



**SMD  
(SURFACE MOUNTED DEVICES)  
REPAIR**

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<b>TABLE OF CONTENTS</b>	<b>PAGE</b>
1. INTRODUCTION	3
2. SMD ADVANTAGES	4
3. SMD LIMITATIONS	4
4. SMD DIALECT	5
5. SMD SIZES AND DIMENSIONS	6
5.1. SMD RESISTORS	6
5.1.1. CONSTRUCTION OF THE SMD RESISTORS	7
5.1.2. MARKING OF THE SMD RESISTORS	7
5.2. SMD TRIMMOTS	9
5.3. SMD CERAMIC MULTILAYER CHIP CAPACITORS	10
5.4. SMD TANTALIUM CAPACITORS	11
5.4. SMD DIODES AND TRANSISTORS	13
5.5. SMD INTEGRATED CIRCUITS	14
5.5.1. DIMENSIONS OF SO - , VSO - , PLCC - AND QFB - CASES	16



## **1. INTRODUCTION**

At earlier eighties began a trend to replace a traditional through - hole technique with the surface mounted technology (SMT) using surface mounted devices (SMD). The SMT, although intended in principle for automatic manufacturing only expand more and more, even into a hobby world. This trend will continue, because many new components are available in SMD versions only. The SMT technique opens advantages and new applications through miniaturising of the components and increasing of reliability. The industry standard unfortunately allows that most of the SMD components does not have a clear description. Since a tiny size of the components they are labelled with a code. Therefore a sure identification of the components is impossible without appropriate technical documentation. Moreover the polarity and pin - outs of different components could be not identified without data sheets. Since all of this factors is SMD for beginners a very hard job.

This brochure brings a help and clearance for a newcomer and moreover should help a service technician to start a repair of the instruments made with the SMD components. It presents most of the SMD components available at the 1998 end with pin-outs and encoding comparison tables: SMD / classic and classic / SMD. The SMD does not present a “new technique”, it is only a miniaturisation of the components. But this components requires a different processing technology.

Surface mounted devices (SMD) are active and passive electronics components without conventional connecting wires.

In the conventional through - hole technology (THT) the components are placed on the “components side” of the printed circuit board (PCB), wires inserted into holes, and soldered to the copper pads on the opposite, “solder side” of the PCB.

The SMD components will be placed on the “solder side” of the PCB and their metal caps soldered to the copper pads of the PCB. Therefore both layers of the PCB could be used as active areas. A thickness of PCBs used for SMD is between 0.8 and 1.00 mm. Historically roots of SMD are hybrid circuits on the ceramic substrates (middle of seventies) but a huge industrial applications of SMD started on a begin eighties.

Miniaturisation of the SMD does not stop. Distance between connection pins is reduced to 0.5 mm (past standard 1.27 mm). The winning standard for capacitors and resistors is **0402** (1.0 x 0.5 mm). The **0402** standard requires ten times less area then standard **1208** and five times less then standard **0805**.



## **2. SMD ADVANTAGES**

1. PCBs area much smaller then by conventional through - hole components.
2. Since the both layers of the PCB could be used for assembling the final PCBs area for the same circuits could be decreased by 50 %.
3. Simple assembling - no bounding and cutting of the wires.
4. Automatic assembling very easy. Low cost of the assembling.
5. Small size of components makes very high packing density possible. For the same circuits a volume of a module assembled with SMD could be reduced to 30 % of the device assembled with the conventional technique. Therefore a size of the whole instrument decrease, too.
6. Very high resistance to mechanical shock and vibration.
7. Low store and transport cost. Low store area and volume.
8. Lack of hole's drilling and metallisation.
9. Thin pads.
10. For great series low manufacturing cost.

## **3. SMD LIMITATIONS**

The real goal of the SMD applications are a maximal packing density and finally volume reduction of the modules and instruments. Exactly this generates for which responsible are not the SMD themselves, but the miniaturisation in general.

1. Using ICs with a high amount of the pins (raster 0.5 to 1.27 mm, max. 148 pins) makes placing of the paths between IC pins impossible.
2. Design of SMD layout is very complex. Distances between soldering pads are fix. Dimensions and distances between paths depends from soldering technology used by manufacturer.
3. High packing density brings thermal problems. Power dissipation of the power components is transferred directly through a copper layer of the PCB. The high temperature of the layer influence a neighbour components.
4. Lack of the general SMD normalisation.
5. Not all SMD components are labelled with a clear text. Moreover, very often the components have no labels at all.
6. Repair is more complex and difficult than by the conventional components.



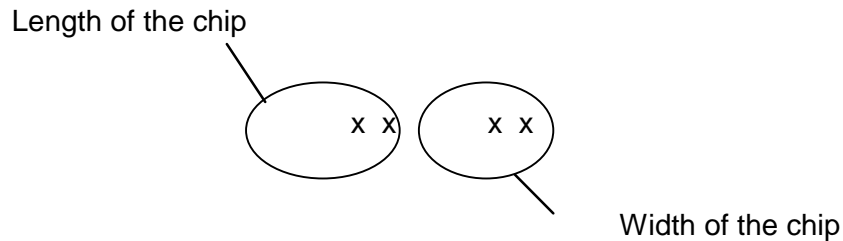
#### **4. SMD DIALECT**

<b>SMD</b>	<b>Surface Mounted Devices</b> (active, passive and electromechanical components)
<b>SMT</b>	<b>Surface Mounted Technology</b> (assembling and montage technology)
<b>SMA</b>	<b>Surface Mounted Technology</b> (module assembled with SMT)
<b>SMD / C</b>	<b>Surface Mounted Devices / Components</b> (components for SMT)
<b>SMP</b>	<b>Surface Mounted Packages</b> (SMD case forms)
<b>SME</b>	<b>Surface Mounted Equipment</b> (SMT assembling machines)
<b>SO</b>	<b>Small Outline</b> (4 to 28 pins)
<b>VSO</b>	<b>Very Small Outline</b> (40 pins)
<b>SOP</b>	<b>Small Outline Package</b> (case)
<b>SOD</b>	<b>Small Outline Diode</b>
<b>SOT</b>	<b>Small Outline Transistor</b>
<b>SOIC</b>	<b>Small Outline Integrated Circuit</b>
<b>CC</b>	<b>Chip Carrier</b>
<b>LCC</b>	<b>Leadless Chip Carrier</b>
<b>PLCC</b>	<b>Plastic Leadless Chip Carrier</b>
<b>LCCC</b>	<b>Leadless Ceramic Chip Carrier</b>
<b>MELF</b>	<b>Metal Electrode Face Bonding</b>
<b>MINI MELF</b>	<b>Mini Metal Electrode Face Bonding</b>
<b>MICRO MELF</b>	<b>Micro Metal Electrode Face Bonding</b>



## 5. SMD SIZES AND DIMENSIONS

The coded description of the any SMD case form consists four digits which represents a length and a width in 1/100" (2.54 mm).



EXAMPLE:

### Form 0805

Length      25.4 mm x 0.08 = 2.032 mm  
Width        25.4 mm x 0.05 = 1.27 mm

### 5.1. SMD RESISTORS

**Table 5.1.1.** Dimensions of the thick film chip resistors

FORM	POWER (Watt)	LENGHT (mm)	WIDTH (mm)
0402	0.063	1.0	0.5
0503	0.063	1.27	0.75
0505		1.27	1.25
0603	0.062	1.60	0.80
0705		1.91	1.27
0805	0.1	2.00	1.25
1005	0.125	2.55	1.25
1010		2.55	2.55
1206	0.25	3.2	1.6
1210	0.25	3.2	2.6
1505		3.8	1.25
2010	0.5	5.08	2.55
2208		5.72	1.90
2512	1.0	6.5	3.25
MELF		5.5	2.2
MINIMELF		3.6	1.4
MICROMELF		2.0	1.27



SMD resistors are available as a chip (rectangular form), or as a MELF (cylinder form). In SMT instead of the jumpers “zero  $\Omega$  resistors” are used. They are available in all standard SMD resistors dimensions and coded mostly with “000”.

The most popular resistors case forms are **1206** ( $l = 3.2$  mm,  $w = 1.6$  mm,  $h = 0.6$  mm,  $P_{max} = 0.25$  W by  $70^\circ$ ) and **0805** ( $l = 2$  mm,  $w = 1.25$  mm,  $P_{max} = 0.125$  W by  $70^\circ$ ). The rectangular chip forms are the same as for capacitors and could be processed by layout design, assembling and repair with the same rules.

The resistance values range is between 1  $\Omega$  and 10 M $\Omega$  and “zero  $\Omega$ ” jumper.

### 5.1.1. CONSTRUCTION OF THE SMD RESISTORS

Chip resistors are constructed with use of the thick film technique on a ceramic substrate. They have metallic areas on the narrow ends of the chip, which allows soldering. The resistive path is covered with a protective glaze. Chip resistors could be soldered with all common soldering techniques: reflow, wave and solder iron.

### 5.1.2. MARKING OF THE SMD RESISTORS

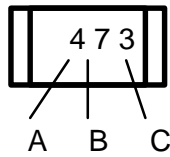
5% and 2% SMD chip resistors are available in values according to IEC E 24 line and marked with the following code:

**Table 5.1.2.1.** 5% and 2% resistors code

RESISTOR	IMPRINT
0 $\Omega$ (bridge)	000
1.0 $\Omega$ to 9.1 $\Omega$	XR $X$ (i.e. 9R1)
10 $\Omega$ to 91 $\Omega$	XXR (i.e. 91R)
100 $\Omega$ to 10 M $\Omega$	See Table 6.3.2.



**Table 5.1.2.2.** Examples



A = 1<sup>st</sup> digit of the resistor's value  
 B = 2<sup>nd</sup> digit of the resistor's value  
 C = number of zeros

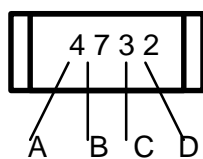
IMPRINT	RESISTANCE VALUE
101	100 Ω
471	470 Ω
102	1 kΩ
122	1.2 kΩ
103	10 kΩ
123	12 kΩ
104	100 kΩ
124	120 kΩ
474	470 kΩ

1% SMD chip resistors are coded with 3 - or 4 - digits. Available values in line E24 (E96).

**Table 5.1.2.3.** 1% resistor code

RESISTOR	IMPRINT
100 Ω to 988 Ω	XXXR
1 kΩ to 1 MΩ	XXXX

**Table 5.1.2.4.** Examples



A = 1<sup>st</sup> digit of the resistor's value  
 B = 2<sup>nd</sup> digit of the resistor's value  
 C = 3<sup>th</sup> digit of the resistor's value  
 D = number of zeros

IMPRINT	RESISTANCE VALUE
100R	100 Ω
634R	634 Ω
909R	909Ω
1001	1kΩ
4701	4.7 kΩ
1002	10 kΩ
1502	15 kΩ
5493	1549 kΩ
1004	1 MΩ

MELF resistors are available in the three case forms:





MELF form 0204, l=5.9 mm, d=2.2 mm  
MINIMELF form 0204, l=3.5 mm, d=1.5 mm  
MICROMELF form 0207, l=2.2 mm, d=1.1 mm

Resistance's value of the MELF resistors are marked with the standard 4 or 5 rings code used by conventional resistors. MELF resistors are available in IEC E24, E96 and E192 lines, but not all tolerances are available.

"Zero  $\Omega$  resistors" are available. Maximum load current is 2 A. The labels are "000" or "0R0".

**Table 5.1.2.5.** International resistors colour code

4-COLORS CODE 5-COLORS CODE	1 RING 1 RING	2 RING 2 - 3 RING	3 RING 4 RING	4 RING 5 RING	TOLERANCE
black	0	0	-	violet	0.1%*100 $\Omega$ -100k $\Omega$
brown	1	1	0	blue	0.25%*47 $\Omega$ -100k $\Omega$
red	2	2	00	green	0.5%*10 $\Omega$ -330k $\Omega$
orange	3	3	000	brown	1%*1 $\Omega$ -5.1M $\Omega$
yellow	4	4	0000	red	2%*1 $\Omega$ -10M $\Omega$
green	5	5	00000	gold	5%*0.22-10M $\Omega$
blue	6	6	000000		
violet	7	7			
grey	8	8			

## 5.2. TRIMMPTS

SMD trimmpots are available in two different mechanical cases: three and four pins. The fourth pin serves as a mechanical support only. The power dissipation of the SMD trimmpot is 0.2 W. The slide could be turned a full angle of 360°, but active angle is 270° only. The rest 90° is a "dead zone", where the slide has no contact to a resistance path. The value of resistance vary between 100  $\Omega$  and 1 M $\Omega$ .

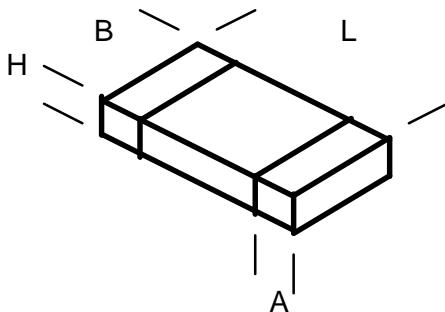


### 5.3. CERAMIC MULTILAYER CHIP CAPACITORS

Ceramic multilayer chip capacitors are available with a very wide range of values, from 0.47 pF to 1  $\mu$ F. These values are covered by seven case forms. The form depends on the capacitor values. The most popular case forms are **0805** and **1206**. Unfortunately, these components are not marked, either with digital values, or colour code. This fact does not represent any problem for industry, where the components are assembled from the roll, but is very dangerous for the service technician.

Be very careful with non-marked components! Avoid mixing them!

**Table 5.3.1.** Ceramic multilayer chip capacitors case forms.



CASE FORM	L (mm)	B (mm)	H (mm)	A (mm)
0508	2.0	1.25	0.51 to 1.27	0.25 to 0.75
0603	1.6	0.8	0.80	
1206	3.2	1.6	0.51 to 1.6	0.25 to 0.75
1210	3.2	2.5	0.51 to 1.9	0.3 to 1.0
1808	4.5	2.0	0.51 to 1.9	0.3 to 1.0
1812	4.5	3.5	0.51 to 1.9	0.3 to 1.0
2220	5.7	5.0	0.51 to 1.9	0.3 to 1.0



## 5.4. SMD TANTALIUM CAPACITORS

SMD tantalum capacitors are available in different case forms, partly without printed values. The + polarity is marked by white line, or white “M”. The case forms depend of capacitance value and nominal voltage.

SMD tantalum capacitors standard sizes are:

- 3.2 x 1.8 mm
- 3.5 x 2.8 mm
- 6.0 x 3.2 mm
- 7.3 x 4.3 mm

The values are coded with digits, or with alphanumerical characters.

### CODING WITH DIGITS:

- first position gives the first digit of the capacitance value
- second position gives the second digit of the capacitance value
- third position gives the number of zeros for value in pF

### EXAMPLE:

Description “224” means 220 000 pF = 220 nF = 0.22 μF

### CODING WITH ALPHANUMERICAL CHARACTERS:

#### CAPACITANCE CODE

CAPACITANCE (pF)	1	1.5	2.2	3.3	4.7	6.8
CODE	A	E	J	N	S	W
MULTIPLICATOR	10 <sup>5</sup>	10 <sup>6</sup>				
CODE	5	6				

#### NOMINAL VOLTAGE CODE

VOLT	4	6.3	10	16	20	25	35
CODE	G	J	A	C	D	E	V

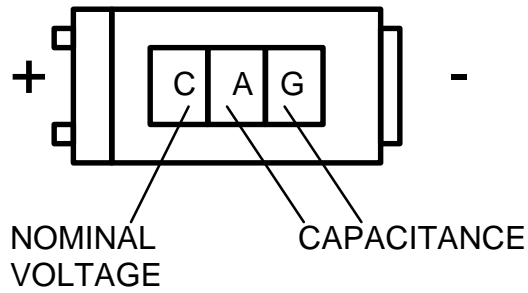


1 EXAMPLE:

1.0  $\mu\text{F}$ , 16 V ..... CA\*

0.22  $\mu\text{F}$ , 35 V ..... VJ\*

2.2  $\mu\text{F}$ , 6.3 V .....JJ\*

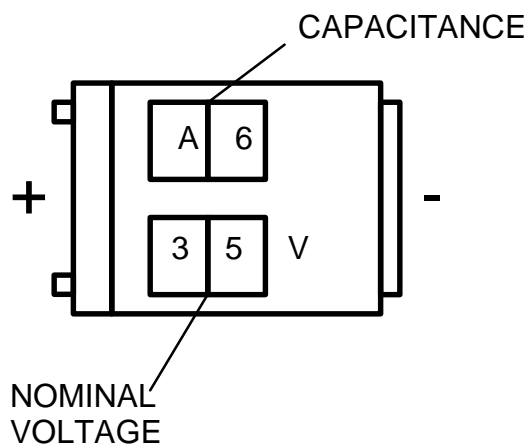


2 EXAMPLE:

A6 .....  $1.0 \times 10^6$  pF = 1.0  $\mu\text{F}$

J5 .....  $2.2 \times 10^5$  pF = 0.22  $\mu\text{F}$

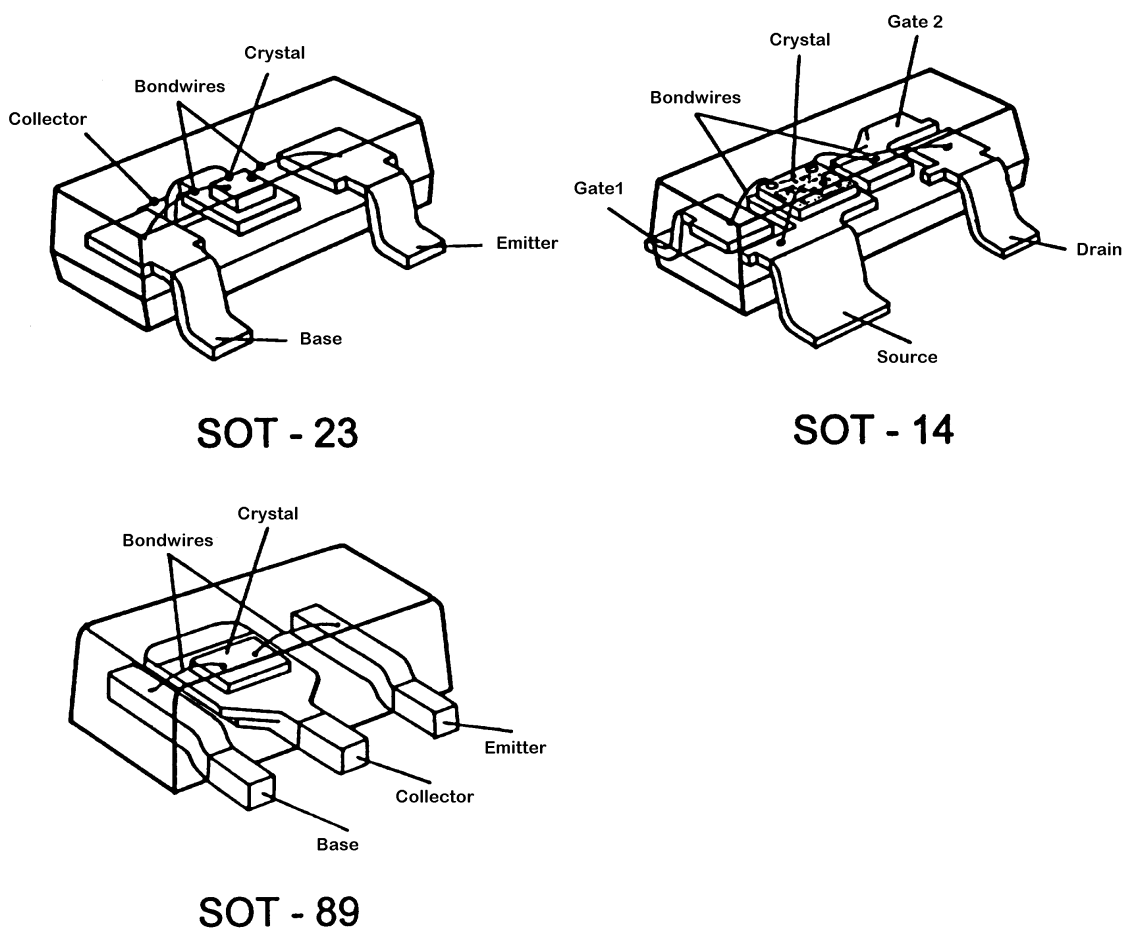
J6 .....  $2.2 \times 10^6$  pF = 2.2  $\mu\text{F}$





## 5.4. SMD DIODES AND TRANSISTORS

Almost all standard diodes and transistors are available as SMD components in SOT - 23, SOT - 89 and SOT - 143 cases. In general electrical parameters of SMD diodes and transistors are the same as comparable standard types in conventional cases. SOT - 23, and SOT - 143 cases are used for components with power dissipation 200 to 400 mW. SOT - 89 cases are used for power dissipation 500 mW to 1W. SMD LEDs are available in SOT - 23 cases. All SMD transistors are marked with codes.



**Figure 5.4.1.** SOT - xx cases



**Table 5.4.1** Examples of SMD transistors coding.

MARK	COMPONENT	CASE
1J	BC848A	SOT -23
4G	BC860C	SOT -23
1F*	MMBT5550	SOT -23
1F*	BC847B	SOT -23
AA*	BCW60A	SOT -23
AA*	BCX51	SOT -89

**\* Hint**

The same mark does not mean the same component!

If SMD transistors with the same marks have different case forms their technical specifications are different as well!

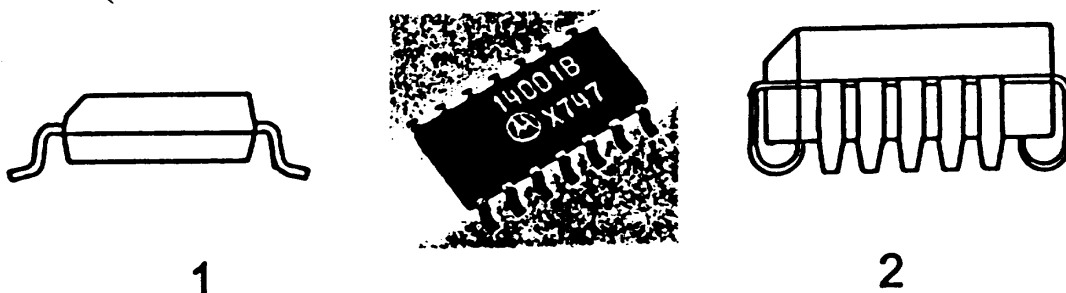
## 5.5. SMD INTEGRATED CIRCUITS

The first SMD ICs were manufactured on begin 70' for hybrid technique. Nowadays (February 1999) are many of new ICs design manufactured in SMD only.

ICs in SMD cases are electrically fully compatible to types in DIL cases therefore both of them have the same marking. The different for SMD (SO-xx case )is only the last character of the mark; i.e. LM 324 N (DIL) = LM 324 D (SO).

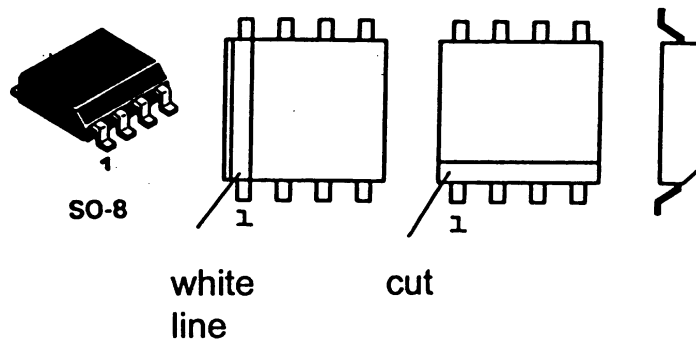
SO cases are produced with two different pin forms:

1. pins bent outside of the case
2. pins bent under the case



**Fig. 5.5.1.** SO case forms.

Pin 1 is marked by a white line on a top of the case or a cut on a front of the case (see Fig. 6.5.2).



**Fig. 5.5.2.** Pin 1 marking.

Different case types have different pin forms and pinout.

**SO (Small Outline)** is used for ICs with 8 to 28 pins. Pins raster is 1.27 mm. Case width is 4 mm for 8, 14 and 16 pins cases and 7.6 mm for 8, 16, 20, 24 and 28 pins cases.

**VSO (Very Small Outline)** is used for ICs with more than 28 pins. Pins raster is 0.76 mm or 0.75 mm (check data sheets of the particular IC).

**PLCC (Plastic Leaded Chip Carrier)** cases are used for ICs with more than 28 pins (i.e. 44 pins). Pins are placed on the all four sides on the case and bent under it. The form of pins gives relative high resistance of the PLCC case against mechanical influence. Negative is relative high case (4.57 mm standard) and localisation of the solder paths with pins raster 1.27 mm under the case. The soldering and following optical quality control of the connections are difficult.

Number of pins is given in description of the case, i.e. PLCC - 20 means that the IC has 20 pins.

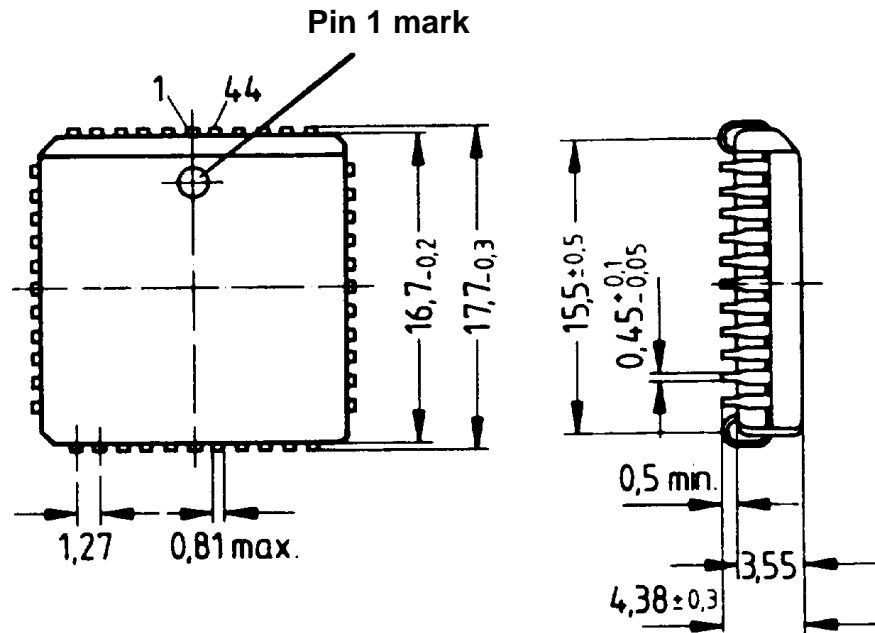


Table 5.5.3. PLCC - 44 case.

**QFP (Quad Flat Pack Case).** In opposite to PLCC case the pins are bent outside of the case. Since it could have a very small raster (1 mm, 0.85 mm, 0.75 mm and 0.65 mm) it represents a very compact case with very high count of pins (over 100).

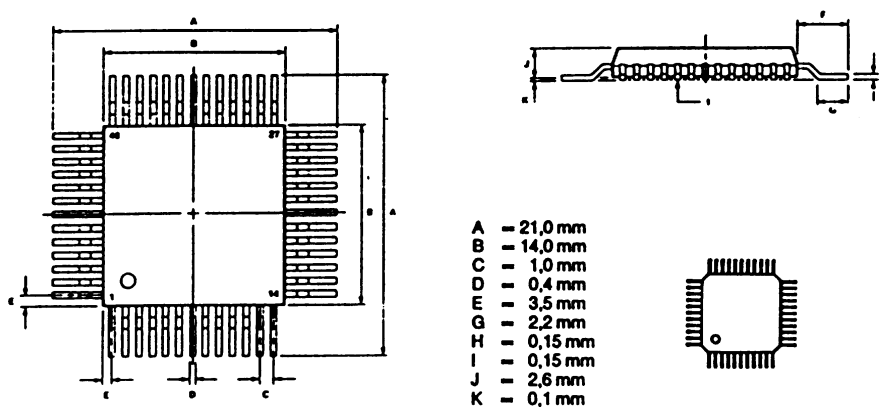


Table 5.5.4. QFP - 48 case





### 5.5.1. DIMENSIONS OF SO - , VSO - , PLCC - AND QFB - CASES

**Table 5.5.1.1**

CASE	NUMBER OF PINS	WIDTH (mm)	LENGHT (mm)	RASTER (mm)
SO - 8	8	4.0	5.0	1.27
SO - 8L	8	7.6	7.6	1.27
SO - 14	14	4.0	8.75	1.27
SO - 16	16	4.0	10.0	1.27
SO - 16L	16	7.6	10.5	1.27
SO - 20L	20	7.6	13.0	1.27
SO - 24L	24	7.6	15.6	1.27
SO - 28L	28	7.6	18.1	1.27
VSO - 40	40	7.6	15.5	0.76
VSO - 56	56	11.1	21.6	0.75
PLCC - 20	20	9.04	9.04	1.27
PLCC - 28	28	11.58	11.58	1.27
PLCC - 44	44	16.66	16.66	1.27
PLCC - 52	52	19.2	19.2	1.27
PLCC - 66	66	24.33	24.33	1.27
PLCC - 84	84	29.41	29.41	1.27
QFB - 44	44	14	14	1.0
QFB - 48	48	10	10	0.75

“L” cases are around 4 mm wider than normal SO cases. The dimensions of plastic cases could vary, but raster and connection width of the pins are always the same.