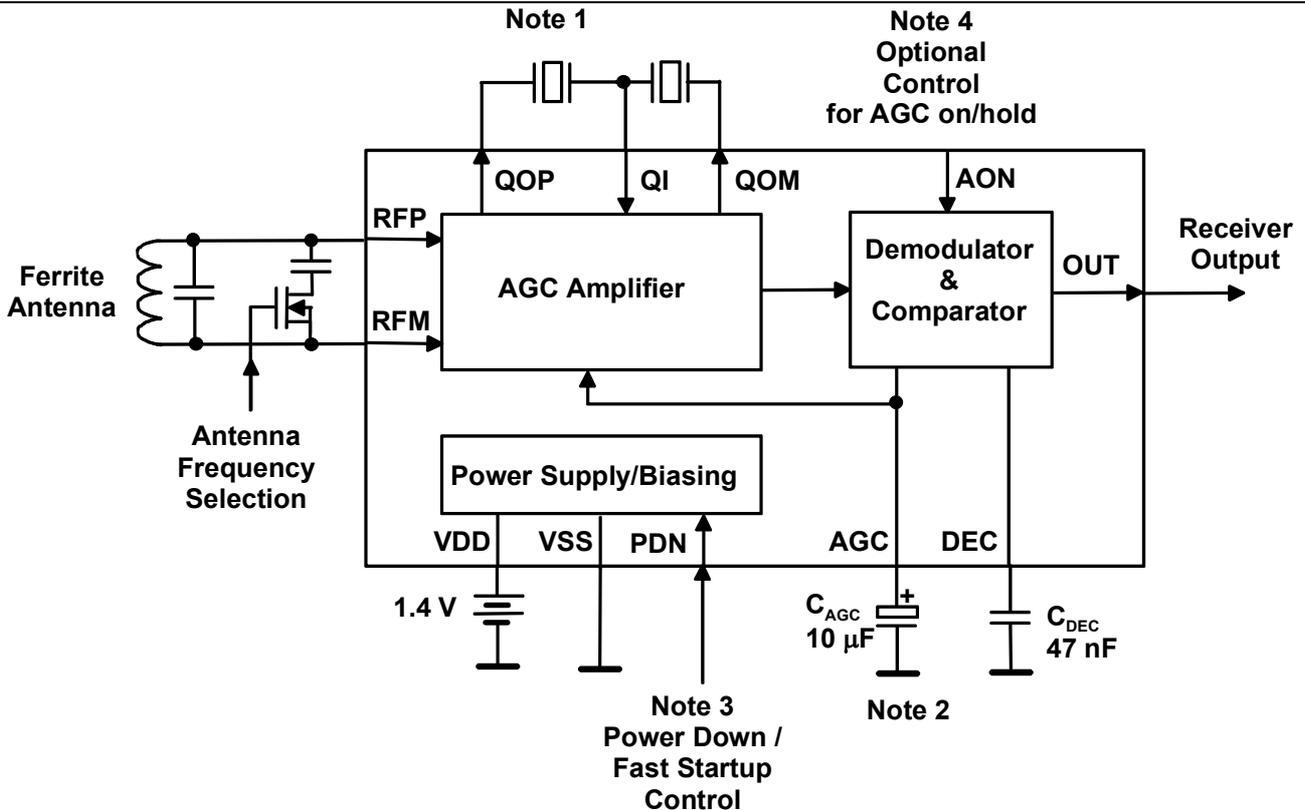
**TYPICAL APPLICATION**



**Figure 1** Application circuit of internal compensation capacitance version MAS9178A1.



**Figure 2** Application circuit of external compensation capacitance version MAS9178A5.

**TYPICAL APPLICATION (Continued)**


**Figure 3** Dual band application circuit of external compensation capacitance version MAS9178A5.

**Note 1: Crystal**

The crystal as well as ferrite antenna frequencies are chosen according to the time-signal system (Table 1). The crystal shunt capacitance  $C_0$  should be matched as well as possible with the internal shunt capacitance compensation capacitor  $C_C=0.875$  pF of MAS9178A1. External compensation pad QOM is unconnected in MAS9178A1. MAS9178A5 does not have internal compensation capacitance  $C_C$  and it requires use of external compensation capacitor  $C_{C\_EXT}$ . It must be connected between pins QOM and QI (see figure 2).  $C_{C\_EXT}$  should have equal value with crystal's effective shunt capacitance  $C_0$ . External compensation version MAS9178A5 should be used when fixed 0.875 pF compensation capacitance of MAS9178A1 does not match well with used crystal's shunt capacitance.

It should be noted that grounded crystal package has reduced shunt capacitance. This value is about 85% of floating crystal shunt capacitance. PCB traces of crystal and external compensation capacitance should be kept at minimum to minimize additional parasitic capacitance which can cause capacitance mismatching.

In dual band receiver configuration the crystals can be connected in parallel thus external compensation capacitor value  $C_{C\_EXT}$  must be sum of two crystals' shunt capacitances. Instead of parallel crystal connection it is also possible to connect other crystal from QOP pin and the other crystal from QOM pin to common QI pin (figure 3). In this circuit configuration no external compensation capacitor is required since the crystals compensate each other. The sensitivity of dual band receiver configuration will be lower than that of single band receiver configuration since the noise band width of crystal filter with two parallel crystals is double.

| Time-Signal System | Location       | Antenna Frequency | Recommended Crystal Frequency |
|--------------------|----------------|-------------------|-------------------------------|
| DCF77              | Germany        | 77.5 kHz          | 77.503 kHz                    |
| MSF                | United Kingdom | 60 kHz            | 60.003 kHz                    |
| WWVB               | USA            | 60 kHz            | 60.003 kHz                    |
| JJY                | Japan          | 40 kHz and 60 kHz | 40.003 kHz and 60.003 kHz     |

**Table 1** Time-Signal System Frequencies

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## TYPICAL APPLICATION (Continued)

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**Note 2: AGC Capacitor**

The AGC and DEC capacitors must have low leakage currents due to very small 40 nA signal currents through the capacitors. The insulation resistance of these capacitors should be higher than 70 M $\Omega$ . Also probes with at least 100 M $\Omega$  impedance should be used for voltage probing of AGC and DEC pins. Electrolyte capacitors cannot be used due to their large leakage current. Instead low leakage tantalum capacitor can be used as AGC capacitor. DEC capacitor can be low leakage chip capacitor.

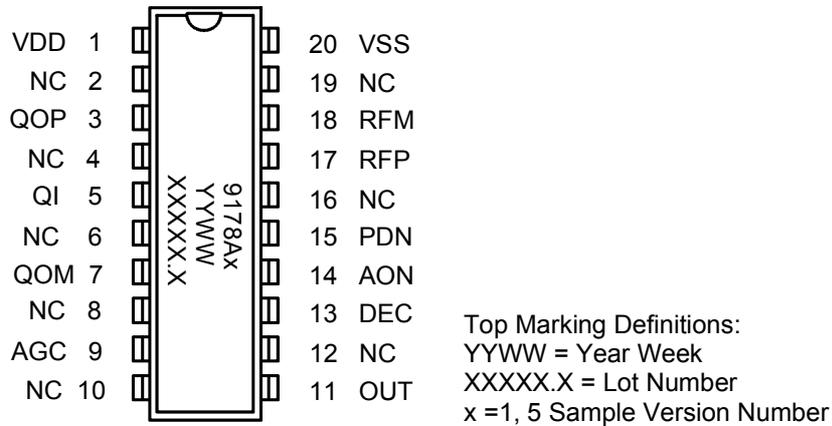
**Note 3: Power Down / Fast Startup Control**

Both power down and fast startup are controlled using the PDN pin. The device is in power down (turned off) if PDN = VDD and in power up (turned on) if PDN = VSS. Fast startup is triggered by the falling edge of PDN signal, i.e., controlling device from power down to power up. The startup time without using the fast startup control can be several minutes but with fast startup it is shortened typically to 12 s.

**Note 4: Optional Control for AGC On/Hold**

AON control pin has internal pull up which turns AGC circuit on all the time if AON pin is left unconnected. Optionally AON control can be used to hold and release AGC circuit. Stepper motor drive etc. can produce disturbing amount of noise which can shift the input amplifier gain to unoptimal level. This can be avoided by controlling AGC hold (AON=VSS) during stepper motor drive periods and releasing AGC (AON=VDD) when motors are not driven.

## SAMPLES IN SBDIL 20 PACKAGE



## PIN DESCRIPTION

| Pin Name | Pin | Type | Function  | Note |
|----------|-----|------|---|------|
| VDD      | 1   | P    | Positive Power Supply   |      |
| NC       | 2   |      |   |      |
| QOP      | 3   | AO   | Quartz Filter Output for Crystal                                    |      |
| NC       | 4   |      |   | 1    |
| QI       | 5   | AI   | Quartz Filter Input for Crystal and External Compensation Capacitor |      |
| NC       | 6   |      |   | 1    |
| QOM      | 7   | AO   | Quartz Filter Output for External Compensation Capacitor            |      |
| NC       | 8   |      |   |      |
| AGC      | 9   | AO   | AGC Capacitor   |      |
| NC       | 10  |      |   |      |
| OUT      | 11  | DO   | Receiver Output   | 2    |
| NC       | 12  |      |   |      |
| DEC      | 13  | AO   | Demodulator Capacitor   |      |
| AON      | 14  | DI   | AGC On Control  | 3    |
| PDN      | 15  | AI   | Power Down Input  | 4    |
| NC       | 16  |      |   |      |
| RFP      | 17  | AI   | Positive Receiver Input   |      |
| RFM      | 18  | AI   | Negative Receiver Input   |      |
| NC       | 19  |      |   |      |
| VSS      | 20  | G    | Power Supply Ground   |      |

### Notes:

- Pins 4 and 6 around quartz crystal filter input pins must be connected to VSS to eliminate DIL package leadframe parasitic capacitances disturbing the crystal filter performance. All other NC (Not Connected) pins are also recommended to be connected to VSS to minimize noise coupling.
- OUT = VSS when carrier amplitude at maximum; OUT = VDD when carrier amplitude is reduced (modulated)
  - the output is a current source/sink with  $|I_{OUT}| > 5 \mu A$
  - at power down the output is pulled to VSS (pull down switch)
- AON = VSS means AGC off (hold current gain level); AON = VDD means AGC on (working)
  - Internal pull-up with current  $< 1 \mu A$  which is switched off at power down
- PDN = VSS means receiver on; PDN = VDD means receiver off
  - Fast start-up is triggered when the receiver is after power down (PDN=VDD) controlled to power up (PDN=VSS) i.e. at the falling edge of PDN signal.

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**SAMPLE INFORMATION**


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| Product Code     | Product                                | Description                         | Capacitance Option              |
|------------------|--|-------------------------------------|---------------------------------|
| MAS9178A1TB00.01 | AM-Receiver IC with Differential Input | EWS-tested wafer, Thickness 480 µm. | $C_C = 0.875$ pF                |
| MAS9178A5TB00.01 | AM-Receiver IC with Differential Input | EWS-tested wafer, Thickness 480 µm. | External Compensation Capacitor |
| MAS9178A1TC00.01 | AM-Receiver IC with Differential Input | EWS-tested wafer, Thickness 400 µm. | $C_C = 0.875$ pF                |
| MAS9178A5TC00.01 | AM-Receiver IC with Differential Input | EWS-tested wafer, Thickness 400 µm. | External Compensation Capacitor |

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