

DATA SHEET

UMA1021M

Low-voltage frequency synthesizer
for radio telephones

Product specification
Supersedes data of 1996 May 06
File under Integrated Circuits, IC17

1996 August 28

Low-voltage frequency synthesizer for radio telephones

UMA1021M

FEATURES

- Low phase noise
- Low current from 3 V supply
- Fully programmable main divider
- 3-line serial interface bus
- Independent fully programmable reference divider, driven from external crystal oscillator
- Dual charge pump outputs
- Hard and soft power-down control.

APPLICATIONS

- 900 MHz and 2 GHz mobile telephones
- Portable battery-powered radio equipment.

GENERAL DESCRIPTION

The UMA1021M BICMOS device integrates a prescaler, programmable dividers, and a phase comparator to implement a phase-locked loop.

The device is designed to operate from 3 NiCd cells, in pocket phones, with low current and nominal 3 V supplies.

The synthesizer operates at RF input frequencies up to 2.2 GHz, with a fully programmable reference divider. All divider ratios are supplied via a 3-wire serial programming bus.

Separate power and ground pins are provided to the analog (charge-pump) and digital circuits. The ground leads should be externally short-circuited to prevent large currents flowing across the die and thus causing damage. V_{DD1} and V_{DD2} must also be at the same potential (V_{DD}). V_{CC} must be equal to or greater than V_{DD} (e.g. $V_{DD} = 3$ V and $V_{CC} = 5$ V for wider VCO control voltage range).

The phase detector has two charge-pump outputs, CP and CPF, the latter of which is enabled directly at pin FAST. This permits the design of adaptive loops. The charge pump currents (phase detector gain) are fixed by an external resistance at pin I_{SET} and via the serial interface. Only a passive loop filter is necessary; the charge pumps function within a wide voltage compliance range to improve the overall system performance.

QUICK REFERENCE DATA

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---------------------------|---|---|------|------|------|--------------|
| V_{DD} | digital supply voltage | $V_{DD1} = V_{DD2}$; $V_{CC} \geq V_{DD}$ | 2.7 | – | 5.5 | V |
| V_{CC} | charge-pump supply voltage | $V_{CC} \geq V_{DD}$ | 2.7 | – | 5.5 | V |
| $I_{DD} + I_{CC}$ | supply current | | – | 10 | – | mA |
| $I_{CC(pd)} + I_{DD(pd)}$ | total supply current in power-down mode | | – | 5 | – | μ A |
| f_{RF} | RF input frequency | | 300 | – | 2200 | MHz |
| f_{xtal} | crystal reference input frequency | | 3 | – | 35 | MHz |
| f_{PC} | phase comparator frequency | | – | 200 | – | kHz |
| T_{amb} | operating ambient temperature | | –30 | – | +85 | $^{\circ}$ C |

ORDERING INFORMATION

| TYPE NUMBER | PACKAGE | | |
|-------------|---------|---|----------|
| | NAME | DESCRIPTION | VERSION |
| UMA1021M | SSOP20 | plastic shrink small outline package; 20 leads; body width 4.4 mm | SOT266-1 |

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BLOCK DIAGRAM

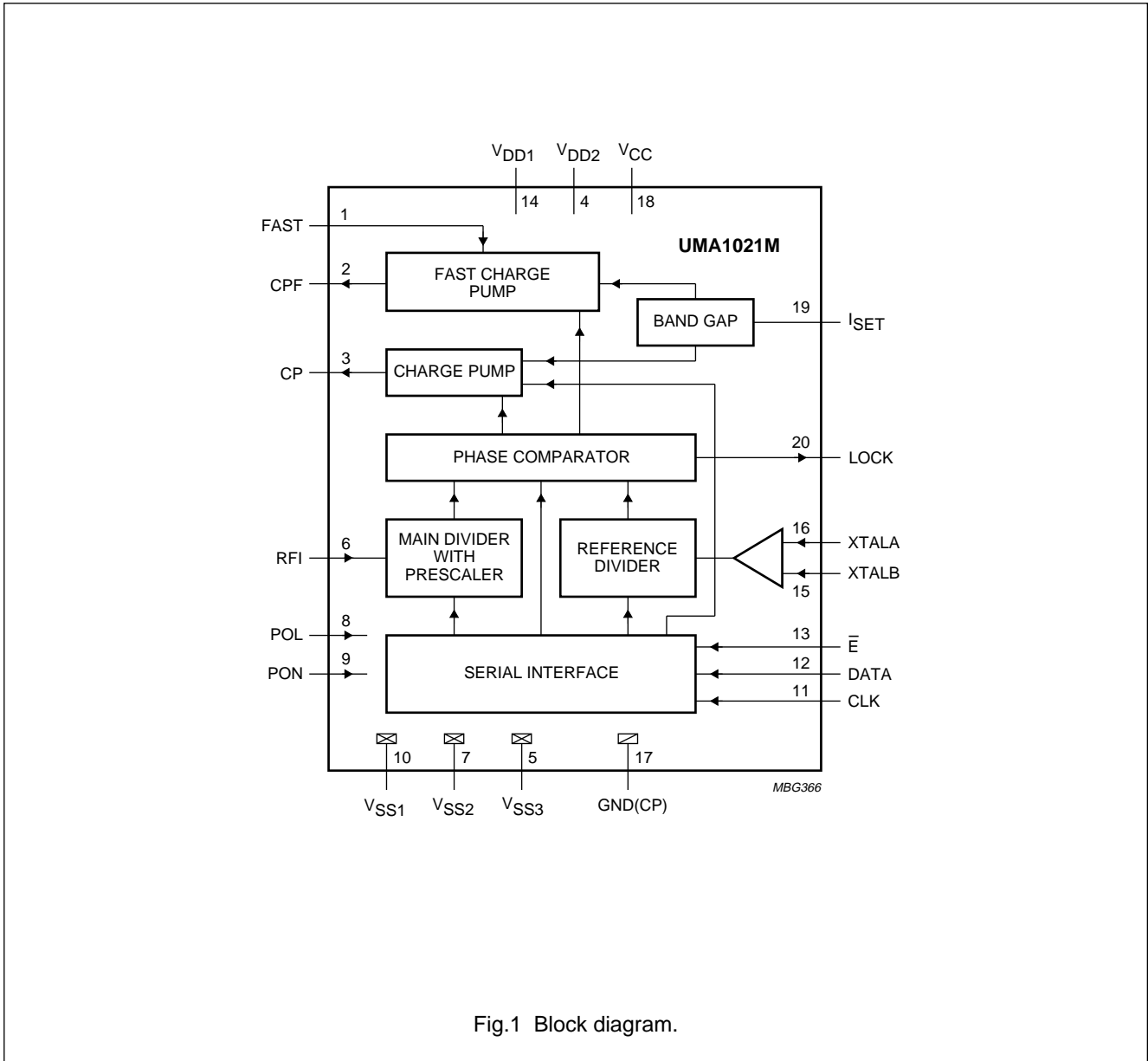


Fig.1 Block diagram.

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PINNING

| SYMBOL | PIN | DESCRIPTION |
|------------------|-----|--|
| FAST | 1 | enable input for fast charge-pump output CPF |
| CPF | 2 | fast charge-pump output |
| CP | 3 | normal charge-pump output |
| V _{DD2} | 4 | power supply 2 |
| V _{SS3} | 5 | ground 3 |
| RFI | 6 | 2 GHz main divider input |
| V _{SS2} | 7 | ground 2 |
| POL | 8 | digital input to select polarity of power-on inputs (PON and sPON): POL = 0 for active LOW and POL = 1 for active HIGH |
| PON | 9 | power-on input |
| V _{SS1} | 10 | ground 1 |
| CLK | 11 | programming bus clock input |
| DATA | 12 | programming bus data input |
| \bar{E} | 13 | programming bus enable input |
| V _{DD1} | 14 | power supply 1 |
| XTALB | 15 | complementary crystal frequency input from TCXO; if not used should be decoupled to ground |
| XTALA | 16 | crystal frequency input from TCXO; if not used should be decoupled to ground |
| GND(CP) | 17 | ground for charge-pump |
| V _{CC} | 18 | supply for charge-pump |
| I _{SET} | 19 | external resistor from this pin to ground sets the charge-pump currents |
| LOCK | 20 | out-of-lock detector output |

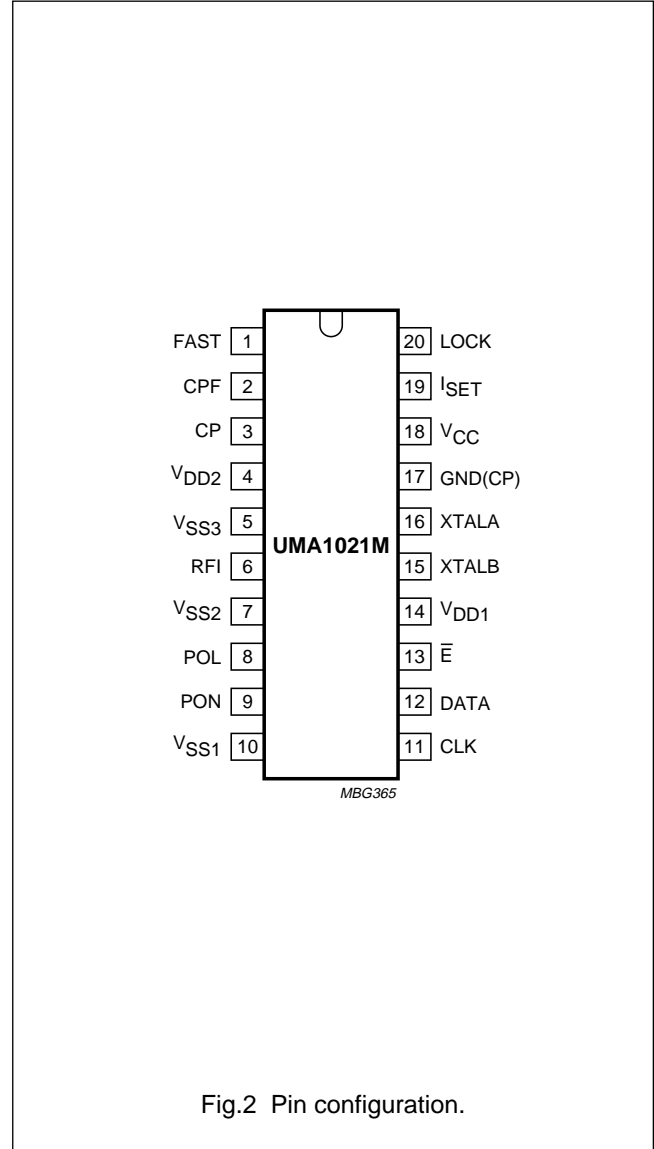


Fig.2 Pin configuration.

FUNCTIONAL DESCRIPTION

Main divider

The main divider is clocked at pin RFI by the RF signal which is AC-coupled from an external VCO. The divider operates with signal levels from 50 to 225 mV (RMS), and at frequencies from 300 MHz to 2.2 GHz. It consists of a fully programmable bipolar prescaler followed by a CMOS counter. Any divide ratios from 512 to 131071 inclusive can be programmed.

Reference divider

The reference divider is clocked by the differential signal between pins XTALA and XTALB. If only one of these inputs is used, the other should be decoupled to ground. The applied input signal(s) should be AC-coupled. The circuit operates with levels from 50 up to 500 mV (RMS) and at frequencies from 3 to 35 MHz. Any divide ratios from 8 to 2047 inclusive can be programmed.

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Phase detector

The phase detector is driven by the output edges of the main and reference dividers. It produces current pulses at pins CP and CPF whose amplitudes are programmed. The pulse duration is equal to the difference in time of arrival of the edges from the two dividers. If the main divider edge arrives first, CP and CPF sink current. If the reference divider edge arrives first, CP and CPF source current.

The currents at CP and CPF are programmed via the serial bus as multiples of a reference current set by an external resistor connected between pin I_{SET} and V_{SS} (see Table 3). CP remains active except in power-down. CPF is enabled via input pin FAST which is synchronized with respect to the phase detector to prevent output current pulses being interrupted. By appropriate connection to the loop filter, dual bandwidth loops can be designed; short time constant during frequency switching (FAST mode) to speed-up channel changes, and low bandwidth in the settled state to improve noise and breakthrough levels.

Additional circuitry is included to ensure that the gain of the phase detector remains linear even for small phase errors.

Out-of-lock detector

The out-of-lock detector is enabled (disabled) via the serial interface by setting bit OOL HIGH (LOW). An open drain transistor drives the output pin LOCK (pin 20). It is recommended that the pull-up resistor from this pin to V_{DD} is chosen to be of sufficient value to keep the sink current in the LOW state to below 400 μ A. When the out-of-lock detector is enabled, LOCK is HIGH if the error at the phase detector input is less than approximately 25 ns, otherwise LOCK is LOW. If the out-of-lock detector is disabled, LOCK remains HIGH.

Serial programming bus

A simple 3-line unidirectional serial bus is used to program the circuit. The 3 lines are DATA, clock (CLK) and enable (\bar{E}). The data sent to the device is loaded in bursts framed by \bar{E} . Programming clock edges and their appropriate data bits are ignored until \bar{E} goes active LOW. The programmed information is loaded into the addressed latch when \bar{E} returns HIGH.

During normal operation, \bar{E} should be kept HIGH. Only the last 21 bits serially clocked into the device are retained within the programming register. Additional leading bits are ignored, and no check is made on the number of clock pulses. The fully static CMOS design uses virtually no current when the bus is inactive. It can always capture new programmed data even during power-down.

When the synthesizer is powered-on, the presence of a TCXO signal at the reference divider input and a VCO signal at the main divider input is **required** for correct programming.

Data format

The leading bits (dt16 to dt0) make up the data field, while the trailing four bits (ad3 to ad0) are the address field. The UMA1021M uses 4 of the 16 available addresses. These are chosen for compatibility with other Philips Semiconductors radio telephone ICs. The data format is shown in Table 1. The first bit entered is dt16, the last bit is ad0. For the divider ratios, the first bits entered (PM16 and PR10) are the most significant (MSB).

The trailing address bits are decoded on the rising edge of \bar{E} . This produces an internal load pulse to store the data in the addressed latch. To avoid erroneous divider ratios, the load pulse is not allowed during data reads by the frequency dividers. This condition is guaranteed by respecting a minimum \bar{E} pulse width after data transfer.

The test register (address 0000) does not normally need to be programmed. However if it is programmed, all bits in the data field should be set to logic 0.

Power-down mode

The synthesizer is on when both the input signals PON and the programmed bit sPON are active. The 'active' level for these two signals is chosen at pin POL (see Table 2). When turned on, the dividers and phase detector are synchronized to avoid random phase errors. When turned off, the phase detector is synchronized to avoid interrupting charge-pump pulses. For synchronisation functions to work correctly on power-up or power-down (using either hardware or software programming), the presence of TCXO and VCO signals is required to drive the appropriate divider inputs. The UMA1021M has a very low current consumption in the power-down mode.

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Table 1 Bit allocation; note 1

| REGISTER BIT ALLOCATION | | | | | | | | | | | | | | | LAST IN | | | | | | | | | | | |
|-------------------------|--------------------------|------|------|------|--------------------|------|---------------------|-------------------------------|-----|-----|---------------------|-----|-----|-----|---------|-----|-----|-----|-----|-----|-----|---|---|---|---|---|
| DATA FIELD | | | | | | | | | | | ADDRESS | | | | | | | | | | | | | | | |
| FIRST IN | dt16 | dt15 | dt14 | dt13 | dt12 | dt11 | dt10 | dt9 | dt8 | dt7 | dt6 | dt5 | dt4 | dt3 | dt2 | dt1 | dt0 | ad3 | ad2 | ad1 | ad0 | | | | | |
| | Test bits ⁽²⁾ | | | | | | | | | | | | | | | | | | | | | | | | | |
| X | X | X | X | X | OOL ⁽³⁾ | X | CR1 | CR0 | X | X | sPON ⁽³⁾ | X | X | X | X | X | X | 0 | 0 | 0 | 0 | 0 | | | | |
| PM16 ⁽⁴⁾ | main divider coefficient | | | | | | | | | | | | | | | | | | | | | | | | | |
| X | X | X | X | X | X | X | PR10 ⁽⁴⁾ | reference divider coefficient | | | | | | | | | | | | | | 0 | 1 | 0 | 0 | 1 |

Notes

1. X = don't care.
2. The test register (address 0000) should not be programmed with any other values except all zeros for normal operation.
3. Bit sPON = software power-up for synthesizer (see Table 2); OOL = Out-Of-Lock (1 = enabled).
4. PM16 is the MSB of the main divider coefficient; PR10 is the MSB of the reference divider coefficient.

Table 2 Power-on programming

| POL | PON | sPON | SYNTHESIZER STATE | COMPATIBILITY |
|-----|-----|------|-------------------|--------------------|
| 0 | 0 | 0 | on | UMA1019M/UMA1019AM |
| 0 | 1 | X | off | UMA1019M/UMA1019AM |
| 0 | X | 1 | off | UMA1019M/UMA1019AM |
| 1 | 0 | X | off | UMA1017M |
| 1 | X | 0 | off | UMA1017M |
| 1 | 1 | 1 | on | UMA1017M |

Table 3 Fast and normal charge pumps current ratio (note 1)

| CR1 | CR0 | Icp | IcPF | IcPF : Icp |
|-----|-----|----------------------|-----------------------|------------|
| 0 | 0 | 2 × I _{SET} | 8 × I _{SET} | 4 : 1 |
| 0 | 1 | 2 × I _{SET} | 16 × I _{SET} | 8 : 1 |
| 1 | 0 | 1 × I _{SET} | 12 × I _{SET} | 12 : 1 |
| 1 | 1 | 1 × I _{SET} | 16 × I _{SET} | 16 : 1 |

Note

1. $I_{SET} = \frac{V_{SET}}{R_{SET}}$; reference current for charge pumps.

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LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

| SYMBOL | PARAMETER | MIN. | MAX. | UNIT |
|-------------------|---|------|----------------|------|
| V_{DD} | digital supply voltage | -0.3 | +5.5 | V |
| V_{CC} | charge-pump supply voltage | -0.3 | +5.5 | V |
| $V_{CC} - V_{DD}$ | difference in voltage between V_{CC} and V_{DD} | -0.3 | +5.5 | V |
| V_n | voltage at pins 6, 8, 9 and 11 to 13 | -0.3 | $V_{DD} + 0.3$ | V |
| | voltage at pins 1, 2, 3, 15, 16, 19 and 20 | -0.3 | $V_{CC} + 0.3$ | V |
| ΔV_{GND} | difference in voltage between any of GND(CP), V_{SS1} , V_{SS2} , and V_{SS3} (these pins should be connected together) | -0.3 | +0.3 | V |
| P_{tot} | total power dissipation | - | 150 | mW |
| T_{stg} | storage temperature | -55 | +125 | °C |
| T_{amb} | operating ambient temperature | -30 | +85 | °C |
| $T_{j(max)}$ | maximum junction temperature | - | 150 | °C |

HANDLING

Inputs and outputs are protected against electrostatic discharge in normal handling. However, to be totally safe, it is desirable to take normal precautions appropriate to handling MOS devices. This device meets class 2 ESD test requirements [Human Body Model (HBM)], in accordance with "MIL STD 883C - method 3015".

THERMAL CHARACTERISTICS

| SYMBOL | PARAMETER | VALUE | UNIT |
|---------------|---|-------|------|
| $R_{th\ j-a}$ | thermal resistance from junction to ambient in free air | 120 | K/W |

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CHARACTERISTICS

All values refer to the typical measurement circuit of Fig.5; $V_{DD1} = V_{DD2} = 2.7$ to 5.5 V; $V_{CC} = 2.7$ to 5.5 V; $T_{amb} = 25$ °C; unless otherwise specified. Characteristics for which only a typical value is given are not tested.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|--|--|---|------|------|--------|------------|
| Supply; pins 4, 14 and 18 | | | | | | |
| V_{DD} | digital supply voltage | $V_{DD1} = V_{DD2}$; $V_{CC} \geq V_{DD}$ | 2.7 | – | 5.5 | V |
| V_{CC} | charge pump supply voltage | $V_{CC} \geq V_{DD}$ | 2.7 | – | 5.5 | V |
| $I_{DD1} + I_{DD2}$ | synthesizer digital supply current | $V_{DD} = 5.5$ V | – | 7 | 9.5 | mA |
| I_{CC} | charge pump supply current | $V_{CC} = 5.5$ V; $R_{SET} = 5.6$ k Ω | – | 3 | 3.8 | mA |
| $I_{CC(pd)} + I_{DD(pd)}$ | total supply current in power-down mode | logic levels 0 V or V_{DD} | – | 5 | 50 | μ A |
| RF main divider input; pin 6 | | | | | | |
| f_{RF} | RF input frequency | | 300 | – | 2200 | MHz |
| $V_{RF(rms)}$ | AC-coupled input signal level (RMS value) | $R_s = 50$ Ω | 50 | – | 225 | mV |
| R_m | main divider ratio | | 512 | – | 131071 | |
| Z_i | input impedance (real part) | $f_{RF} = 1$ GHz | – | 1 | – | k Ω |
| | | $f_{RF} = 2$ GHz | – | 60 | – | Ω |
| C_i | typical pin input capacitance | $f_{RF} = 1$ GHz | – | 1 | – | pF |
| | | $f_{RF} = 2$ GHz | – | 1 | – | pF |
| Synthesizer reference divider input; pins 15 and 16 | | | | | | |
| f_{xtal} | crystal reference input frequency | | 3 | – | 35 | MHz |
| $V_{xtal(rms)}$ | sinusoidal input signal level between pins 15 and 16 (RMS value) | | 50 | – | 500 | mV |
| R_{ref} | reference division ratio | | 8 | | 2047 | |
| Z_i | input impedance (real part) | $f_{xtal} = 13$ MHz | – | 10 | – | k Ω |
| C_i | typical pin input capacitance | $f_{xtal} = 13$ MHz | – | 1.5 | – | pF |
| Phase detector | | | | | | |
| f_{PCmax} | maximum loop comparison frequency | | – | 2000 | – | kHz |
| Charge pump current setting resistor input; pin 19 | | | | | | |
| R_{SET} | external resistor connected between pin 19 and ground | | 5.6 | – | 12 | k Ω |
| V_{SET} | regulated voltage at pin 19 | $R_{SET} = 5.6$ k Ω | – | 1.2 | – | V |

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| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|--|---|---|-------------|---------|----------------|---------------|
| Charge pump outputs; pins 2 and 3; $R_{SET} = 5.6 \text{ k}\Omega$ | | | | | | |
| $I_{ocp(Err)}$ | charge pump output current error | | -25 | - | +25 | % |
| I_{match} | sink-to-source current matching | | - | ± 5 | - | % |
| I_{Llcp} | charge pump off leakage current | $V_{CP/CPF} = \frac{1}{2}V_{CC}$ | -5 | ± 1 | +5 | nA |
| $V_{CP/CPF}$ | charge pump voltage compliance | | 0.4 | - | $V_{CC} - 0.4$ | V |
| Phase noise | | | | | | |
| N_{900} | synthesizer's contribution to close-in phase noise of 900 MHz RF signal at 1 kHz offset (GSM) | $f_{xtal} = 13 \text{ MHz};$ $V_{xtal} = 0 \text{ dBm};$ $f_{PC} = 200 \text{ kHz}$ | - | -88 | - | dBc/Hz |
| N_{1800} | synthesizer's contribution to close-in phase noise of 1.8 GHz RF signal at 1 kHz offset (DCS1800) | $f_{xtal} = 13 \text{ MHz};$ $V_{xtal} = 0 \text{ dBm};$ $f_{PC} = 200 \text{ kHz}$ | - | -82 | - | dBc/Hz |
| Interface logic input signal levels; pins 1, 8, 9, 11, 12 and 13 | | | | | | |
| V_{IH} | HIGH level input voltage | | $0.7V_{DD}$ | - | $V_{DD} + 0.3$ | V |
| V_{IL} | LOW level input voltage | | -0.3 | - | $0.3V_{DD}$ | V |
| I_{bias} | input bias current | logic 1 or logic 0 | -5 | - | +5 | μA |
| C_i | input capacitance | | - | 2 | - | pF |
| Lock detect output signal; pin 20; open-drain output | | | | | | |
| V_{OL} | LOW level output voltage | $I_{sink} < 0.4 \text{ mA}$ | - | - | 0.4 | V |
| t_{OOL} | phase error threshold for out-of-lock detector | | - | 25 | - | ns |

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SERIAL BUS TIMING CHARACTERISTICS

$V_{DD} = V_{CC} = 3\text{ V}$; $T_{amb} = 25\text{ }^\circ\text{C}$; unless otherwise specified.

| SYMBOL | PARAMETER | MIN. | TYP. | MAX. | UNIT |
|---|---------------------------------------|---------------------|------|------|------|
| Serial programming clock; CLK | | | | | |
| t_r | input rise time | – | 10 | 40 | ns |
| t_f | input fall time | – | 10 | 40 | ns |
| T_{cy} | clock period | 100 | – | – | ns |
| Enable programming; \bar{E} | | | | | |
| t_{START} | delay to rising clock edge | 40 | – | – | ns |
| t_{END} | delay from last falling clock edge | –20 | – | – | ns |
| $t_{W(min)}$ | minimum inactive pulse width | 4000 ⁽¹⁾ | – | – | ns |
| $t_{SU;\bar{E}}$ | enable set-up time to next clock edge | 20 | – | – | ns |
| Register serial input data; DATA | | | | | |
| $t_{SU;DAT}$ | input data to clock set-up time | 20 | – | – | ns |
| $t_{HD;DAT}$ | input data to clock hold time | 20 | – | – | ns |

Note

1. The minimum pulse width ($t_{W(min)}$) can be smaller than 4 μs provided all the following conditions are fulfilled:

- a) Main divider input frequency $f_{RF} > \frac{447}{t_{W(min)}}$.
- b) Reference divider input frequency $f_{xtal} > \frac{3}{t_{W(min)}}$.

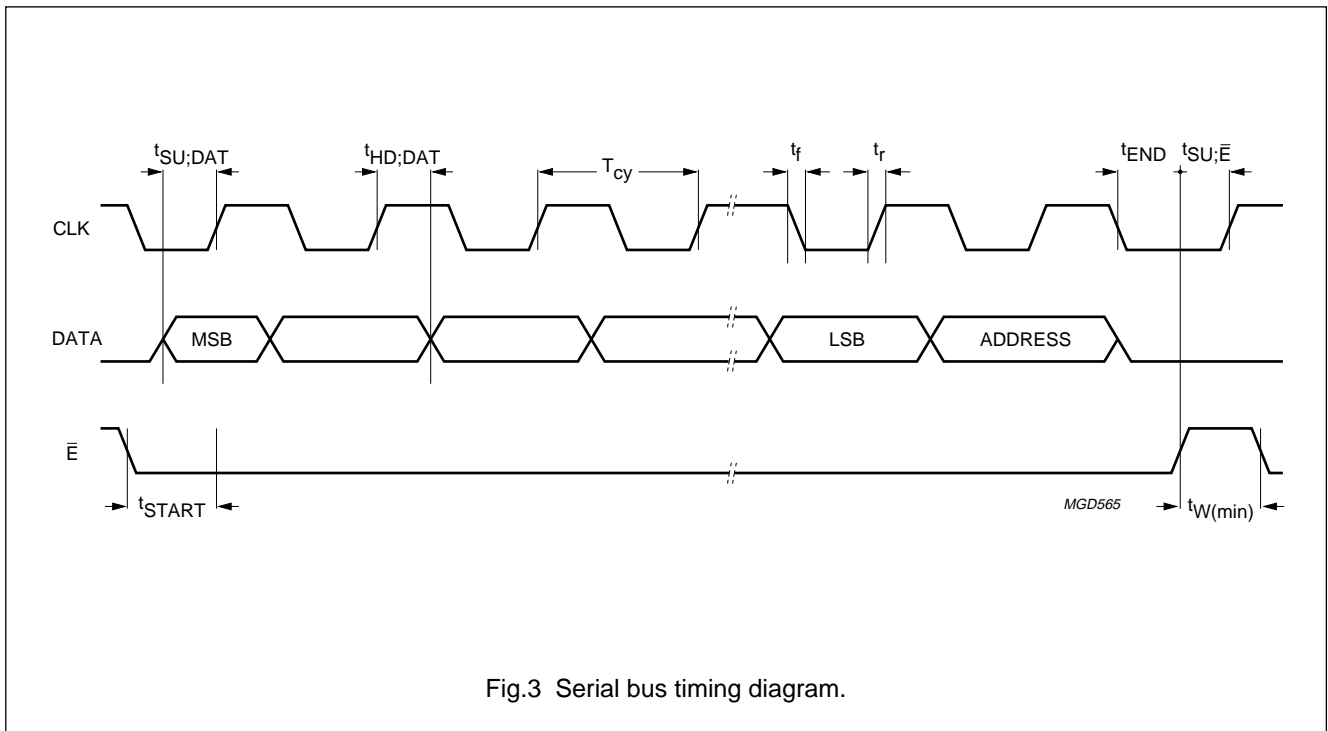


Fig.3 Serial bus timing diagram.

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APPLICATION INFORMATION

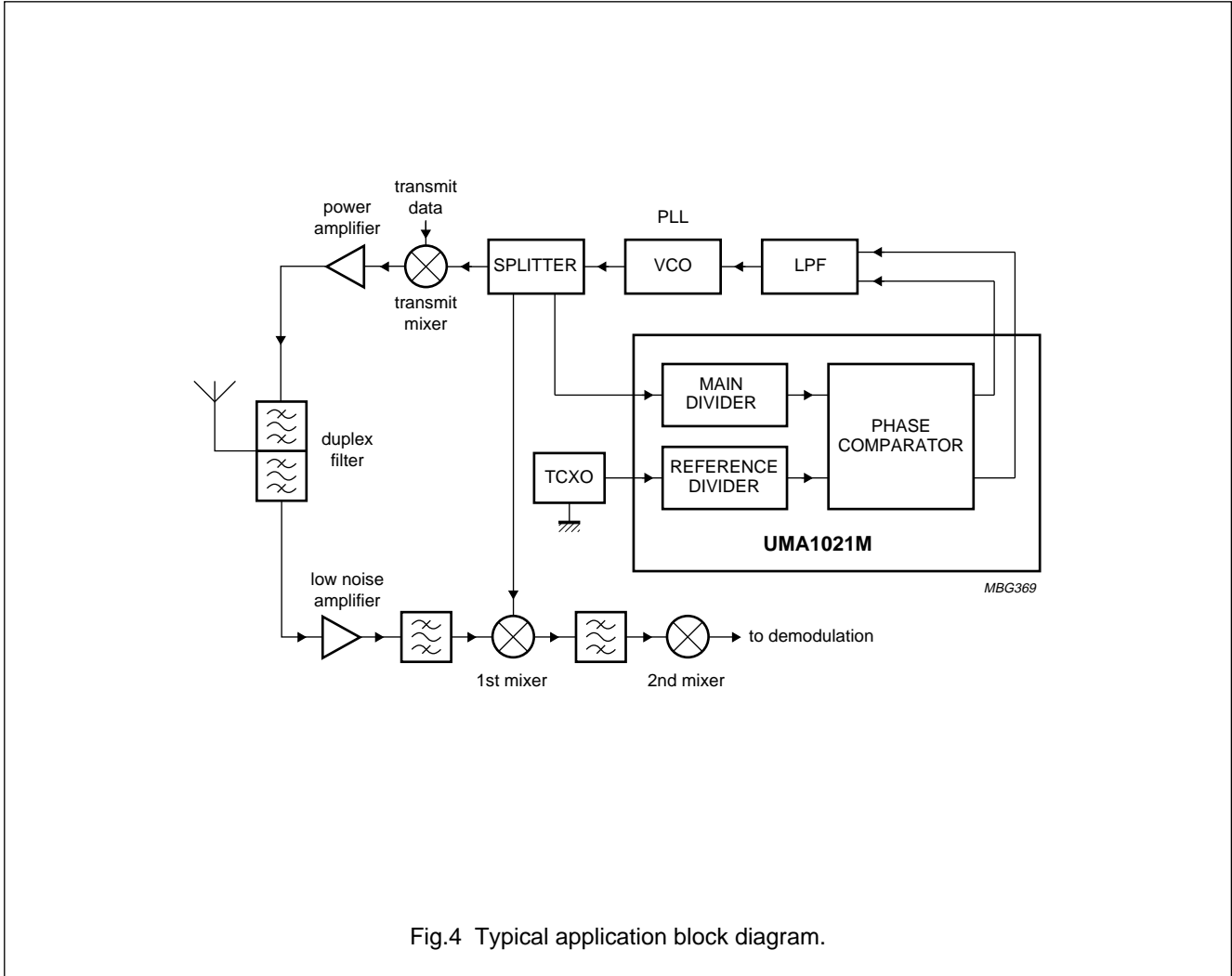
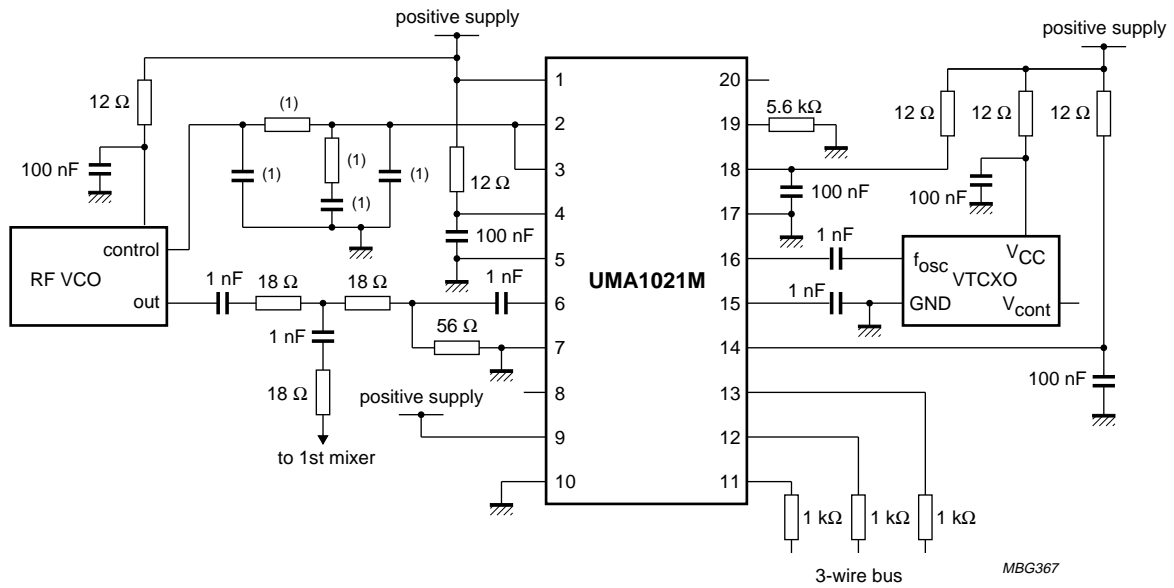


Fig.4 Typical application block diagram.

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(1) Values depend on application.

Fig.5 Typical test and application diagram.

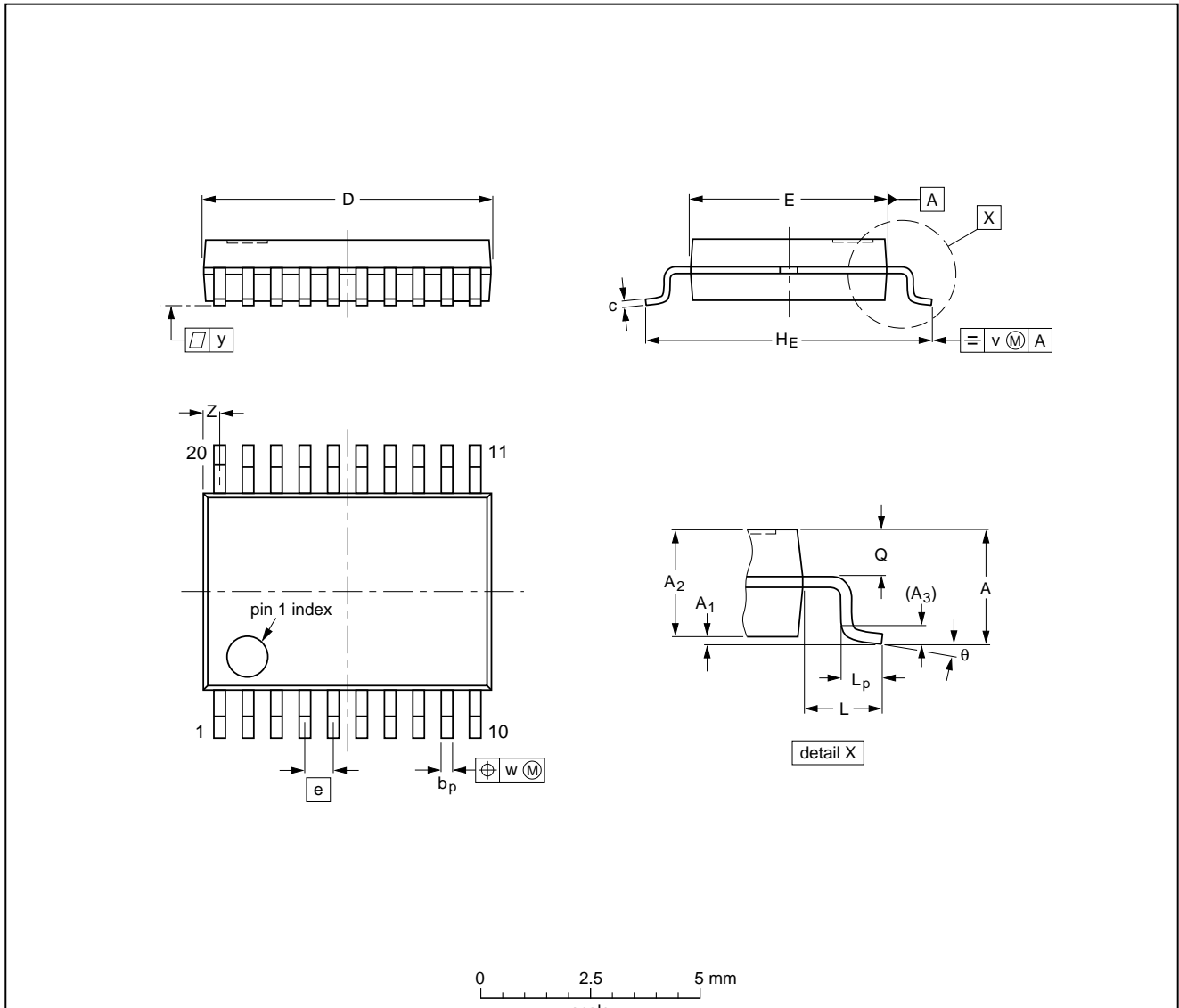
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PACKAGE OUTLINE

SSOP20: plastic shrink small outline package; 20 leads; body width 4.4 mm

SOT266-1



DIMENSIONS (mm are the original dimensions)

| UNIT | A max. | A ₁ | A ₂ | A ₃ | b _p | c | D ⁽¹⁾ | E ⁽¹⁾ | e | H _E | L | L _p | Q | v | w | y | Z ⁽¹⁾ | θ |
|------|--------|----------------|----------------|----------------|----------------|--------------|------------------|------------------|------|----------------|-----|----------------|--------------|-----|------|-----|------------------|-----------|
| mm | 1.5 | 0.15 0 | 1.4 1.2 | 0.25 | 0.32 0.20 | 0.20 0.13 | 6.6 6.4 | 4.5 4.3 | 0.65 | 6.6 6.2 | 1.0 | 0.75 0.45 | 0.65 0.45 | 0.2 | 0.13 | 0.1 | 0.48 0.18 | 10° 0° |

Note

1. Plastic or metal protrusions of 0.20 mm maximum per side are not included.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|-------|------|--|---------------------|----------------------|
| | IEC | JEDEC | EIAJ | | | |
| SOT266-1 | | | | | | 90-04-05 95-02-25 |

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SOLDERING

Introduction

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mounted components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mounted ICs, or for printed-circuits with high population densities. In these situations reflow soldering is often used.

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our "*IC Package Databook*" (order code 9398 652 90011).

Reflow soldering

Reflow soldering techniques are suitable for all SSOP packages.

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt. Dwell times vary between 50 and 300 seconds depending on heating method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 minutes at 45 °C.

Wave soldering

Wave soldering is **not** recommended for SSOP packages. This is because of the likelihood of solder bridging due to closely-spaced leads and the possibility of incomplete solder penetration in multi-lead devices.

If wave soldering cannot be avoided, the following conditions must be observed:

- **A double-wave (a turbulent wave with high upward pressure followed by a smooth laminar wave) soldering technique should be used.**
- **The longitudinal axis of the package footprint must be parallel to the solder flow and must incorporate solder thieves at the downstream end.**

Even with these conditions, only consider wave soldering SSOP packages that have a body width of 4.4 mm, that is SSOP16 (SOT369-1) or SSOP20 (SOT266-1).

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder is 10 seconds, if cooled to less than 150 °C within 6 seconds. Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

Repairing soldered joints

Fix the component by first soldering two diagonally-opposite end leads. Use only a low voltage soldering iron (less than 24 V) applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C. When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

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DEFINITIONS

| | |
|---|---|
| Data sheet status | |
| Objective specification | This data sheet contains target or goal specifications for product development. |
| Preliminary specification | This data sheet contains preliminary data; supplementary data may be published later. |
| Product specification | This data sheet contains final product specifications. |
| Limiting values | |
| Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability. | |
| Application information | |
| Where application information is given, it is advisory and does not form part of the specification. | |

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

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