RF ICs for Wireless Communications
Data Book
1996

TEMIC

TELEFUNKEN Semiconductors

Contents

TEMIC's Commitment to the World of Telecommunication

The Semiconductor Division of TEMIC integrates the products, technologies and resources of leading semiconductor manufacturers into a unified organization conceived for today's worldwide electronics market.

With a technology portfolio which includes bipolar, BICMOS, GaAs, CMOS and DMOS processes, TEMIC Semiconductors provides a unique set of components and solutions for the telecommunications industry.

All basic electronic functions – control and compute, memory, interfacing and power management – are addressed by TEMIC.

While each entity has its specific background and specialities, TEMIC will continuously develop the synergy between its set of technologies and products in order to offer innovative and effective solutions for communication networks as well as desktops or mobile terminals.

Communication systems, whether using analog or digital transmission techniques, rely heavily on advanced semiconductor technologies for realization of the complex VLSI and low-power analog integrated circuits used within them. TEMIC is able to provide the process technologies, a strong application experience and the innovative design necessary to achieve maximum performance and integration goals while ensuring that minimum power consumption is obtained for optimum portable operation.

From analog processing of the microphone signals right to the way through to the UHF antenna output (and, of course, for the return path to the earphone), TEMIC integration skills are in evidence. These also include DSP functions, control, displays and the human interface where high levels of very low-power integration are achieved through use of advanced manufacturing processes provided by the TEMIC group.

For even higher integration, TEMIC can provide subassemblies or multi-chip module, to reduce further the size, weight and power consumption of mobile communication equipment (as well as reducing cost and improving overall reliability).

TEMIC is a leading producer of application-specific semiconductors for high-volume applications. Using bipolar, BICMOS and GaAs technologies, Telefunken Semiconductors develops and delivers a broad range of **A**pplication-**S**pecific **S**tandard **P**roducts (ASSPs) including integrated circuits as well as optoelectronic components and discrete components.

Its portfolio of technologies and experience fits the present and upcoming needs of telecommunications well, from optoelectronic interface and drivers to fast analog and analog-digital signal processing up to RF. Fast switching and protection, high-frequency processing, analog-digital interfacing and infrared transmission are also part of TEMIC's offering for telecommunications.

Small size is achieved by SMD packaging, low-power technologies and high-level integration – replacing many components and manual adjustments as well as characterizing outstanding features of the advanced product developments for battery-powered, portable communication devices.

In this data book you will find TEMIC Telefunken Semiconductors ICs for RF telecommunications. These ICs are designed for different applications, e.g., GSM, DAMPS, DCS1800, PCS, PDC, CT0, CT1 and CT2. To simplify the search for the right device, please refer to the selection guide (see table 1).

Table 1. Selection guide for RF ICs

	Cellular Phones						Cordless Phones				Wireless LAN			
	(D) AMPS	IS-54	GSM	PDC	DCS 1800	PCS 1900	CT1	CT2	DECT	PHS	CDPD	Wi-Lan	CATV	HFC
U2760B, CT2 RX/TX IC								x						
U2781B, 1.1 GHz PLL	x		x				x				x			
U2782B, 1.1 GHz Twin PLL	x		x				x				x			
U2783B, 1.1 GHz/ 400 MHz PLL	x		x						x		x			
U2784B, 2.2 GHz/ 400 MHz Twin PLL				x	x	x			x	x				
U2790B, 1000 MHz Modulator			x								x			
U2791B, 1000 MHz Demodulator	x		x	x							x		x	x
U2793B, 300 MHz Modulator	x		x	x						x	x		x	x
U2794B, 1000 MHz Demodulator	x		x	x							x		x	x
U2795B, 2 GHz Mixer	x		x	x	x	x	x	x	x	x	x			
U2796B, 2.5 GHz Mixer	x		x	x	x	x	x	x	x	x	x			
U2797B, 1000 MHz Modulator	x		x	x							x		x	x
U2891B, 2.5 GHz Up-Converter	x		x	x	x	x	x	x	x	x	x	x		
U3770M, I/Q Modulator								x						
U7001BG, GaAs Front end								x						

IC Overview

TEMIC's strategy is to provide the customers with high performance and high-integrated solutions for wireless applications. Therefore, a chip set for mobile applications (e.g., cellular phones) is introduced first.

This chip set consists of three different I/Q modulators, two demodulators, two mixers and four PLLs which can be selected to fit the customers needs appropriately. The basic block diagram of a mobile telephone RF part is shown in figure 1 and figure 2.

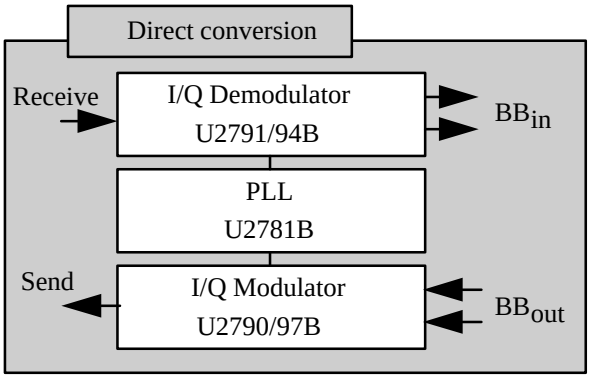


Figure 1. Direct conversion

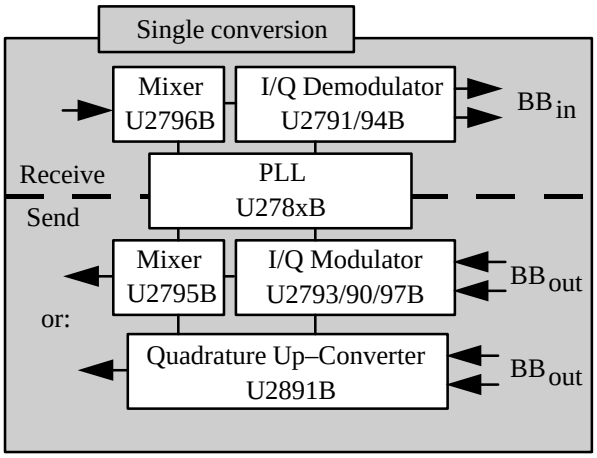


Figure 2. Single conversion

I/Q Modulators and Demodulators

Due to the principle of I/Q modulation, the devices are suitable for all different kinds of modulation like e.g. QAM, MSK, GMSK, FSK, DQPSK. This includes applications in mobile phones, satellite and cable TV.

TEMIC offers three I/Q modulators for RF communication for the frequency range from 30 – 1000 MHz.

U2793B is the modulator for the IF in the 30 – 300 MHz range. It features a power consumption of 15 mA for an output power of 0 dBm and a sideband suppression of 45 dB at 150 Mhz. It is especially suited for designs that make use of high Q-series bandpass filters between the modulator and the up-conversion mixer.

U2790B is the modulator which can be used for direct conversion in the frequency range from 100 to 1000 MHz. This circuit features a power consumption of 30 mA for an output level of -1 dBm at a sideband suppression of 40 dB at 900 MHz and 35 dB at 150 MHz.

U2797B is the newest IC in the modulator family. It is based on the U2790B and features a higher baseband input impedance than U2790B and a smaller package (SSO20).

For a short overview, the main differences of the modulators are listed in table 2.

U2791B is the I/Q demodulator for frequencies between 100 and 1000 MHz. The device features a power consumption of 28 mA, a double sideband noise figure of 12 dB and a third-order intercept point of 3 dBm.

U2794B is a variation of U2791B. The minimum operation frequency is lowered to 70 MHz and the output DC offset is decreased below 5 mV. Therefore, higher amplification in the baseband part is possible.

The main differences of the two quadrature demodulators are listed in table 3.

In all TEMIC I/Q modulators and demodulators, a patended phase splitter and a 90° phase shift control loop are integrated. Therefore, no external components are needed for the phase shifting.

Table 2. Comparison of TEMIC quadrature modulators

	U2790B	U2793B	U2797B
LO frequency range	100 to 1000 MHz	30 to 300 MHz	100 to 1000 MHz
Current consumption	Typically 30 mA	Typically 15 mA	Typically 30 mA
Baseband input	Typically 3.2 kΩ	Typically > 100 kΩ	Typically > 100 kΩ
Internal biasing of base-band inputs	Yes	No (external biasing circuit using the imple-mented reference voltage possible)	No (external biasing circuit using the imple-mented reference voltage possible)
Package	SO16 package	SSO20 package	SSO20 package

Table 3. Comparison of TEMIC quadrature modulators

	U2791B	U2794B
LO frequency range	100 to 1000 MHz	70 to 1000 MHz
RF frequency range	100 to 1000 MHz	50 to 1000 MHz
Baseband output DC offset voltage	Typically < 30 mV	Typically < 5 mV
Package and pinning	SSO20 package, identical pinning as U2794B with exeption of Pin 15 = ground	SSO20 package, identical pinning as U2791B with exeption of Pin 15 = LOX_{in} (may be ac-grounded)

Special Features

Although the phase shift performance of the ICs is excellent, some I/Q modulators feature extra pins to optimize the phase shift externally in case that external components show phase inaccuracies. At the PC/PCX pins, a potentionmeter (see figure 3) can be connected which affects the phase control loop in the following way: the phase difference of the I and Q signal is below 90° if V_S is turned towards PC or more than 90° when V_S is turned towards PCX. The total control range with an 10 kΩ potentio-meter is approximately ± 5°. These pins can also be used for software-controlled optimization of the phase performance, for example to compensate a non-constant group delay of a subsequent filter.

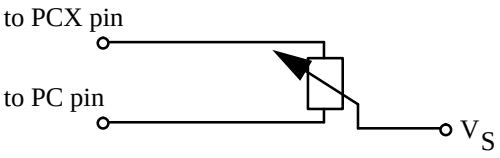


Figure 3.

A special feature of the U2793B (and also U2891B) is the possibility to connect a very narrow band LC filter just behind the I/Q modulation part via extra pins as shown in figure 4.

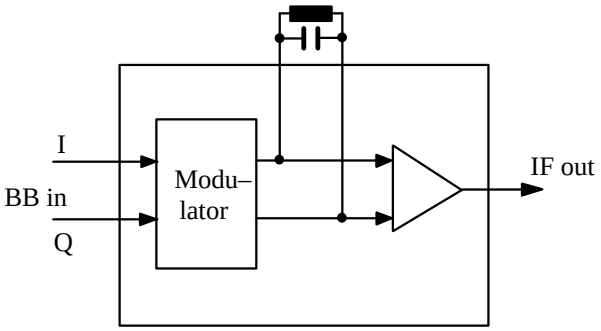


Figure 4.

This simple and cheap technique enables the customer to save costs in the RF filter part; e.g. in a mobile phone application, the performance of a low-cost duplexer is sufficient and saves money.

Mixers

The chip set for RF telecom applications includes two mixers: U2795B is designed for up-conversion, U2796B is designed for down-conversion.

U2795B is a double-balance mixer designed for up-conversion , but can also be used for down conversion. It can be operated from 50 MHz – 2.5 GHz, inputs and outputs

are single-ended. This mixer features an output compression point of -7 dBm, a third-order intercept point of -1 dBm – both of which are programmable – and a noise figure of 1 dB. U2795B works in a supply voltage range of 2.7 to 5.5 V, and is perfectly suited for dual-conversion applications or offset loop digital modulation designs.

U2796B can be operated in the same supply-voltage range and in a frequency range of 0 to 2.0 GHz. It is a single-balanced mixer with a power consumption of 3.2 mA for a gain of 9 dB, third-order intercept point of -4 dB and a noise figure of 9 dB.

Up-Converter

The I/Q quadrature Up-Converter U2891B is an integration of TEMIC's U2793B modulator and the 2.5 GHz mixer. U2891B is a full 3 V solution in a shrink small outline package (SSO24). The integrated I/Q modulator features a frequency range of 30 – 500 MHz at a current consumption of 14 mA. The LO frequency is internally regenerated and the patended phase shifter (with a 90° control loop) is also integrated. The mixer of U2891B can be operated up to 2.5 GHz at a current consumption of 11 mA. Of course U2891B has two separate power-down functions for modulator and mixer with a very low current consumption in sleep mode of < 1 µA.

PLLs

The new telecom PLLs from TEMIC cover the frequency range of 200 MHz to 2.2 GHz.

The single PLL U2781B features a frequency range up to 1.1 GHz at a current consumption of 5 mA. A programmable 64/65 or 128/129 prescaler is integrated.

The Twin PLL U2782B doubles the functionality of U2781B and therefore features two PLLs with a maximum operating frequency of 1.1 GHz for both PLLs. The 64/65 prescaler is also integrated. The current consumption of U2782B is 11 mA. The Twin PLL U2783B integrates a PLL for frequencies up to 1.25 GHz and a PLL for the frequency range up to 400 MHz, the integrated prescaler factors are 64/65 and 32/33, respectively. The current consumption is about 10 mA. The highest frequency range is covered by the Twin PLL U2784B, featuring one PLL for 2.2 GHz and one PLL for 200 MHz. Here, the prescaler factors are 64/65 and 8/9 respectively. Due to the high maximum operating frequency, this device has the highest current consumption of 12 mA.

The PLLs are programmed via the 3-wire bus with a clock rate up to 1 MHz. The charge pump current can be switched for each higher frequency PLL of the Twin PLLs by a factor of five to 1 mA. The two PLLs of the Twin PLLs can be powered up or down separately by hardware connectors.

The main features of the PLLs are listed in table 4.

The value of the phase noise at the phase comparator is calculated to -147 dBc/Hz to be compared to other ICs. The phase noise in the loop depends very much on the application and the used scaling factors. Therefore, the phase noise (PN_c) can be calculated as follows:

$$PN_c = PN_m - 20 \times \log (S_{tot})$$

PN_m is the measured phase noise in the loop and S_{tot} is the total scaling factor.

An important feature of all telecom PLLs is the high input sensitivity of 20 mV/rms. Therefore, the VCO can be operated at a much lower level and the PLL still locks correctly. Using a lower VCO level reduces crosstalk problems.

Table 4. TEMIC high-speed PLLs at a glance

Type	Frequency Range PLL 1	Frequency Range PLL 2	Typical Current Consumption	Package
U2781B	1100 MHz		5 mA	SSO20
U2782B	1100 MHz	1100 MHz	11 mA	SSO20
U2783B	1250 MHz	400 MHz	10 mA	SSO20
U2784B	2200 MHz	200 MHz	12 mA	SSO20

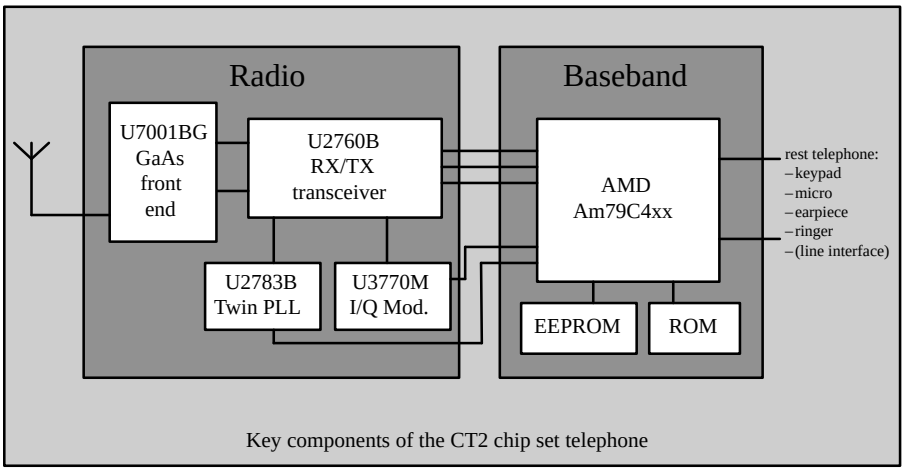


Figure 5.

CT2 Chip Set

The CT2 chip set (see figure 5) was developed together with the French company Wavecom. The CT2 chip set consists of four ICs representing the complete RF part of the telephone and an AMD PhoX™ controller (Am79C4xx). The design of the complete telephone (PCB and bill of material) was made by Wavecom. In contrast to the analog standards like CT1, CT2 offers the advantages of digital standards, e.g. high transmission quality and low susceptibility to eavesdropping.

The four TEMIC ICs come in SSO or SO packages to save space. In the GaAs front end of U7001BG, the antenna switch, the power amplifier and the low noise amplifier are integrated. In the receive mode, the device has a current consumption of only 4 mA and in the transmit mode of less than 39 mA. The power amplifier features the very high efficiency of 45%.

The RX/TX IC U2760B, a bipolar monolithic silicon chip, includes the mixers, the VCOs (**V**oltage-**C**ontrolled **O**scillators), the demodulator and the RSSI (**R**eceive **S**ignal **S**trength **I**ndicator). One of the key features of this high integrated device is the low-current consumption of 23 mA and the simple external circuitry with very few components.

The twin PLL (**P**hase **L**ocked **L**oop) U2783B is also a bipolar silicon chip for frequencies up to 1250 MHz and 400 MHz for the two PLLs respectively. Both can be operated with one external reference frequency. The I/Q modulator U3770M is made by using a CMOS technology. It also generates the clock frequency of the system.

Manufacturers of digital cordless phones can choose between two different approaches:

1. Customers can develop their own design based on the TEMIC CT2 chip set. They will be supported by TEMIC with samples and test boards. In this case, customers get the complete RF part of the cordless phone which can be operated at 3 V and is completely adjustment-free. The complete system integration, however, has to be done by the customers themselve.
2. Customers can use the full CT2 know-how of TEMIC and Wavecom. Wavecom can provide customers with the demo board (for the complete telephone) as well as the schematics, the bill of material and the software license. Wavecom can also support the full product integration and the transfer to production. In this case, customers get a complete phone with a stand-by time of 380 h and a talk time of 36 h. The size of the phone PCB is below $55 \times 45 \times 10$ mm^2. It can be operated with only two battery cells.

The advantage of this approach is obvious: low risk, short time-to-market.

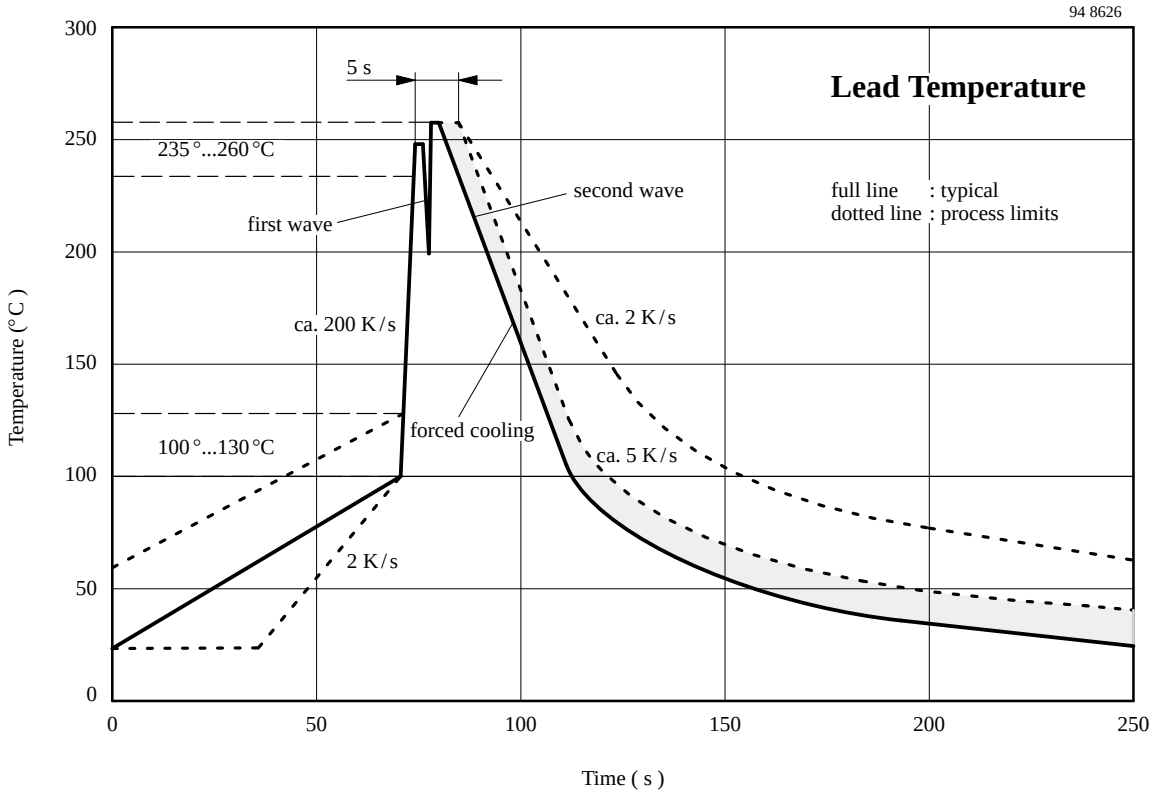


Figure 6.

Assembly Instructions

TEMIC's RF ICs are all in SMD (**S**urface-**M**ount **D**evice) packages. They can be mounted directly onto the surface of a printed circuit board.

The main concern during assembly is the prevention of ESD (**E**lectro**S**tatic **D**ischarge) and overheating of the device. The recommended maximum soldering temperatures and time-temperature profils are shown in figure 6.

Note: Excessive heating of the device can cause malfunction.

Quality Data

With the extensive system of qualification, probing and final tests, TEMIC endeavors to supply customers with ICs which fulfill the specifications of the OEM industry.

If you are interested in detailed information regarding the quality assurance of semiconductor components, please ask for the booklet ‘Quality and Reliability’.

- Process control by SPC, FMEA and DOE.
- All TEMIC facilities are ISO9001-approved
- General flow of electrical test and lot release:
  1. Wafer probing:
     – 100% of dice and wafers tested
  2. Final test:
     – 100% of packaged products tested
     – 100% of function and specified parameters tested
     – Test window correlates with specified limits and specified temperature range of data
  3. Lot release:
     – Electrical test 200 – 0
     – Visual inspection/ mechanical defects 200 – 0

These precautions result in the delivery quality shown in figure 7.

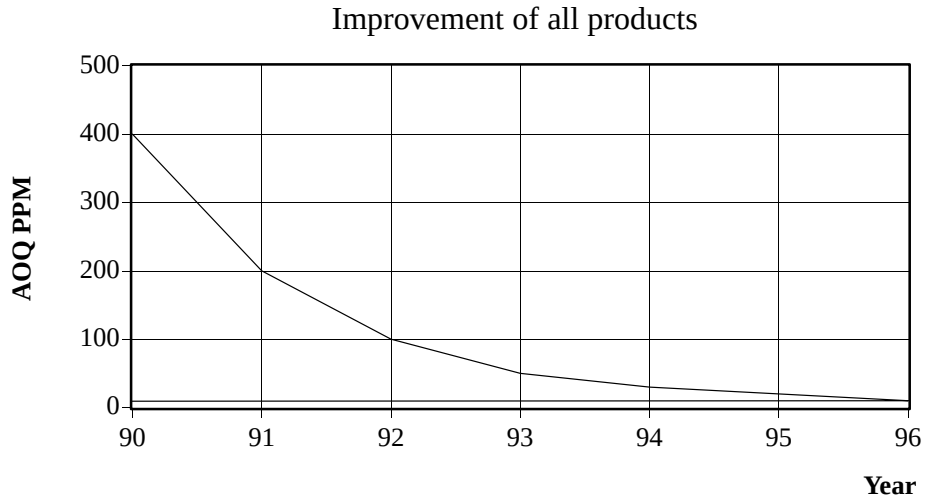
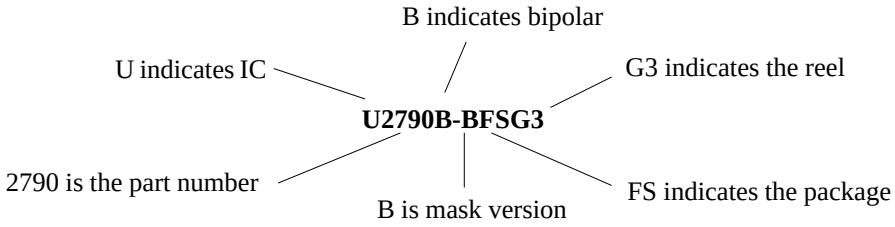


Figure 7. Worldwide electrical AOQ

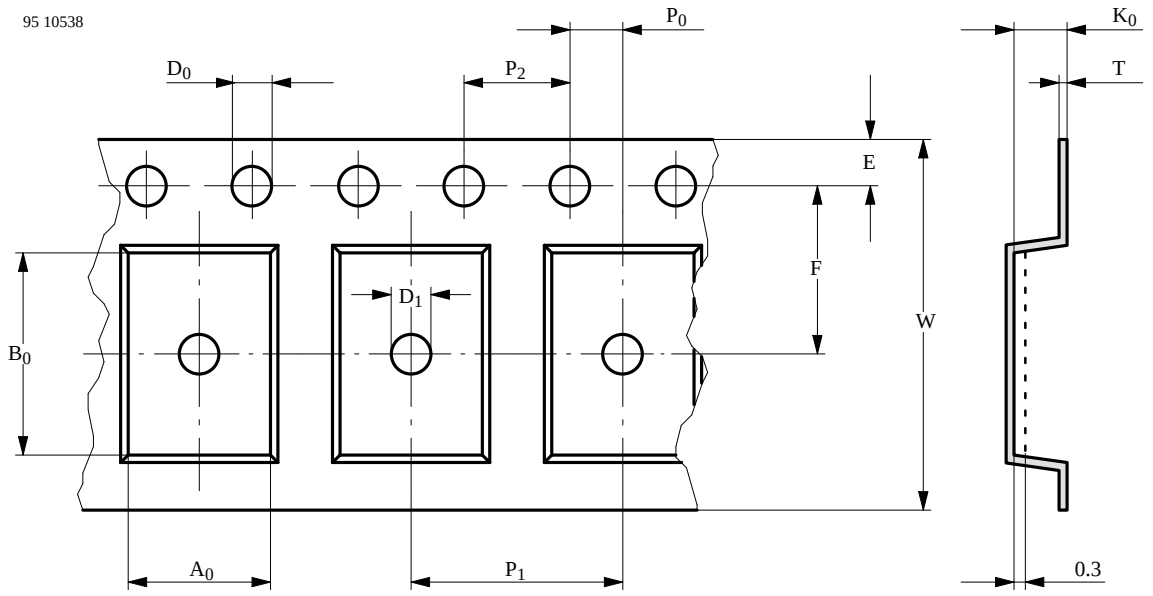
Ordering Information

Structure of TEMIC's part numbers:



Part Number	Packaging	Pcs per Rail/ Reel	Min. Order Quantity
U2760B–AFS	rail	60	600
U2760B–AFSG3	reel	4000	4000
U2781B–AFS	rail	83	830
U2781B–AFSG3	reel	4000	4000
U2782B–AFS	rail	83	830
U2783B–AFSG3	reel	4000	4000
U2783B–AFS	rail	83	830
U2783B–AFSG3	reel	4000	4000
U2784B–BFS	rail	83	830
U2784B–BFSG3	reel	4000	4000
U2790B–BFP	rail	56	560
U2790B–BFPG3	reel	4000	4000
U2791B–AFS	rail	83	830
U2791B–AFSG3	reel	4000	4000
U2793B–AFS	rail	83	830
U2793B–AFSG3	reel	4000	4000
U2794B–AFS	rail	83	830
U2794B–AFSG3	reel	4000	4000
U2795B–CFP	rail	112	1120
U2795B–CFPG3	reel	4000	4000
U2796B–BFP	rail	112	1120
U2796B–BFPG3	reel	4000	4000
U2797B–AFS	rail	83	830
U2797B–AFSG3	reel	4000	4000
U2891B–AFS	rail	69	690
U2891B–AFSG3	reel	4000	4000
U3770M–AFP	rail	56	560
U3770M–AFPG3	reel	4000	4000
U7001BG–AFS	rail	83	830
U7001BG–AFSG3	reel	4000	4000
U6024BS–AFP	rail	112	1120
U832BS–AFP	rail	112	1120
U832BS–AFPG3	reel	4000	4000

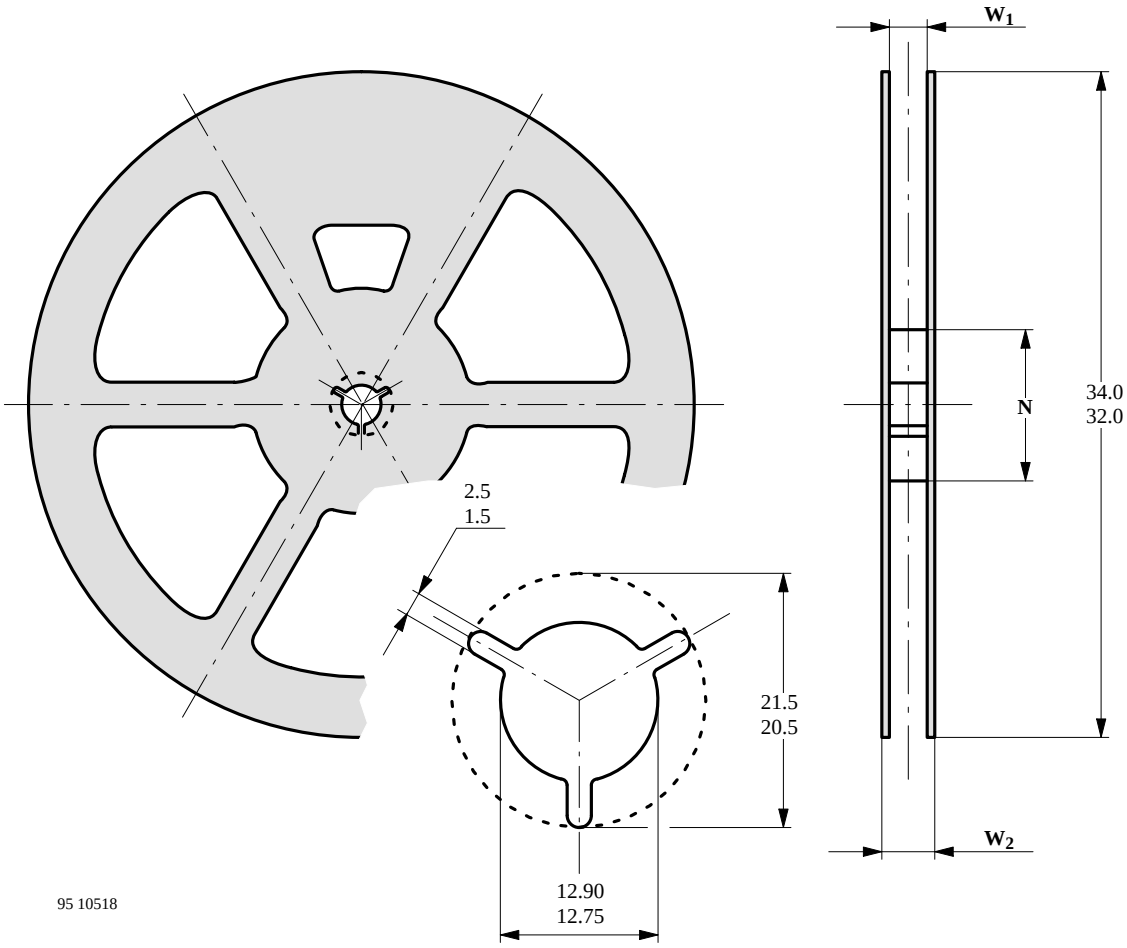
Packaging Information



Package	Punched Cavaty			Carrier Tape Sizes									Material
	A_0	B_0	K_0	W	T	P_0	P_2	P_1	D_0	D_1	E	F	
SO8	6.4 ± 0.1	5.2 ± 0.1	2.1 ± 0.1	12 ± 0.3	0.3 max.	4 ± 0.1	2 ± 0.1	8 ± 0.1	1.5 ± 0.1	1.5 ± 0.1	1.75 ± 0.1	5.5 ± 0.05	Conduc-tive
SO16	6.4 ± 0.1	10.3 ± 0.1	2.1 ± 0.1	16 ± 0.3	0.3 max.	4 ± 0.1	2 ± 0.1	8 ± 0.1	1.5 ± 0.1	1.5 ± 0.1	1.75 ± 0.1	7.5 ± 0.05	Conduc-tive
SSO20	6.6 ± 0.1	6.65 ± 0.1	1.5 ± 0.1	12 ± 0.3	0.3 max.	4 ± 0.1	2 ± 0.1	8 ± 0.1	1.5 ± 0.1	1.5 ± 0.1	1.75 ± 0.1	5.5 ± 0.05	Conduc-tive
SSO24	6.6 ± 0.1	7.95 ± 0.1	1.5 ± 0.1	16 ± 0.3	0.3 max.	4 ± 0.1	2 ± 0.1	8 ± 0.1	1.5 ± 0.1	1.5 ± 0.1	1.75 ± 0.1	5.5 ± 0.05	Conduc-tive
SSO28	6.6 ± 0.1	9.25 ± 0.1	1.5 ± 0.1	16 ± 0.3	0.3 max.	4 ± 0.1	2 ± 0.1	8 ± 0.1	1.5 ± 0.1	1.5 ± 0.1	1.75 ± 0.1	5.5 ± 0.05	Conduc-tive

Packaging Information

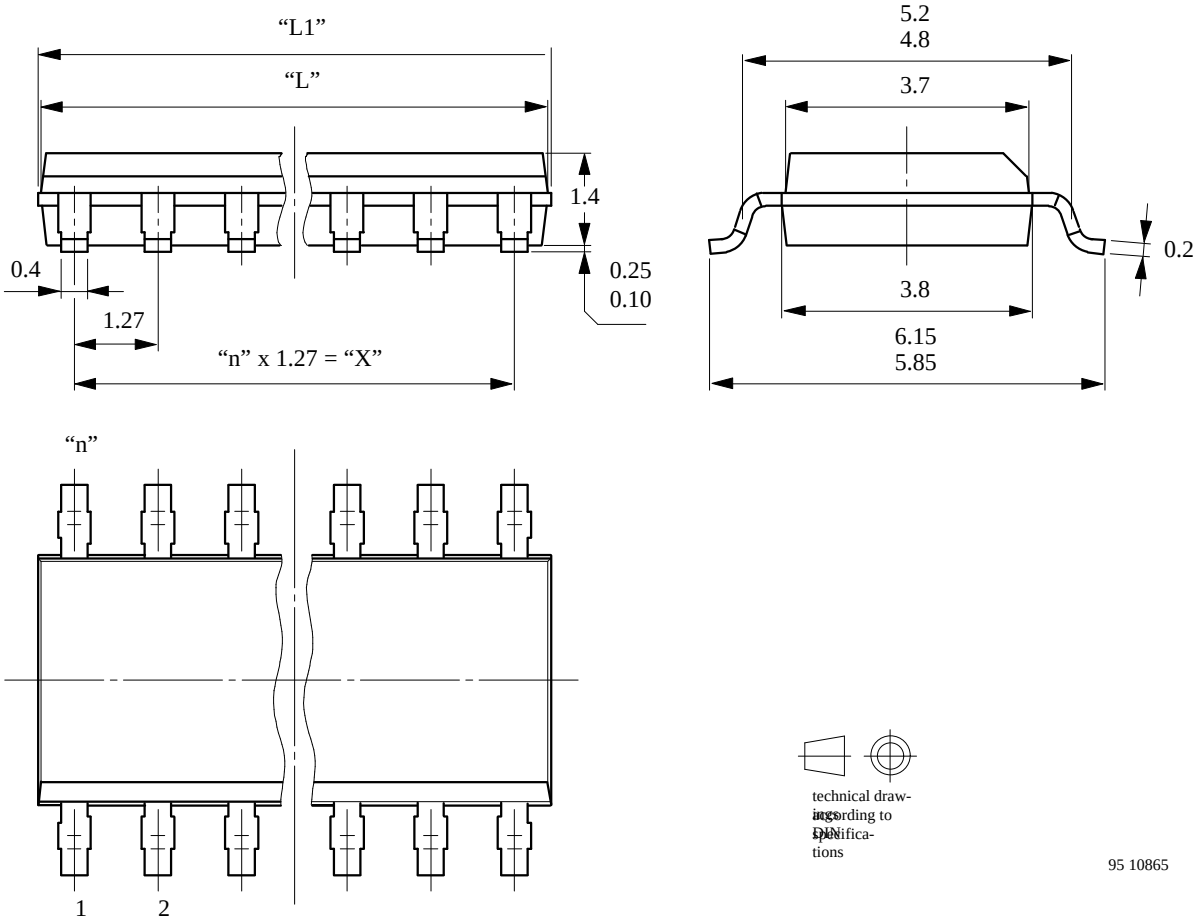
SO8 – 16, SSO20 – 28 tape and reel



Version	Tape Width “W”	“N”	“W_1”	“W_2 max.”
A	12	62 ± 1.5	12.4 +2 / –0	18.4
B	16	60.5 to 77.5	16.4 +2 / –0	22.4
C	24	100 ± 1.5	24.4 +2 / –0	30.4
D	36	100 ± 1.5	32.4 +2 / –0	38.4

Dimensions in mm

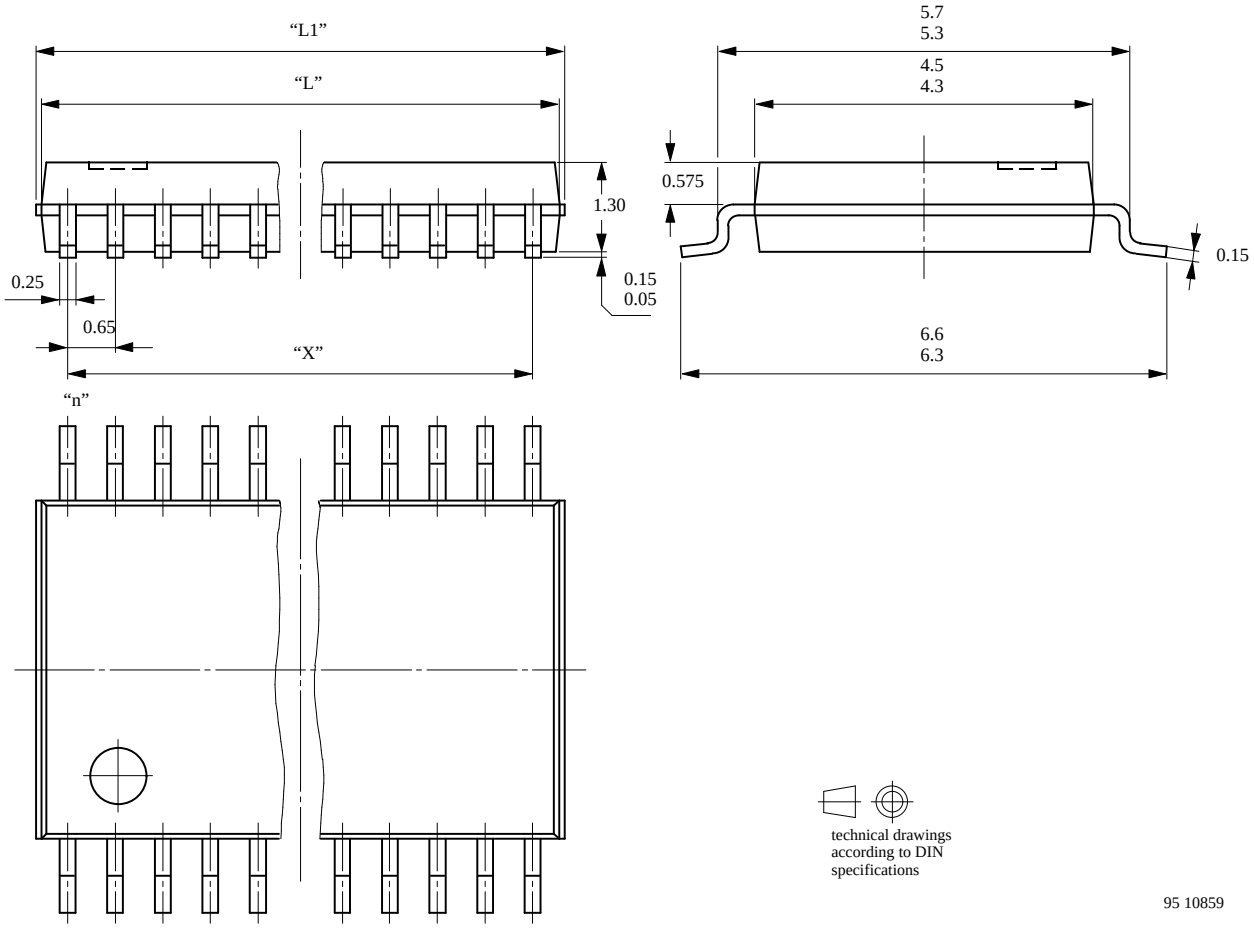
Package: SO8 – SO16



Dimension	Package	Millimeters	
		Min.	Max.
L1	SO8	4.85	5.00
L1	SO16	9.85	10.00
L	SO8	4.90	4.90
L	SO16	9.90	9.90

Dimensions in mm

Package: SSO20 – 28



Dimension	Package	Millimeters	
		Min.	Max.
L1	SSO20	6.50	6.75
L1	SSO24	7.80	8.05
L1	SSO28	9.10	9.35
L	SSO20	6.50	6.70
L	SSO24	7.80	8.00
L	SSO28	9.01	9.03