

EMI filters E01 & E07 feedthrough capacitors

The E01 and E07 ranges of feedthrough MLCC chip 'C' filters are 3 terminal chip devices designed to offer reduced inductance compared to conventional MLCCs when used in signal line filtering.

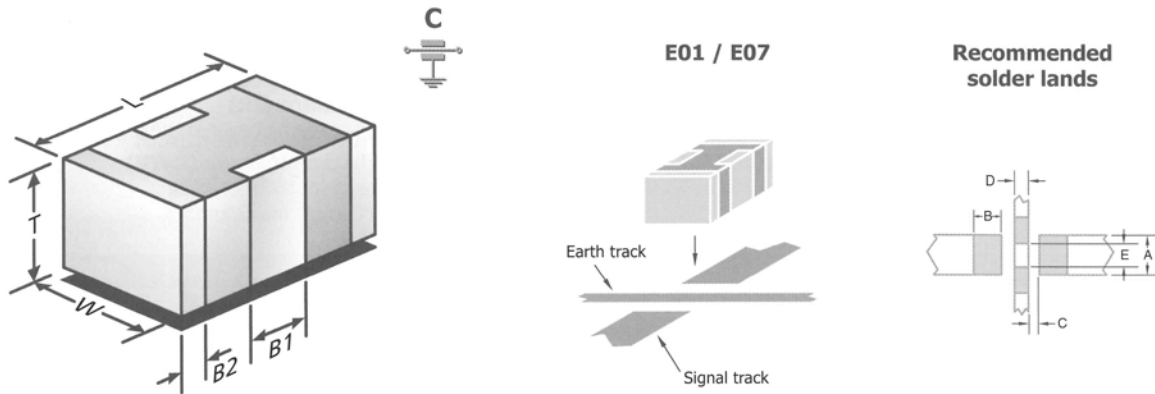
The filtered signal passes through the chip internal electrodes and the noise is filtered to the grounded side contacts, resulting in reduced length noise transmission paths.

Available in COG/NPO & X7R dielectrics, with current ratings of 300mA, 1A, 2A, 3A and voltage ratings of 25Vdc to 200Vdc. Also available with FlexiCap™ termination which is strongly recommended for new designs.

Commonly used in automotive applications, a range qualified to AEC-Q200 is also available.

Electrical Details		
Capacitance Range		10pF to 1.8µF
Temperature Coefficient of Capacitance (TCC)	COG/NPO	0 ± 30ppm/°C
	X7R	±15% from -55°C to +125°C
Dissipation Factor	COG/NPO	Cr > 50pF ≤ 0.0015
	X7R	Cr ≤ 50pF = 0.0015(15 ÷ Cr + 0.7)
Insulation Resistance (IR)		100GΩ or 1000secs (whichever is the less)
Dielectric Withstand Voltage (DWV)		Voltage applied for 5 ± 1 seconds, 50mA charging current maximum
Ageing Rate	COG/NPO	Zero
	X7R	<2% per time decade

E01 300mA, **E07** 1A/2A/3A



Dimensions

	0805	1206	1806	1812
L	2.0 ± 0.3 (0.079 ± 0.012)	3.2 ± 0.3 (0.126 ± 0.012)	4.5 ± 0.35 (0.177 ± 0.014)	4.5 ± 0.35 0.18 ± 0.014
W	1.25 ± 0.2 (0.049 ± 0.008)	1.6 ± 0.2 (0.063 ± 0.008)	1.6 ± 0.2 (0.063 ± 0.008)	3.2 ± 0.3 0.126 ± 0.012
T	1.0 ± 0.15 (0.039 ± 0.006)	1.1 ± 0.2 (0.043 ± 0.008)	1.1 ± 0.2 (0.043 ± 0.008)	2.0 ± 0.3 (0.079 ± 0.012)
B1	0.60 ± 0.2 (0.024 ± 0.008)	0.95 ± 0.3 (0.037 ± 0.012)	1.4 ± 0.3 (0.055 ± 0.012)	1.45 ± 0.35 (0.057 ± 0.014)
B2	0.3 ± 0.15 (0.012 ± 0.006)	0.5 ± 0.25 (0.02 ± 0.01)	0.5 ± 0.25 (0.02 ± 0.01)	0.75 ± 0.25 (0.03 ± 0.01)
	0805	1206	1806	1812
A	0.95 (0.037)	1.2 (0.047)	1.2 (0.047)	2.65 (0.104)
B	0.9 (0.035)	0.9 (0.035)	1.4 (0.055)	1.4 (0.055)
C	0.3 (0.012)	0.6 (0.024)	0.8 (0.031)	0.8 (0.031)
D	0.4 (0.016)	0.8 (0.031)	1.4 (0.055)	1.4 (0.055)
E	0.75 (0.030)	1.0 (0.039)	1.0 (0.039)	2.05 (0.081)

- Notes: 1) All dimensions mm (inches).
 2) For length (L) of FlexiCap™ terminated parts, add 0.1mm (0.004") to upper tolerance limit. For example, case size 0805 with FlexiCap™ termination has length of 2.0 +0.40/-0.30 (0.079 +0.016/-0.012).
 3) Pad widths less than chip width gives improved mechanical performance.
 4) The solder stencil should place 4 discrete solder pads. The unprinted distance between ground pads is shown as dimension E.
 5) Insulating the earth track underneath the filters is acceptable and can help avoid displacement of filter during soldering but can result in residue entrapment under the chip.

Type		E01		
Chip Size		0805	1206	1806
Max Current		300mA	300mA	300mA
Max DC Resistance		0.4Ω	0.35Ω	0.35Ω
Rated Voltage	Dielectric	Standard Range – minimum/maximum capacitance values		
25Vdc	COG/NPO	180pF-1.5nF	560pF-3.9nF	820pF-4.7nF
	X7R	470pF-100nF	5.6nF-330nF	3.9nF-560nF
50Vdc	COG/NPO	22pF-820pF	22pF-3.3nF	22pF-3.9nF
	X7R	560pF-68nF	4.7nF-220nF	3.3nF-330nF
100Vdc	COG/NPO	22pF-560pF	22pF-2.2nF	22pF-3.3nF
	X7R	560pF-27nF	1.8nF-100nF	3.3nF-180nF
200Vdc	COG/NPO	-	560pF-1.2nF	56pF-1nF
	X7R	-	2.7nF-56nF	3.9nF-100nF
Rated Voltage	Dielectric	AEC-Q200 Qualified Range – minimum/maximum capacitance values		
50Vdc	COG/NPO	22pF-820pF	22pF-1nF	22pF-2.2nF
	X7R	560pF-47nF	4.7nF-100nF	3.3nF-200nF
100Vdc	COG/NPO	22pF-560pF	22pF-1nF	22pF-2.2nF
	X7R	560pF-15nF	1.8nF-15nF	3.3nF-68nF

Type		E07			
Chip Size		0805	1206	1806	1812
Max Current		1A	2A	2A	3A
Max DC Resistance		0.06Ω	0.06Ω	0.06Ω	0.06Ω
Rated Voltage	Dielectric	Standard Range - minimum/maximum capacitance values			
25Vdc	COG/NPO	180pF-1.5nF	<u>560pF-3.9nF</u>	<u>820pF-4.7nF</u>	-
	X7R	820pF-100nF	10nF-330nF	22nF-560nF	560nF-1.8μF
50Vdc	COG/NPO	10pF-220pF	22pF-1nF	100pF-1.5nF	-
	X7R	1nF-68nF	10nF-220nF	22nF-330nF	330nF-1.5μF
100Vdc	COG/NPO	10pF-120pF	22pF-560pF	100pF-680pF	-
	X7R	1nF-27nF	10nF-100nF	22nF-180nF	180nF-820nF
200Vdc	COG/NPO	-	15pF-180pF	56pF-470pF	-
	X7R	-	12nF-56nF	22nF-100nF	100nF-270nF
Rated Voltage	Dielectric	AEC-Q200 Qualified Range – minimum/maximum capacitance values			
50Vdc	COG/NPO	10pF-220pF	22pF-1nF	100pF-1.5nF	-
	X7R	1nF-47nF	10nF-100nF	22nF-200nF	-
100Vdc	COG/NPO	10pF-120pF	22pF-560pF	100pF-680pF	-
	X7R	1nF-15nF	10nF-15nF	22nF-68nF	-

Note: E07 25Vdc COG/NPO 1206 to 1806 have a maximum current of 1A

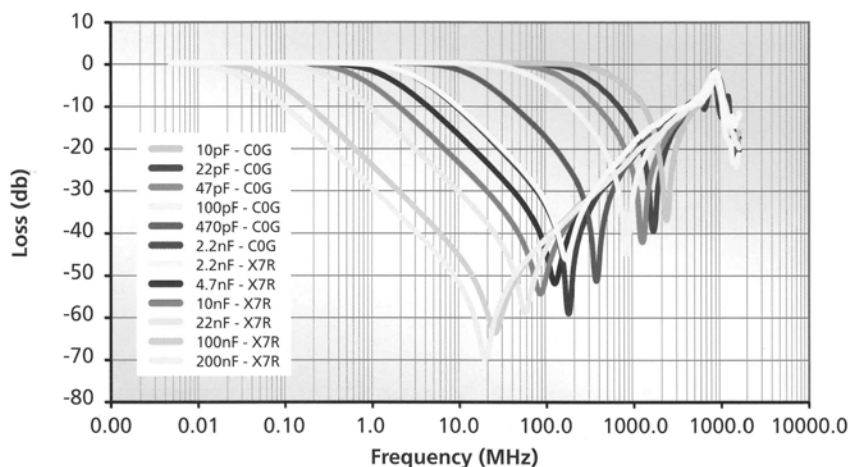
Ordering Information – E01 & E07 feedthrough capacitors

1206	Y	100	0103	M	X	T	E07
Chip Size	Termination	Rated Voltage	Capacitance in Pico farads (pF)	Capacitance Tolerance	Dielectric Codes	Packaging	Type
0805 1206 1806 1812	J = Nickel Barrier (Tin) *Y = FlexiCap™ (Tin - X7R only) *A = (Tin/Lead) Not RoHS compliant. *H = FlexiCap™ (Tin/Lead) Not RoHS compliant.	025 = 25V 050 = 50V 100 = 100V 200 = 200V	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: 0103=10000pF.	M = ±20%	A = COG/NPO AEC-Q200 C = COG/NPO E = X7R AEC-Q200 X = X7R	T = 178mm (7") reel R = 330mm (13") reel B = Bulk pack – tubs or trays	E01 E07

* Note: Terminations Y, A and H are only available in X7R material. Please contact our Sales Office for any special requirements.

Open board insertion loss performance in 50Ω system

Open Board Performance						
Capacitance	0.1MHz	1MHz	10MHz	100MHz	1GHz	Resonance Freq (MHz) approx.
10pF	0	0	0	0	7.5	2200
22pF	0	0	0	0	16	1600
33pF	0	0	0	1	22	1350
47pF	0	0	0	2	28	1150
68pF	0	0	0	3	41	900
100pF	0	0	0	5	28	800
150pF	0	0	0	8	24	700
220pF	0	0	0	12	20	600
330pF	0	0	1	15	20	500
470pF	0	0	2	18	20	425
560pF	0	0	3	20	20	350
680pF	0	0	4	22	20	300
820pF	0	0	5	24	20	260
1nF	0	0	7	27	20	220
1.5nF	0	0	9	31	20	200
2.2nF	0	0	12	34	20	170
3.3nF	0	1	14	39	20	135
4.7nF	0	2	18	46	20	110
6.8nF	0	3	21	50	20	90
10nF	0	5	24	48	20	80
15nF	0	8	27	45	20	65
22nF	0	12	31	43	20	56
33nF	1	14	34	40	20	40
47nF	2	17	38	40	20	34
68nF	4	20	41	40	20	30
100nF	6	24	45	40	20	28
150nF	8	26	48	40	20	24
220nF	10	30	52	40	20	17
330nF	13	33	55	40	20	15.5
470nF	16	36	60	40	20	14
560nF	18	39	65	40	20	12



Soldering Information

Knowles MLCCs are compatible with all recognised soldering/mounting methods for chip capacitors. For more information, refer to application note AN0028 on the website.

Reflow Soldering

Knowles recommend reflow soldering as the preferred method for mounting MLCCs. Our MLCCs can be reflow soldered using a reflow profile generally defined in IPC/FEDEC J-STD-020. Sn plated termination chip capacitors are compatible with both conventional and lead free soldering with peak temperatures of 260 to 270°C acceptable.

The heating ramp rate should be such that components see a temperature rise of 1.5 to 4°C per second to maintain temperature uniformity through the MLCC.

The time for which the solder is molten should be maintained at a minimum, so as to prevent solder leaching. Extended times above 230°C can cause problems with oxidation of Sn plating. Use of an inert atmosphere can help if this problem is encountered. Palladium/Silver (Pd/Ag) terminations can be particularly susceptible to leaching with free lead, tin rich solders and trials are recommended for this combination.

Cooling to ambient temperature should be allowed to occur naturally, particularly if larger chip sizes are being soldered. Natural cooling allows a gradual relaxation of thermal mismatch stresses in the solder joints. Forced cooling should be avoided as this can induce thermal breakage.

Wave Soldering

Wave soldering is generally acceptable, but the thermal stresses caused by the wave have been shown to lead to potential problems with larger or thicker chips. Particular care should be taken when soldering SM chips larger than size 1210 and with a thickness greater than 1.0mm for this reason.

Max. permissible wave temperature is 270°C for SM chips.

The total immersion time in solder should be kept to a minimum. It is strongly recommended that Sn/Ni plated terminations are specified for wave soldering applications.

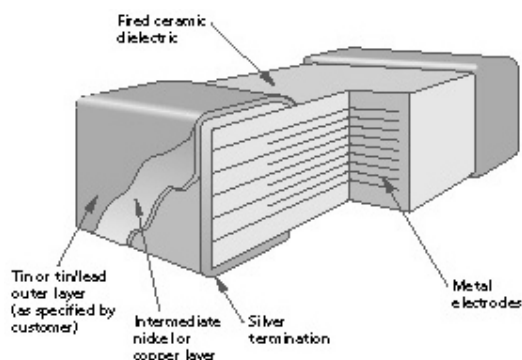
Solder Leaching

Leaching is the term for the dissolution of silver into the solder causing a failure of the termination system which causes increased ESR, $\tan \delta$ and open circuit faults, including ultimately the possibility of the chip becoming detached.

Leaching occurs more readily with higher temperature solders and solders with a high tin content. Pb free solders can be very prone to leaching certain termination systems. To prevent leaching, exercise care when choosing solder allows and minimize both maximum temperature and dwell time with the molten solder.

Plated terminations with nickel or copper anti-leaching barrier layers are available in a range of top coat finishes to prevent leaching occurring. These finishes also include FlexiCap™ for improved stress resistance post soldering.

MLCC with nickel or copper barrier termination



Rework of Chip Capacitors

Knowles recommend hot air/gas as the preferred method of applying heat for rework. Apply even heat surrounding the component to minimise internal thermal gradients. Soldering irons or other techniques that apply direct heat to the chip or surrounding area should not be used as these can result in micro cracks being generated.

Minimise the rework heat duration and allow components to cool naturally after soldering.

Use of Silver Loaded Epoxy Adhesives

Chip capacitors can be mounted to circuit boards using silver loaded adhesive provided the termination material of the capacitor is selected to be compatible with the adhesive. This is normally PdAg. Standard tin finishes are often not recommended for use with silver loaded epoxies as there can be electrical and mechanical issues with the joint integrity due to material mismatch.

Handling & Storage

Components should never be handled with fingers; perspiration and skin oils can inhibit solderability and will aggravate cleaning.

Chip capacitors should never be handled with metallic instruments. Metal tweezers should never be used as these can chip the product and leave abraded metal tracks on the product surface. Plastic or plastic coated metal types are readily available and recommended – these should be used with an absolute minimum of applied pressure.

Incorrect storage can lead to problems for the user. Rapid tarnishing of the terminations, with an associated degradation of solderability, will occur if the product comes into contact with industrial gases such as sulphur dioxide and chlorine. Storage in free air, particularly moist or polluted air, can result in termination oxidation.

Packaging should not be opened until the MLCs are required for use. If opened, the pack should be re-sealed as soon as practicable. Alternatively, the contents could be kept in a sealed container with an environmental control agent.

Long term storage conditions, ideally, should be temperature controlled between -5 and +40°C and humidity controlled between 40% and 60% R.H.

Taped product should be stored out of direct sunlight, which might promote deterioration in tape or adhesive performance.

Product, stored under the conditions recommended above, in its "as received" packaging, has a minimum shelf life of 2 years.

SM Pad Design

Knowles' conventional 2-terminal chip capacitors can generally be mounted using pad designs in accordance with IPC-7351, Generic Requirements for Surface Mount Design and Land Pattern Standards, but there are some other factors that have been shown to reduce mechanical stress, such as reducing the pad width to less than the chip width. In addition, the position of the chip on the board should also be considered.

3-terminal components are not specifically covered by IPC-7351, but recommended pad dimensions are included in the Knowles catalogue/website for these components.

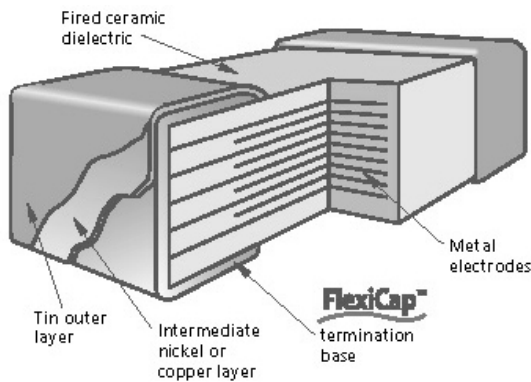
FlexiCap™ Termination

FlexiCap™ has been developed as a result of listening to customer's experiences of stress damage to MLCCs from many manufacturers, often caused by variations in production processes.

Our answer is a proprietary flexible epoxy polymer termination material that is applied to the device under the usual nickel barrier finish. FlexiCap™ will accommodate a greater degree of board bending than conventional capacitors.

Ranges are available with FlexiCap™ termination material offering increased reliability and superior mechanical performance (board flex and temperature cycling) when compared with standard termination materials. Refer to application note reference AN0001. FlexiCap™ capacitors enable the board to be bent almost twice as much as before mechanical cracking occurs. Refer to application note AN0002.

FlexiCap™ is also suitable for space applications having passed thermal vacuum outgassing tests. Refer to application note reference AN0026.



FlexiCap™ MLCC cross section

Knowles has delivered millions of FlexiCap™ components and during that time has collected substantial test and reliability data, working in partnership with customers worldwide, to eliminate mechanical cracking.

An additional benefit of FlexiCap™ is that MLCCs can withstand temperature cycling from -55 to 125 °C in excess of 1,000 times without cracking.

FlexiCap™ termination has no adverse effect on any electrical parameters, nor affects the operation of the MLCC in any way.

Application Notes

FlexiCap™ may be handled, stored and transported in the same manner as standard terminated capacitors. The requirements for mounting and soldering FlexiCap™ are the same as for standard SMD capacitors.

For customers currently using standard terminated capacitors there should be requirement to change the assembly process when converting to FlexiCap™.

Based upon the board bend tests in accordance with IEC 60384-1 the amount of board bending required to mechanically crack a FlexiCap™ terminated capacitor is significantly increased compared with standard terminated capacitors.

Product: X7R	Typical bend performance under AEC-Q200 test conditions
Standard Termination	2mm to 3mm
FlexiCap™	Typically 8mm to 10mm

REACH (Registration, Evaluation, Authorisation and restriction of Chemicals) Statement

The main purpose of REACH is to improve the protection of human health and the environment from the risks arising from the use of chemicals.

None of the products covered by this datasheet contain any SVHCs as defined by the REACH legislation. Knowles continue to monitor the REACH legislation for routine updates.

For further information, please contact our sales office.

RoHS Compliance

Knowles routinely monitors worldwide material restrictions (e.g., EU/China and Korea RoHS mandates) and is actively involved in shaping future legislation.

All products covered by this datasheet are compliant with the EU RoHS directive unless specified with tin/lead plating finish. Those with tin plated terminations are suitable for soldering common lead free solder alloys (refer to 'Soldering Information' for more details on soldering limitations). Compliance with EU RoHS directive automatically signifies compliance with some other legislation (e.g., Korea RoHS). China RoHS demands special labelling requirements, with which Knowles complies. Please refer to the Sales Office for details of compliance with other materials legislation.

Environmental certificates, full material declarations, SGS analysis reports and tin whisker test results are available on request.

Check the Knowles website for latest RoHS update.

Export Controls and Dual-use Regulations

Certain Knowles catalogue components are defined as 'dual-use' items under international export controls – those that can be used for civil and military purposes which meet certain specified technical standards.

The defining criteria for a dual-use component with respect to Knowles products is one with a voltage rating of >750V and a capacitance value >250nF and a series inductance <10nH.

Components defined as 'dual-use' under the above criteria automatically require a licence for export outside the EU, and may require a licence for export with the EU.

The application for a licence is routine, but customers for these products will be asked to supply further information.

Please refer to the sales office if you require any further information on export restrictions.

Other special components may additionally need to comply with export regulations.

Ageing of Ceramic Capacitors

Capacitor ageing is a term used to describe the negative, logarithmic capacitance change which takes place in ceramic capacitors with time. The crystalline structure for barium titanate based ceramics changes on passing through its Curie temperature (known as the Curie Point) at about 125°C. The domain structure relaxes with time and in doing so, the dielectric constant reduces logarithmically; this is known as the ageing mechanism of the dielectric constant. The more stable dielectrics have the lowest ageing rates.

The ageing process is reversible and repeatable. Whenever the capacitor is heated to a temperature above the Curie Point the ageing process starts again from zero.

The ageing constant, or ageing rate, is defined as the percentage loss of capacitance due to the ageing process of the dielectric which occurs during a decade of time (a tenfold increase in age) and is expressed as percent per logarithmic decade of hours. As the law of decrease of capacitance is logarithmic, this means that for a capacitor with an ageing rate of 1% per decade of time, the capacitance will decrease at a rate of:

- 1% between 1 and 10 hours
- An additional 1% between the following 10 and 100 hours
- An additional 1% between the following 100 and 1000 hours
- An additional 1% between the following 1000 and 10000 hours
- The ageing rate continues in this manner throughout the capacitor's life.

Typical values of the ageing constant for our MLCCs are

Dielectric Class	Typical Values
Ultra Stable COG/NPO	Negligible capacitance loss through ageing
Stable X7R	<2% per decade of time

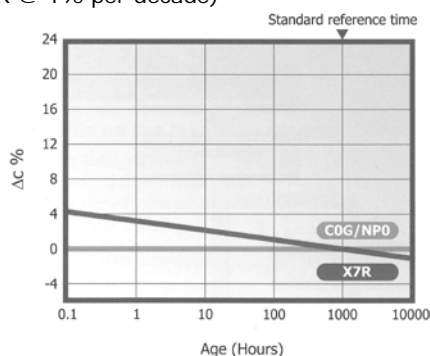
Capacitance Measurements

Because of ageing it is necessary to specify an age for reference measurements at which the capacitance shall be within the prescribed tolerance. This is fixed at 1000 hours, since for all practical purposes there is not much further loss of capacitance after this time.

All capacitors shipped are within their specified tolerance at the standard reference age of 1000 hours after having cooled through their Curie temperature.

The ageing curve for any ceramic dielectric is a straight line when plotted on semi-log paper.

Capacitance vs. Time (Ageing X7R @ 1% per decade)



Tight Tolerance

One of the advantages of Knowles' unique 'wet process' of manufacture is the ability to offer capacitors with exceptionally tight capacitance tolerances.

The accuracy of the printing screens used in the fully automated, computer controlled manufacturing process allows for tolerance as close as $\pm 1\%$ on COG/NPO parts greater than or equal to 10pF. For capacitance value less than 4.7pF tolerances can be as tight as $\pm 0.05pF$.

Periodic Tests Conducted and Reliability Data

For standard surface mount capacitors components are randomly selected on a sample basis and the following routine tests conducted:

- Load Test. 1,000 hours @ 125°C (150°C for X8R). Applied voltage depends on components tested
- Humidity Test. 168 hours @ 85°C/85%RH
- Board Deflection (bend test)

Test results are available on request.

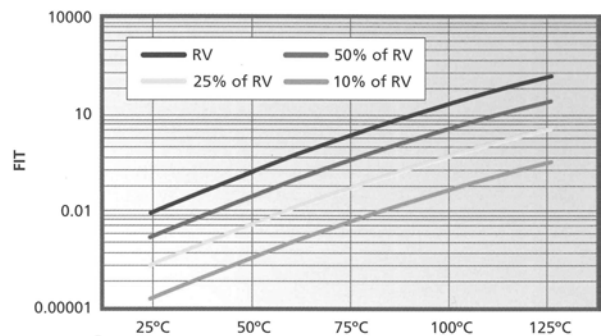
Conversion Factors

From	To	Operation
FITs	MTBF (hours)	$10^9 \div \text{FITs}$
FITs	MTBF (years)	$10^9 \div (\text{FITs} \times 8760)$

FIT = Failures In Time. 1 FIT = 1 failure in 10^9 hours

MTBF = Mean Time Between Failure

Example of FIT Data Available



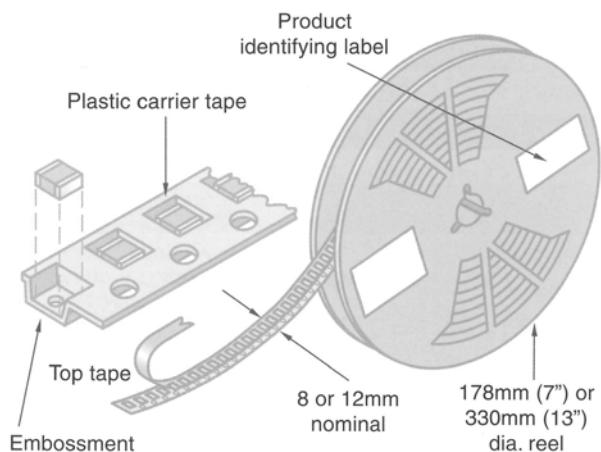
Component type: 0805 (COG/NPO and X7R)

Testing Location: Knowles reliability test department

Results based on: 16,622,000 component test hours

Packaging Information

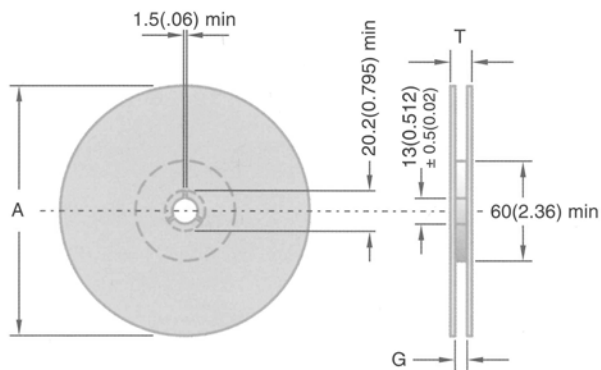
Tape and reel packing of surface mounting chip capacitors for automatic placement are in accordance with IEC60286-3.



Peel Force

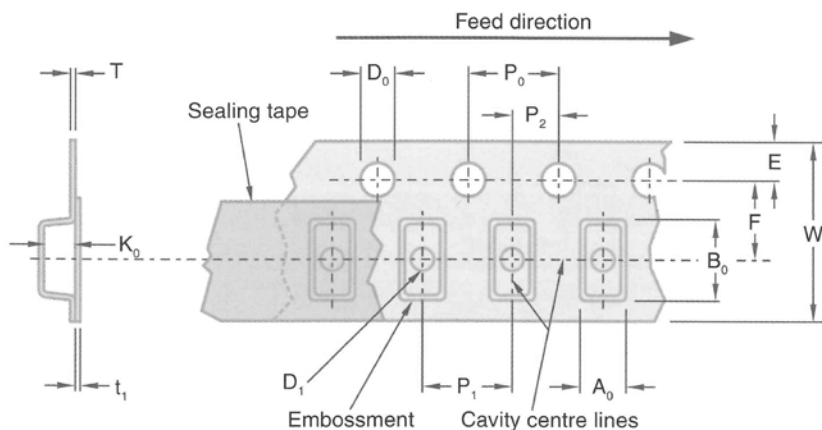
The peel force of the top sealing tape is between 0.2 and 1.0 Newton at 180°. The breaking force of the carrier and sealing tape in the direction of unreeling is greater than 10 Newton.

Reel Dimensions



Symbol	Description	178mm Reel	330mm Reel
A	Reel diameter	178 (7)	330 (13)
G	Reel inside width	8.4 (0.33)	12.4 (0.49)
T	Reel outside width	14.4 (0.56) max	18.4 (0.72) max

Tape Dimension



Symbol	Description	Dimensions mm (inches)	
		8mm Tape	12mm Tape
A ₀	Width of cavity	Dependent on chip size to minimize rotation	
B ₀	Length of cavity		
K ₀	Depth of cavity		
W	Width of tape	8.0 (0.315)	12.0 (0.472)
F	Distance between drive hole centres and cavity centres	3.5 (0.138)	5.5 (0.213)
E	Distance between drive hole centres and tape edge	1.75 (0.069)	
P ₁	Distance between cavity centres	4.0 (0.156)	8.0 (0.315)
P ₂	Axial distance between drive hole centres and cavity centres	2.0 (0.079)	
P ₀	Axial distance between drive hole centres	4.0 (0.156)	
D ₀	Drive hole diameter	1.5 (0.059)	
D ₁	Diameter of cavity piercing	1.0 (0.039)	1.5 (0.059)
T	Carrier tape thickness	0.3 (0.012) ± 0.1 (0.04)	0.4 (0.016) ± 0.1 (0.04)
t ₁	Top tape thickness	0.1 (0.004) max	

Packing Information

Missing Components

The number of missing components in the tape may not exceed 0.25% of the total quantity with not more than three consecutive components missing. This must be followed by at least six properly placed components

Identification

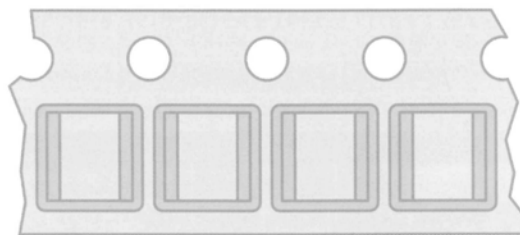
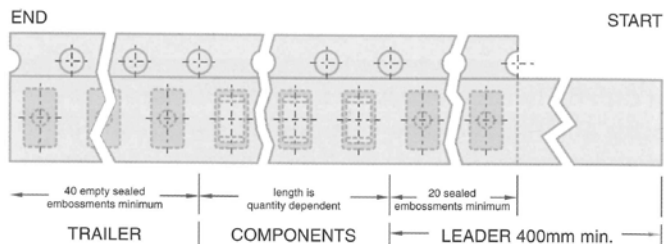
Each reel is labelled with the following information: manufacturer, chip size, capacitance, tolerance, rated voltage, dielectric type, batch number, date code and quantity of components.

Component Orientation

Tape and reeling is in accordance with IEC 60286 part 3, which defines the packaging specifications for leadless components on continuous tapes.

- Notes:
- 1) IEC60286-3 states A0 < B0
 - 2) Regarding the orientation of 1825 and 2225 components, the termination bands are right to left, NOT front to back. Please see diagram.

Leader Trailer

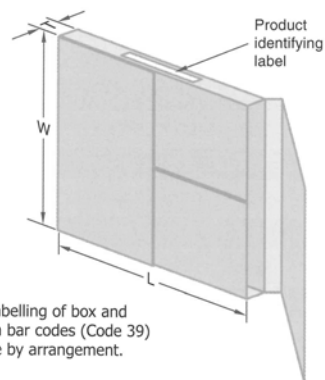


Orientation of 1825 & 2225 components

Outer Packaging

Outer carton dimensions mm (inches) max

Reel Size	No. of Reels	L	W	T
178 (7)	1	185 (7.28)	185 (7.28)	25 (0.98)
178 (7)	4	190 (7.48)	195 (7.76)	75 (2.95)
330 (13)	1	335 (13.19)	335 (13.19)	25 (0.98)



Note: Labelling of box and reel with bar codes (Code 39) available by arrangement.

Reel Quantities

178mm (7") reel	0805	1206	1806	330mm 13" reel	0805	1206	1806
	3000	2500	2500		12000	10000	10000

Bulk Packing – Tubs

Chips are supplied in rigid re-sealable plastic tubs together with impact cushioning wadding. Tubs are labelled with the details: chip size, capacitance, tolerance, rated voltage, dielectric type, batch number, date code and quantity of components.

Dimensions mm (inches)

H	60mm (2.36")
D	50mm (1.97")

