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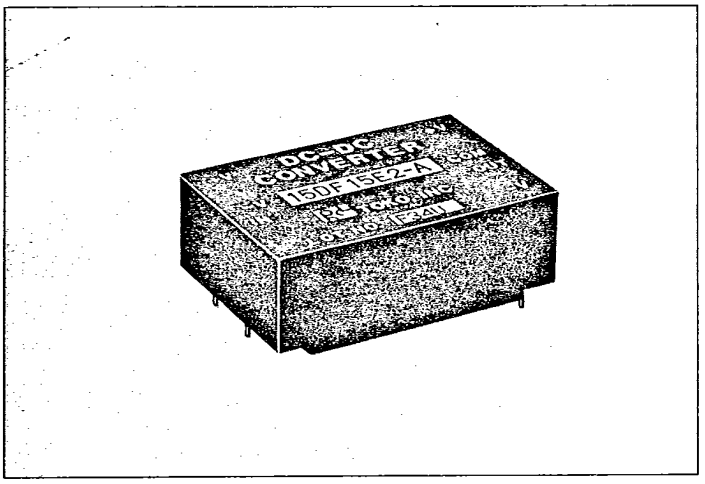
7. E-Series DC-DC Converters (Floating Output)



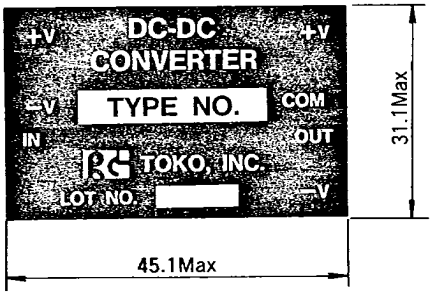
7-1 Introduction

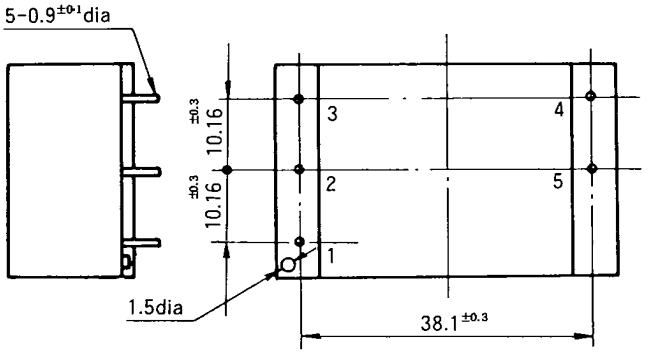
The Converters in this series have the input and output sides in floating condition, i.e., isolated. The specifications are the same as in the F , M , K Series except that built-in filters are included at the input and output sides. Thus, the ripple and spike noise are kept at low values without need of external parts and wiring is at a minimum.

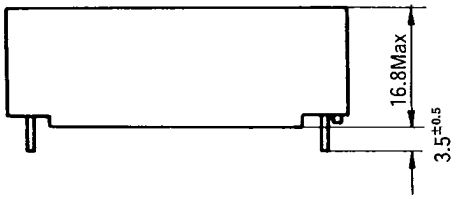
7-2 General Specifications

Operating Temperature Range:	−10° to +60°C
Storage Temperature Range:	−25° to +85°C
Operating Humidity Range:	10% to 85% R.H.
Storage Humidity Range:	10% to 90% R.H.
Insulation Pressure Tightness:	1500VAC(1min.)between input and output sides.
Insulation Resistance:	Over 500MΩ at 500VDC between input and output sides.

7-3 Physical Dimention and Pin Assignment







Unit: mm

1. V_{out} (−)
2. COM/NC
3. V_{out} (+)
4. V_{in} (+)
5. V_{in} (−)

*1-Channel Type, Pin No. 2 is not used (NC)

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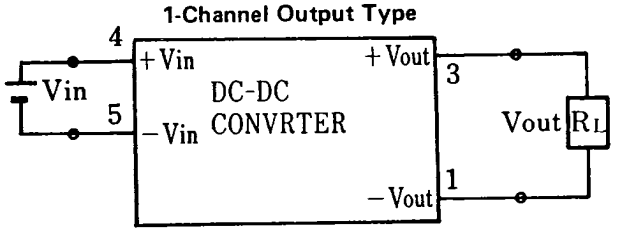
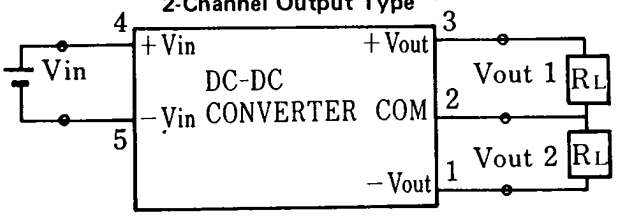
7-4 Connections

1-Channel Output Type



2-Channel Output Type



NOTES

The above schematic shows the general connections. Although the Converters include input/output filters, use of a suitable capacitor at the output side will reduce even more the ripple and spike noise.

7-5 E-Series Specifications

Type No.	Input Voltage V_{in} (V)	Output Voltage		Output Current I_o(mA)	Rated Output Power P_o(mW)	Regulation		Ripple & Spike Voltage (mV_{pp}) *4	Conversion Efficiency η (%) *5	Temp. Coeff. (%/°C) *6
		V_{out} (V)	TOL (%) *1			Line (%) *2	Load (%) *3			
12F15E1-A	5V±10%	12	±5	25~125	1500	±1.0	±4.5	150	55	0.1
15F15E1-A		15	±5	20~100		±1.0	±4.0	150	60	0.1
24F15E1-A		24	±5	15~ 60		±1.0	±4.0	150	65	0.1
12DF15E1-A		±12	±6	±12~±63		±1.0	±4.5	100	60	0.1
15DF15E1-A		±15	±6	±10~±50		±1.0	±4.5	100	60	0.1
5F15E2-A	12V±20%	5	±6	60~300		±1.0	±8.0	100	55	0.1
15F15E2-A		15	±5	20~100		±1.5	±4.0	150	65	0.1
12DF15E2-A		±12	±6	±12~±63		±1.5	±4.0	100	65	0.1
15DF15E2-A		±15	±6	±10~±50		±1.0	±4.0	100	65	0.1
5F15E3-A	24V±20%	5	±6	60~300		±1.0	±6.0	100	55	0.1
12F15E3-A		12	±5	25~125		±1.5	±4.0	150	65	0.1
15F15E3-A		15	±5	20~100		±1.5	±4.0	150	65	0.1
12DF15E3-A		±12	±6	±12~±63		±1.0	±4.0	100	65	0.1
15DF15E3-A		±15	±6	±10~±50		±1.0	±4.0	100	65	0.1

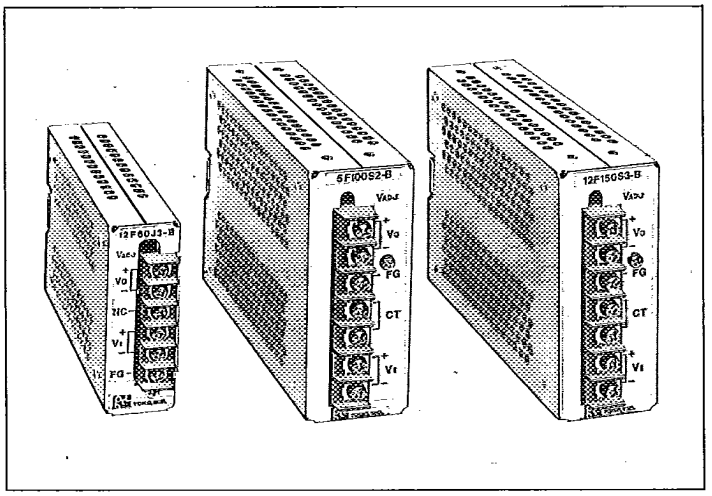
NOTES

*1 Output Voltage Tolerance : Vin = TYP, Io = Io Max x 0.6
*2 Regulation (Line) : Vin = at Min ~ Max
*3 Regulation (Load) : Vin = TYP, Io at Min ~ Max
*4 Ripple : Vin TYP, Io Max
*5 Efficiency : Vin TYP, IoMax x0.6
*6 Temp Coff : Vin TYP, IoMax, Ta = -10~+60°C

Precautions in Use of DC-DC Converter.

1. Conditions under which the specified performance of the converters may not be obtained, and further, cause possible damage, are as follows:
   a. Short-circuiting the output terminals, or excessive overloading for 30 seconds or longer.
   b. Operating at over 1.5 times the rated output current for 10 minutes or longer.
   c. Application of over-voltage, approximately X2, at the input side for 10 minutes or longer.
   d. Others, such as use at abnormal conditions, i.e., with incorrect terminal connections other than as indicated, etc.
2. When using the Converter under conditions not within the specifications or range of application, or when there are questions, please contact Toko' Sales Office.
3. For the 2-Channel output type, when there is an unbalance in the + and − output currents, the total output must be within the min. to max. current rating.

8. J,S,H, Series



8-1 Introduction

This Series developed for DC-DC conversion uses the converter modules of the F,M,K, and E Types and the technology applied to the J, S and H Type Switching Power Supplies.
The Series has a wide range of use due to the high reliability and stability characteristics. The products are most suited for use in various electronic equipment, particularly on shipboard and for stand by sources.

Features

1. Primary and secondary sides are isolated.
2. High stability.
3. High reliability.
4. Small sized packaging and light weight.
5. Overload protection provided.

8-2 General Specifications

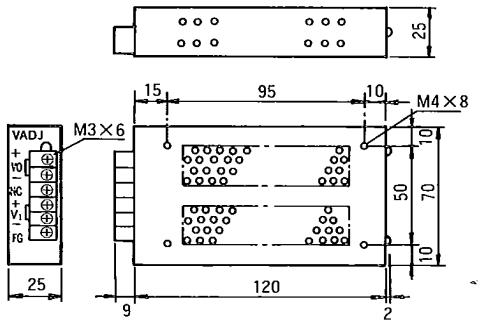
Input Condition	Input Voltage	12, 24VDC
OutPut Condition	Adjustable Voltage	±5%
	Efficiency	65% (TYP)
	Overall Regulation	±3%
	Ripple, including noise	100mVpp Max

General Conditions

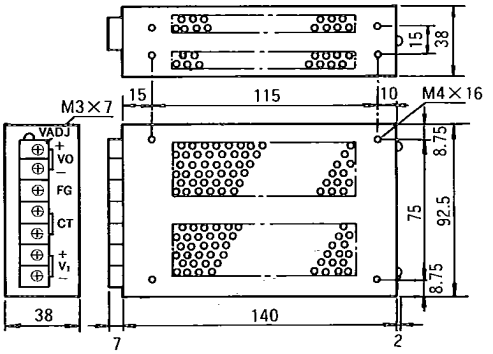
Dielectric Strength (Input to case)	1min at 1300VAC
Insulation Resistance (Output to case)	>30MΩ at 500VDC
Operating Temperature	0 to +60°C
Storage Temperature	−20 to +85°C

8-3 Physical Dimensions Unit : mm

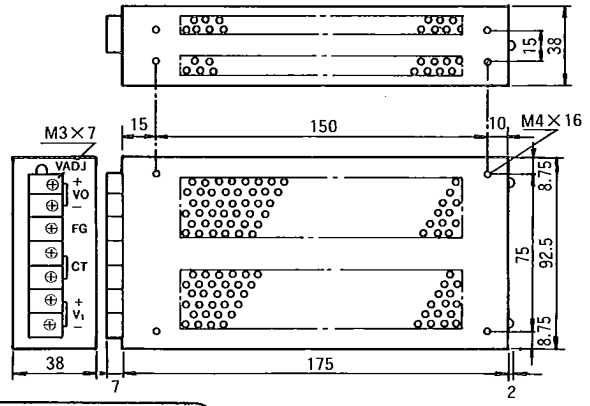
J Type



S Type



H Type



8-4 Electrical Characteristics

J Type 6W

Type NO.	Input Voltage (V) ±20%	Output Voltage V	Output Current A
5F60J2-B	12V	5	1.2
12F60J2-B		12	0.5
24F60J2-B		24	0.25
5F60J3-B	24V	5	1.2
12F60J3-B		12	0.5
24F60J3-B		24	0.25

H Type 17W

Type NO.	Input Voltage (V) ±20%	Output Voltage V	Output Current A
5F170H2-B	12V	5	3.4
12F170H2-B		12	1.42
24F170H2-B		24	0.71
5F170H3-B	24V	5	3.4
12F170H3-B		12	1.42
24F170H3-B		24	0.71

S Type 10W, 15W

Type NO.	Input Voltage (V) ±20%	Output Voltage V	Output Current A
5F100S2-B	12V	5	2
9F100S2-B		9	1.1
12F100S2-B		12	0.83
15F100S2-B		15	0.67
24F100S2-B		24	0.42
5F150S3-B	24V	5	3
9F150S3-B		9	1.67
12F150S3-B		12	1.25
15F150S3-B		15	1
24F150S3-B		24	0.63

8-5 Functions of Terminals

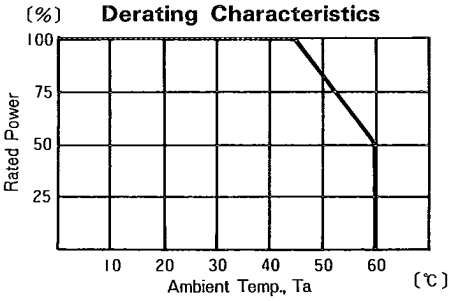
Marking	Name	Use	Remarks
+ V_I −	DC Input	For DC input	9.6~14.4VDC Range : or 19.2~28.8VDC
V_O + −	DC Output	For connections to the load	Insulated from primary side and case.
FG	Case Ground	For grounding the case	Minimizes the HF current due to switching.
CT	Remote Control Terminals : only on S and H Series	For switching on/off the DC output with DC input at on. V_O off with terminals shorted V_O on with terminals open.	Use a relay between the terminals. This relay must have current of 400mA or more.
V_{ADJ}	Voltage Adjuster	For screw-driver adjustment of DC output Voltage.	Range of adjustment : ±5%

Notes on Mounting

- Holes for mounting the unit are tapped for M4 (ISO) screws as shown in the figures.
- The mounting screws should be tightened with force not exceeding 6kg-cm.
- The unit should be mounted in an area with good ventilation.
- When operated at the rated power, case temperature will rise about 30°C above the surroundings;parts susceptible to heat should be arranged away from the unit.
- When mounted in horizontal direction, parts should not be placed above the unit.
- When two or more units are used, they should be separated by at least 20mm.
- Upper ventilation holes should not be covered;allow at least 30mm.

8-6 Derating vs. Temperature

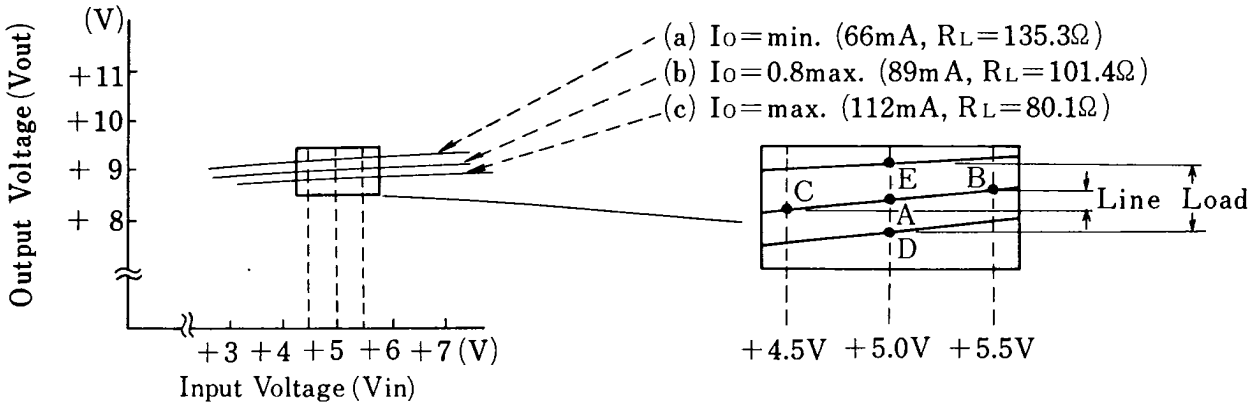
- The figure shows the relation between ambient temperature and power output conditions.
- The overall case temperature should be kept below 75°C



9. Definition of Parameters

Example: P/N 9P10K1 (V_{in} = +5V ±10%, V_{out} = 9V, I_{out} = 66 ~ 112mA)

9-1 Line Regulation and Load Regulation



$$\text{Line Regulation, (+)} = \frac{B - A}{A} \times 100\%$$

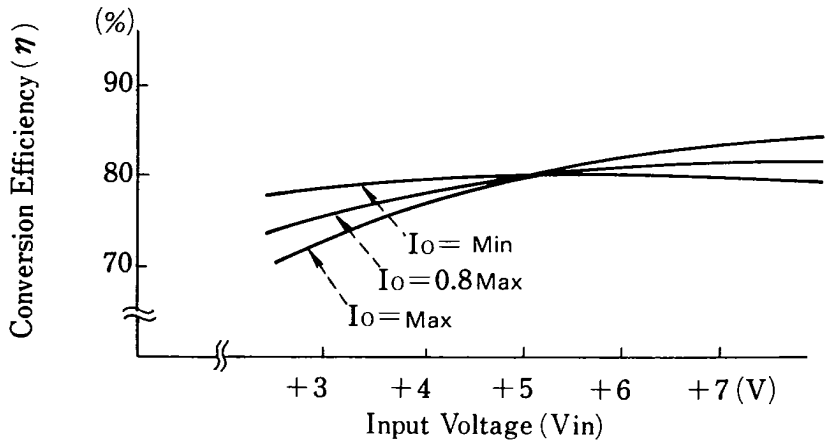
$$\text{Line Regulation, (–)} = \frac{C - A}{A} \times 100\%$$

$$\text{Load Regulation,} = \frac{E - D}{A} \times 100\%$$

where:

A : V_{out} at V_{in} = +5V I_o = 0.8 Max
B : V_{out} at V_{in} = +5.5V I_o = 0.8 Max
C : V_{out} at V_{in} = +4.5V I_o = 0.8 Max
D : V_{out} at V_{in} = +5V I_o = Max
E : V_{out} at V_{in} = +5V I_o = Min

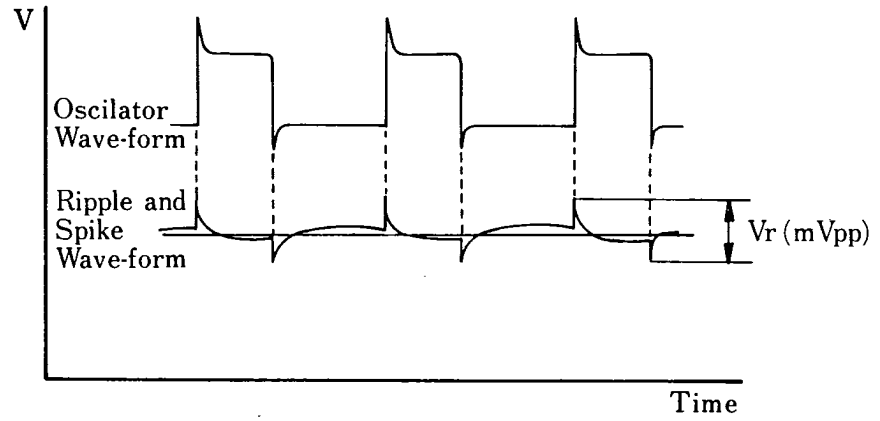
9-2 Conversion Efficiency (η)



$$\eta = \frac{P_{out}}{P_{in}} \times 100\%$$

where: P_{in} = Input Power
P_{out} = Output Power

9-3 Ripple and Spike Wave-form



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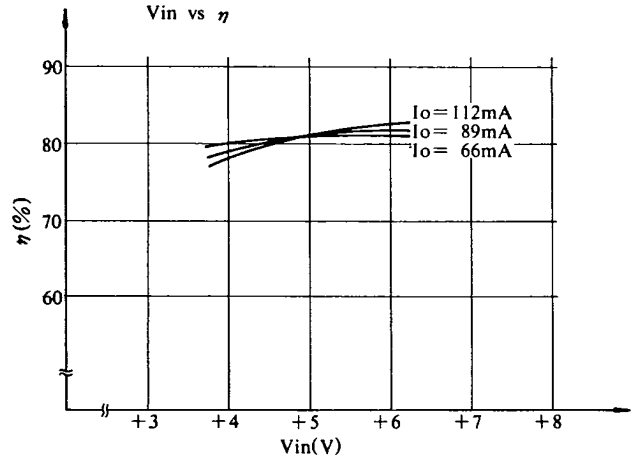
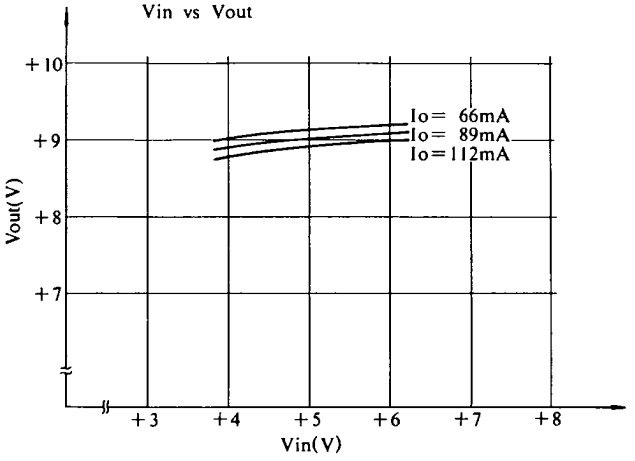
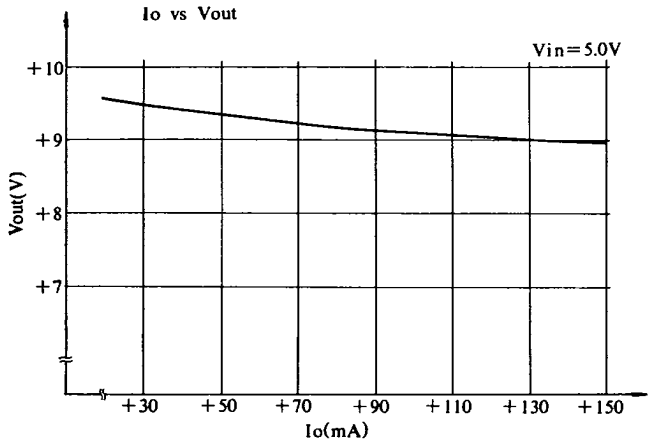
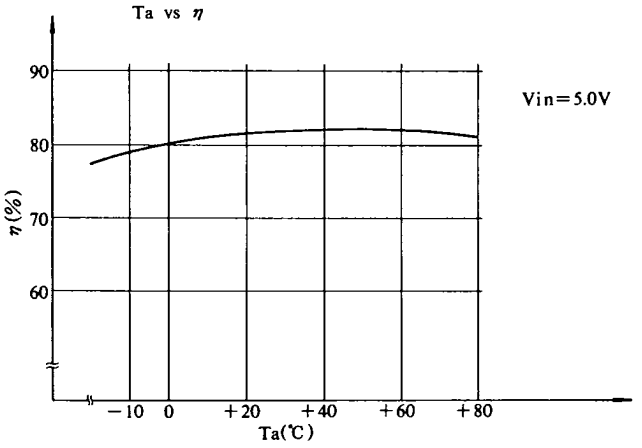
10. Characteristic Data

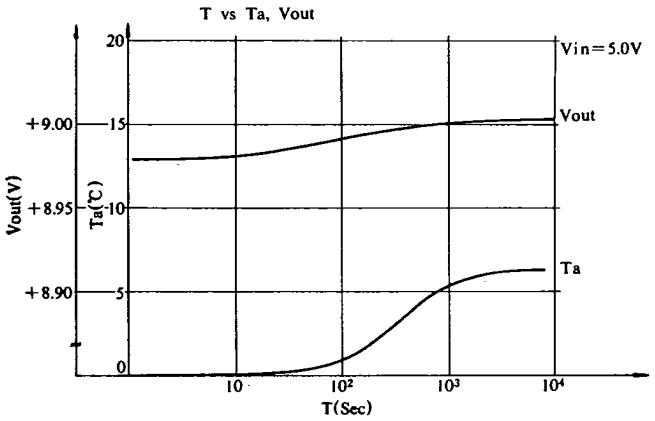
10-1 F, M, K Series (9P10K1) Plus (+) Output Voltage Type

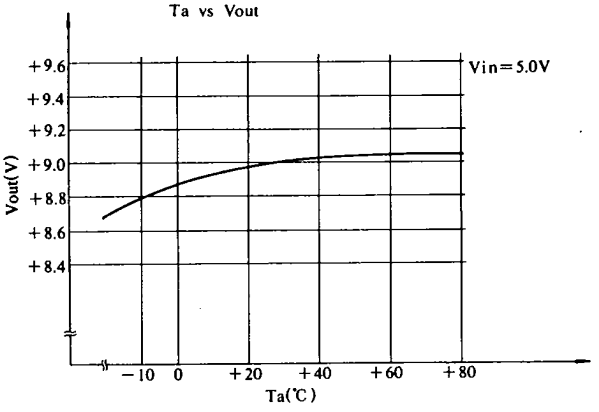












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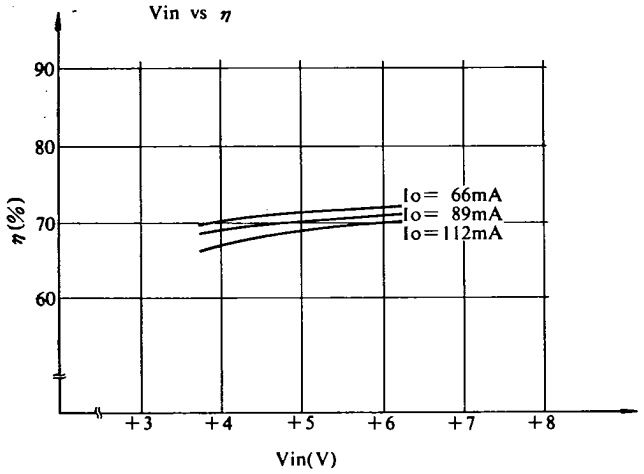
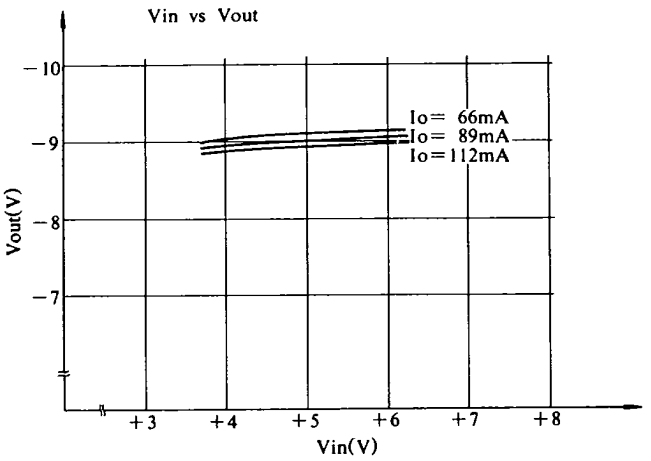
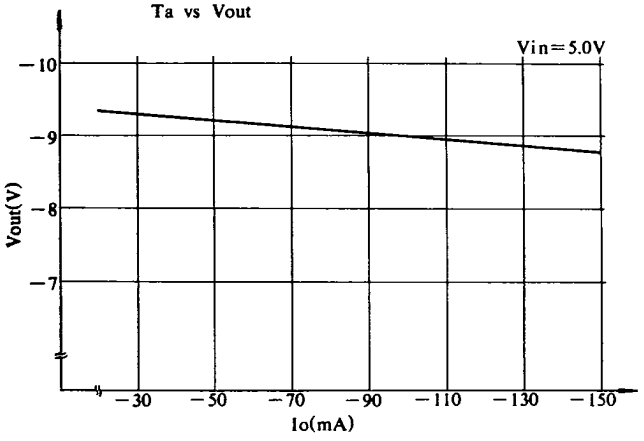
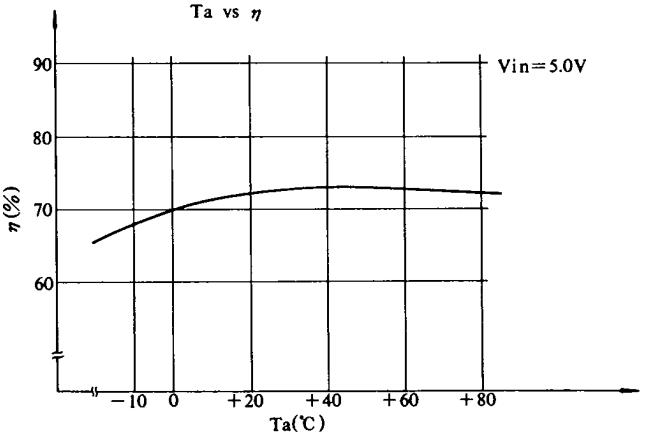
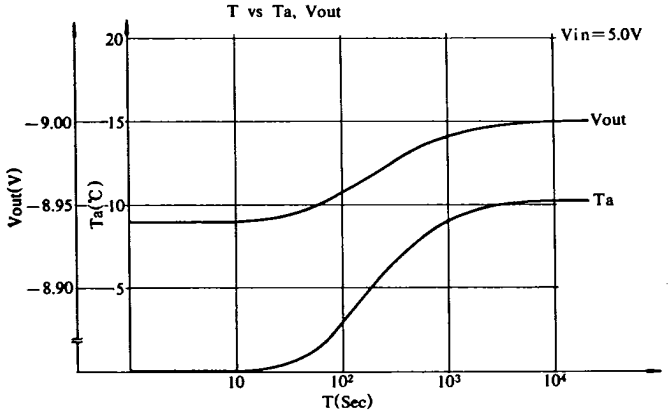
10-2 F, M, K Series (9N10K1) Minus (–) Output Voltage Type

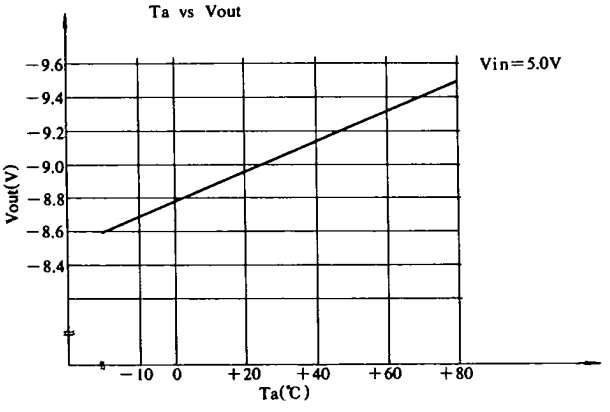












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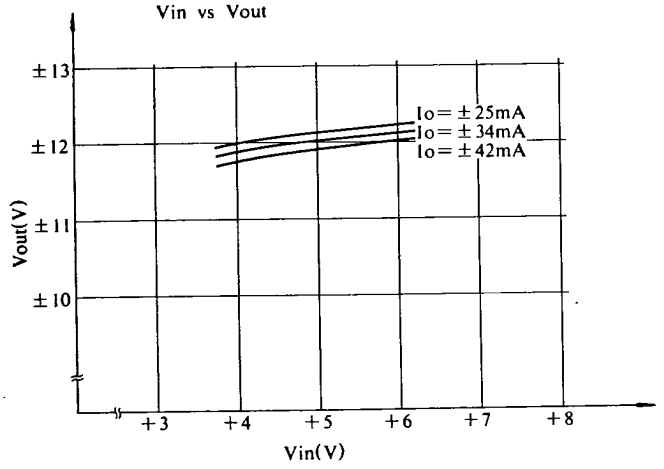
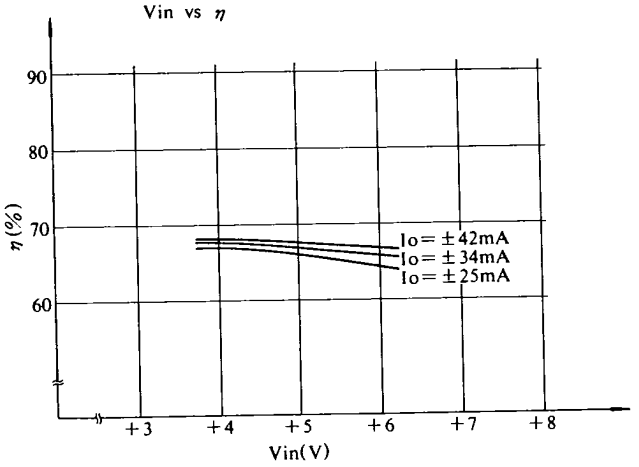
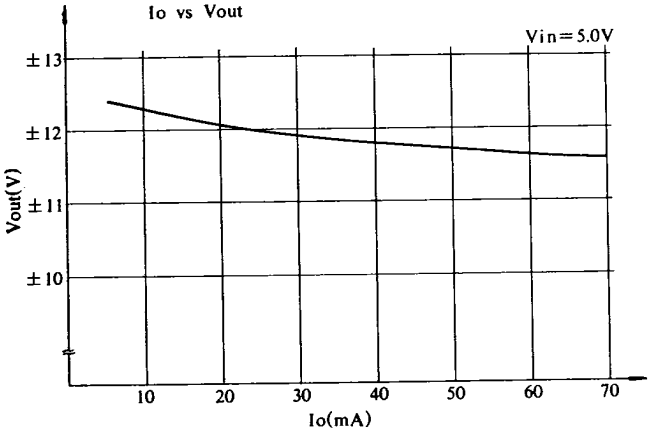
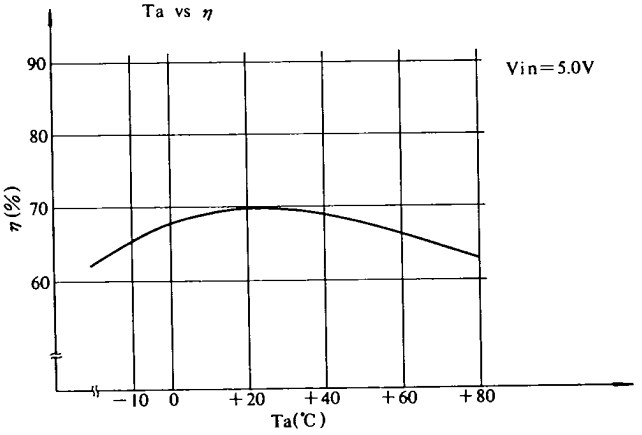
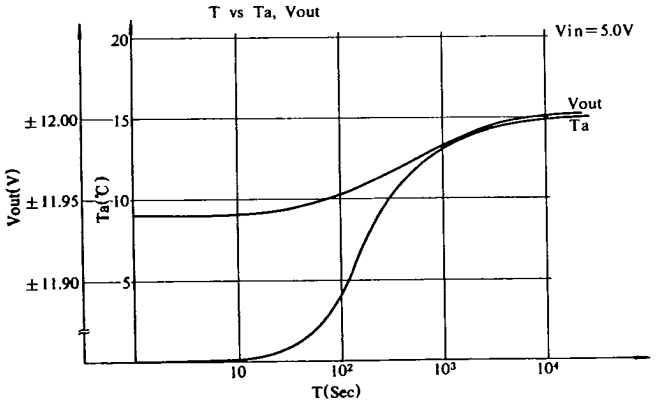
10-3 F, M, K Series (12D10K1) Plus (+), Minus (–) Output Voltage Type

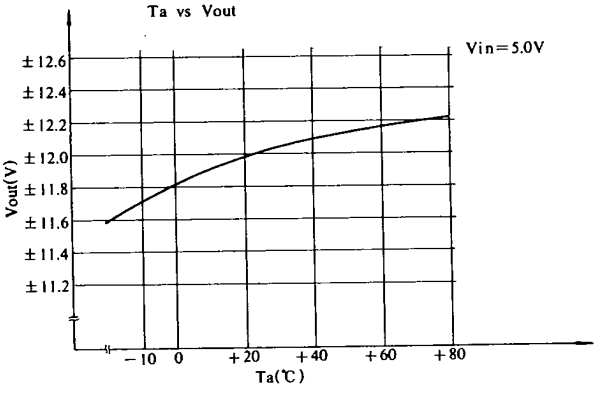












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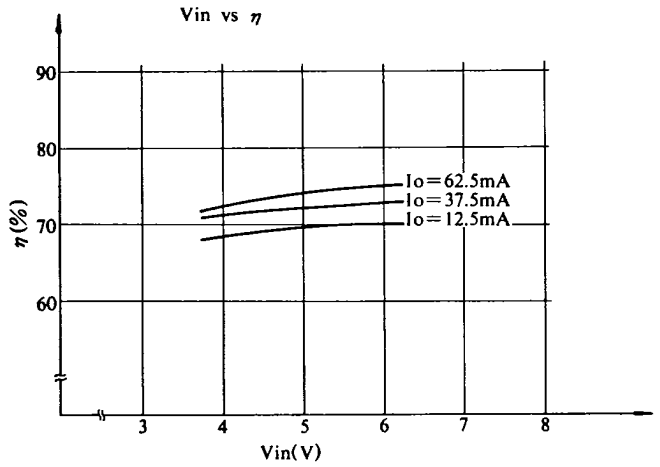
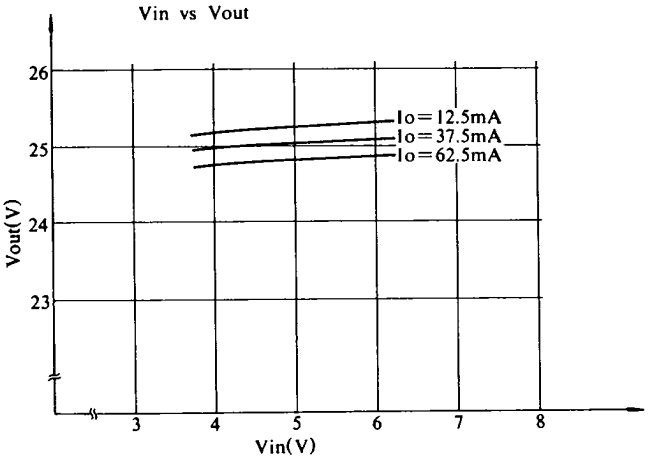
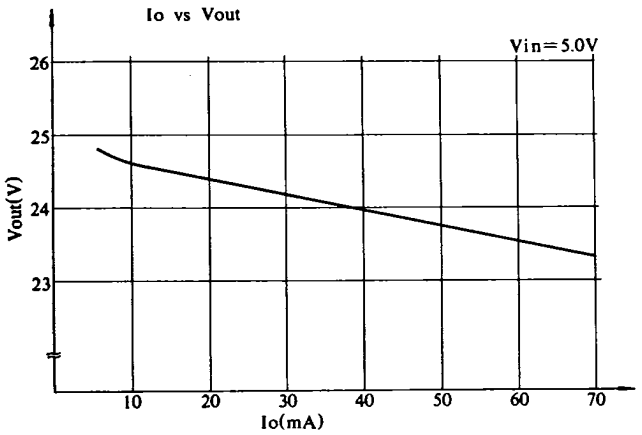
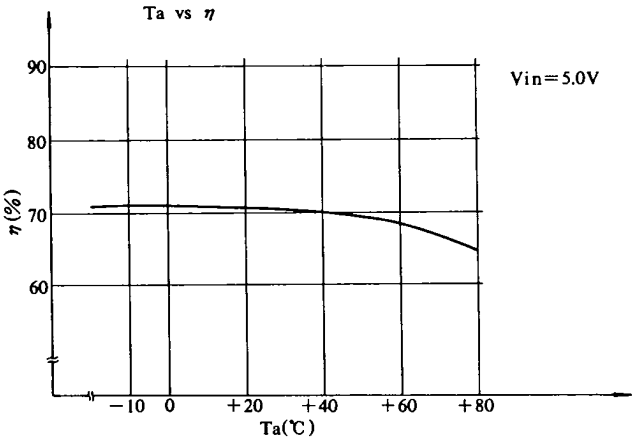
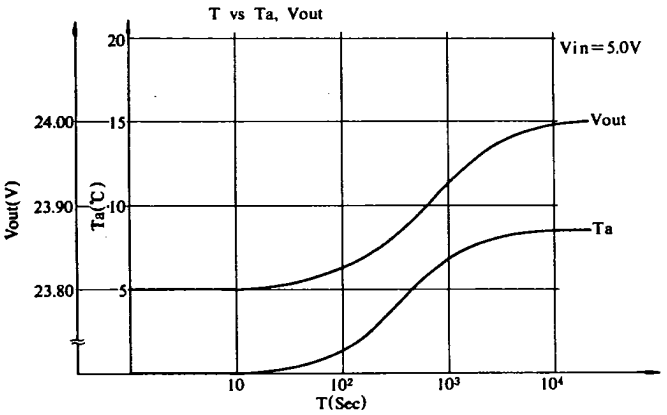
10-4 E-Series (24F15E1) Floating Type

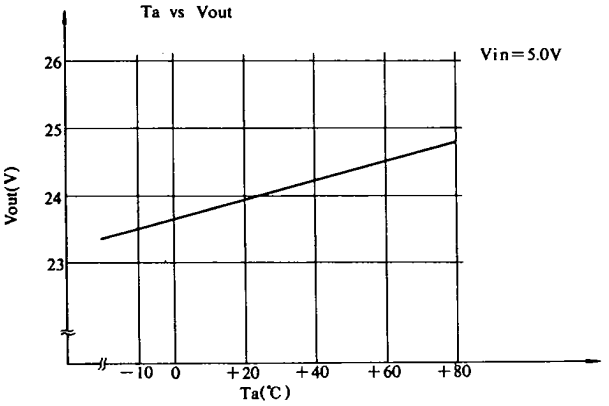












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11. Quality Assurance Program

The quality of a product must be considered and evaluated from all possible aspects before production. The products are then quality controlled during processing and inspection. The tests conducted to assure the highest performance characteristics are listed in the table which follows.

11-1 Quality Assurance Program (F,M,K Series · E Series)

Test Parameter	Test Condition	Remarks
Solderability	280° ± 5°C; dipping time, 5sec ±½sec	MIL-STD-202E Method 208C
Solvent Resistance	Isopropyl alcohol 1-1-1 trichloroethane brushing Trichloro-triple-ethane	Method 215
Soldering Heat Resistance	260° ± 5°C at 10 ±1sec	Method 210A
Temperature-Humidity Cycling	+65° ~ −10°C: 10 days at 1 cycle per day; 80% — 98% R.H.	Method 106D
Heat Shock	10 cycles, 30min each at −25°C and +85°C	Method 107D
Vibration	10—2000Hz for 2hr in each of three axes	Method 204C
Impact Shock	One impact at 500gr in each of three axes	Method 213B
Temperature Exposure	1,000hr at +40°C, 95% R.H.	Method 103B
High Temperature Exposure	1,000hr at +55°C	Method 108A
Salt Water Spray	48hr	Method 101D
Flammability		UL Specifications: HB equivalent
Terminal Strength	Pull: 2.27kg Bending: 2 times at 90°	Method 211A

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12. Technical Information

A. Precaution in use of DC-DC Converter

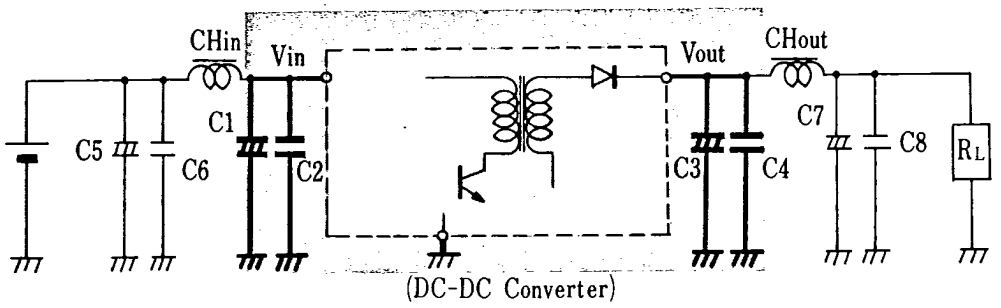

Fig. 1. Output Stage of F,M,K Series Converter (1 Channel-P Type)

12-1 External Parts

(a) External Parts

The output stage (internal) of F, M, K, Series DC-DC Converters is shown in Fig. 1. It will be noted that the rectified output waveform is in ripple form. Therefore an output filter — combination of a choke coil and a capacitor must be used. On the other hand, at the input side, the input current is in a square-wave form, being controlled with the switching process. Thus, use of a capacitor is advised. Further, use of a filter, consisting of a capacitor or a capacitor combined with a choke coil is recommended. When the load impedance is very low or there is no noise problem, components other than C1 are not necessary at the input side of the converter.

NOTE

The filter is unnecessary when the impedance looking out from the converter side to the input source is low enough to be negligible or when the converter is used in such circuit that the noise is not to be considered.

(b) Recommended External Parts

As previously mentioned, it is necessary to use filter capacitor or capacitor combined with choke coil when using the F-, M-, and K-Series Converters. Electrolytic capacitors which have good high frequency characteristics are recommended (If, however, there is insufficient h-f bypassing, then ceramic capacitors should be connected in parallel.) The minimum capacitance of the electrolytics should be at least 10μF. The voltage rating should be greater 1.2 times the impressed voltage for aluminum electrolytics; for tantalum types, the rating should be greater than 1.4 times. On the other hand, the choke coil in the L-C filter structure is used to reduce the ripple voltage to a negligible amount. Large values of the choke coil inductance will considerably reduce the ripple voltage — however, it must be noted that there is a limitation in the current capacity.

(c) PCB Pattern Design

The oscillation frequency of the F-, M-, K-Series Converters is in the 80~180kHz range, with square waveform output. Consequently, long external leads of external parts will cause induced effects and nullify the filtering conditions. For this reason, the heavy lines shown in Fig. 1 should be made as short as possible, not longer than 20mm. This applies particularly in the design of the pattern on the PCB. Unless this is done, the ripple voltage will increase and at the same time the desired output voltage will not be obtained. In addition, the regulation will be impaired.

(d) Effect of Faulty External Parts

Careful attention must be paid in the selection of external parts.

This applies in particular to electrolytic capacitors. If such electrolytic capacitors, whose capacity are lost or whose performances are deteriorated are used, output voltage of the Converter will be differed from its rating; further, the Converter is liable to be damaged. Only the most reliable and not deteriorated one must be used.

(e) E-Series Converter

In this Series, filter circuits are built-in at the input and output sides. Therefore, in general, external parts are not required. However, connection of external capacitors will even more reduce the ripple voltage and spike noise, resulting in superior performance.

12-2. Radiation Noise

A certain amount of unwanted noise will be radiated from the DC-DC Converter. When the Converter is used in a circuit which is affected by such noise, the physical placement must be considered; for example, in a precision analog system. Location at some distance may solve the problem. Precautions, such as use of a ground pattern at the bottom of the Converter, or an iron shield case around the Converter, will have good effect, see Fig. 2. It must be noted, however, that use of an iron shield will increase the magnetic loss, lower the conversion efficiency, and also lower the maximum output rating. In these cases, it is desirable to use the Converter after some experiments.

In audio equipment, use of the standard Converter types is not suited since the unwanted noise will create problems.

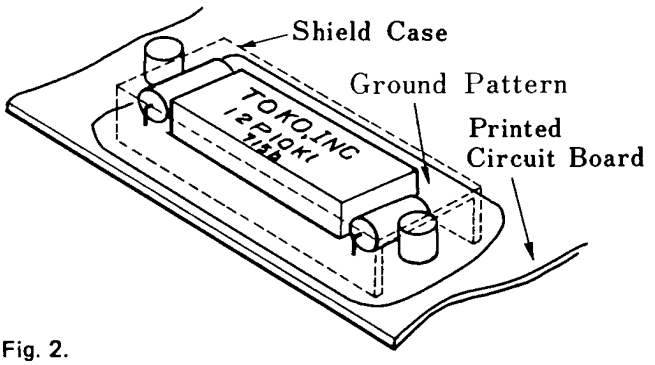

Fig. 2.

12-3. Under and Over-Current Condition

(a) Under-Current Operation

When a particular Converter is used under such condition that the output current is lower than the specified minimum value of it, the output voltage will become higher than specified, see Fig. 3. At extremely low output currents, area "A" in the figure, the output voltage will suddenly rise and cause intermittent oscillation. If this condition is permissible, operation is possible at lower than the minimum specified current, area "B". However, for best results, the lower current limit, I_{01}, should be kept at 10% of the maximum rated current, I_{omax}. This can be done with a dummy load, see Fig. 4.

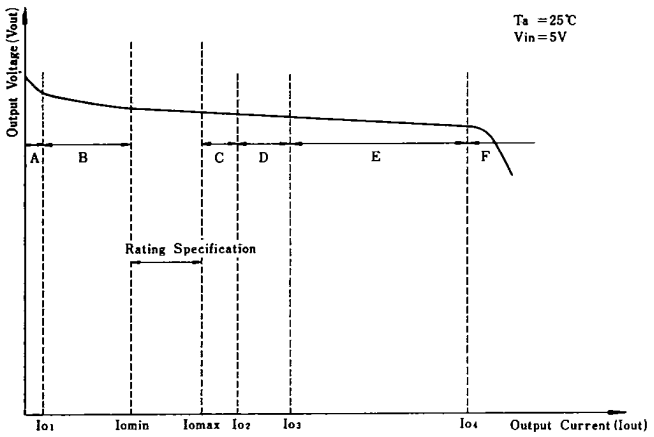

Fig.3 Iout-Vout Characteristics of DC-DC Converter

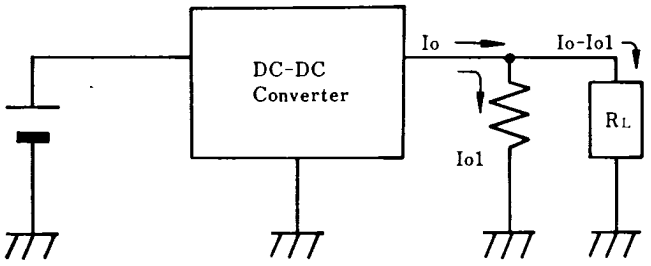

Fig.4 Dummy of Light Load Operation.

(b) Over-Current Operation

Operation with the output current in excess of the specified maximum value will lower the output voltage, see Fig. 3. In addition, since there is no built-in overload protection circuit, damage may result to the Converter. Up to the limit, I_{02}, in the same figure, the current may be continuously supplied without damage. Next, when used continuously in range "D" (I_{02} to I_{03}) there is great risk of damage. In range at "E", continued use cannot be made. Again, at below I_{04}, or area "F", operation becomes abnormal and damage by short-circuit will result. It must be noted that the current ranges will vary in small amounts with different converter types; the general Conditions are given in TABLE 1.

(Table 1) Precautions when Operating with Output Currents Outside the Rating.

Output Range		Operating Condition	Precaution
At LOWER VALUES than RATING	A	Output voltage will be abnormally high and cause intermittent oscillation	Use a dummy load in parallel
	B	Output voltage will be higher than specified	If permissible, operation is possible
At HIGHER VALUES of RATING	C	Output voltage will be lower than specified	Continuous operation is possible but warrantee regarding specifications will not apply
	D	Same as "C" above; Converter will begin to Overheat	Continuous operation not possible some of the Converter will be damaged
	E	Same as "C" above; Converter will become even more overheated	Same as in "D" above; Almost all of the Converter will be damaged
	F	Abnormal operation	Same as in "D" above; Converter will be damaged within a short time

OUTPUT CURRENT DETERMINATION		T_a = 25°C V_{in} = 5V	
Value	Relation	Value	Relation
I_{o1}	IoMax X 0.1	I_{o2}	IoMax X 1.2
IoMin	IoMax X 0.6	I_{o3}	IoMax X 1.5
IoMax	IoMax X 1	I_{o4}	IoMax X 2.5

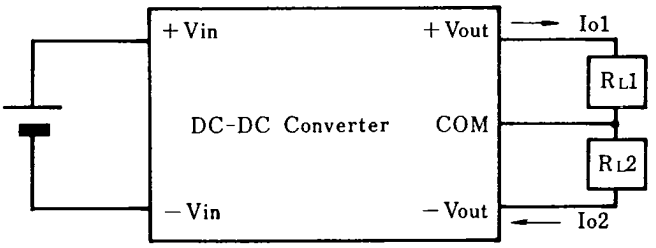

Fig.5. 2-Channel Output Type DC-DC Converter.

(c) 2-Channel Converter Operattion

Fig. 5 shows the 2-Channel Output Converter. In this type, output currents, plus (+) and minus (−), are defined independently not only under the balanced output converter condition but also under the unbalanced one, each channel output must be within the specified ratings. In other words, I_{01} and I_{02} apply to each channel and not to the total current. Therefore, one channel must not be loaded to the total amount.

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12-4. Input at Other Than the Specified Voltage

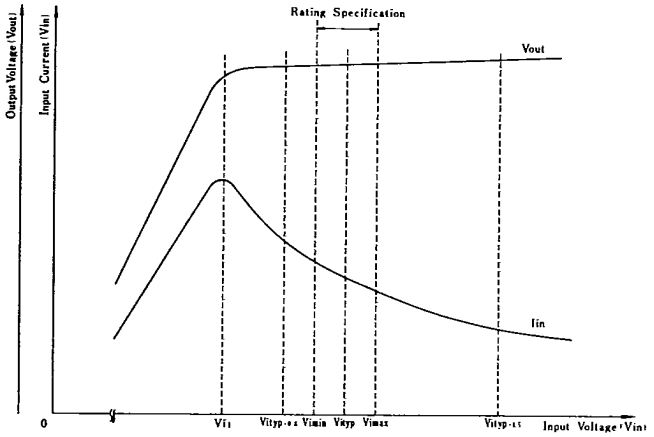

Fig.6. Vin-Vout; Iin Characteristic.

(a) Lower Input Voltage
As shown in Fig. 6, the output voltage will gradually become lower and drop suddenly at $V_{in}1$, or at the start of the stabilization. The input current, I_{in}, will vary as in the Fig. 6 and consequently the burden becomes high in the Converter at $V_{in}1$ point also $V_{in}1$ point will shifts towards V_{in} min, as the load becomes heavy. Although there will be some differences with the type of Converter used, in general, continuous use at input voltages lower than V_{inTYP} XO.8 should be avoided (NOTE: TYP = typical).

(b) Higher Input Voltage
When higher than the specified voltage is applied at the input, the output voltage will gradually increase as shown in Fig. 6. When the input voltage exceeds the limiting value, damage will result. Although there will be some differences with the Converter in use, in general, the input limit, V_{inTYP}XO.8, should be used for guide.

12-5. Environmental Condition

In an installation, the conditions given in the Catalog should be met for temperature ranges and relative humidity. In addition, use in locations listed hereunder should be avoided.

(a) The Converter should be kept away from parts where the local temperature rise in high even though the overall temperature rise in the installation is kept low.

(b) At locations wherein heat radiation is hindered, for example in a total enclosure. Thus if the environmental conditions are full met, forced air cooling is not required. (Location at a point of natural air flow is advised.)

12-6. Resistance to Solvents

The TOKO Converters are fully encapsulated with epoxy molding and have superior solvent resistance characteristics. However, certain precautions must be taken with the following –

1-1-1 Trichloroethylene
Trichloroethane

Trichloroethane application will meet with the MIL standards. However, when used, the epoxy will dissolve by a small amount and it is considered unsuitable. Tests at TOKO show that the following solvents can be used without trouble – Freon TE, Freon TMC, and isopropyl alcohol. (Refer to the reliability test table.)

12-7. Improper Connections

(a) Parallel Output Connections
Connecting two Converter outputs in parallel to increase the output should not be made. If necessary, the outputs should be distributed to each individual load circuit, see Fig. 7.

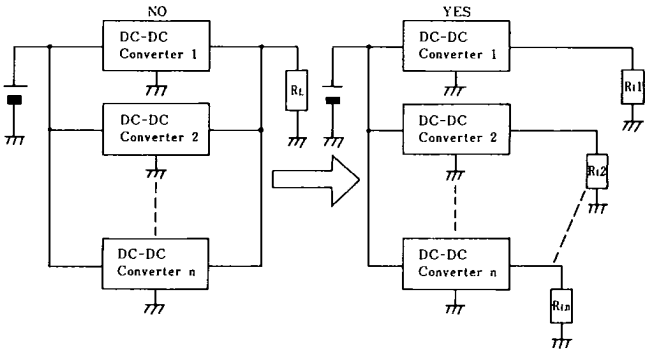

Fig. 7. Parallel Output Connections

(b) Common Ground Connections
The F-, M- and K-Series Converters have the input and output ground connected in common. Care must be taken in grounding that the output polarities are correct.

B. Application of DC-DC Converter

12-8. Use of Battery for the Primary Power Source

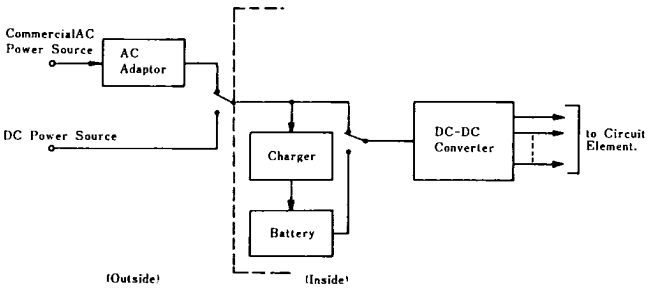

Fig. 8. DC-DC Converter Application Where Battery is used as a Primary Power Source.

The conventional use of a battery in electronic equipment is shown in Fig. 8. Examples include small test instruments, medical apparatus, computer peripherals, desk calculators, etc. Others are used where 24-hour continuous operation is required, such as automatic controllers, memory systems, alarms, and monitoring systems. In these instances, not only the whole system is power supplied by the batteries. A part of such equipment may have the power supplied from sections which are used in continuous operation. In portable equipment some use more than two sets of

batteries as shown at "a" in Fig. 9 (a). At "b" in the same figure, use of a DC-DC Converter makes it possible to use only one battery source. This has the advantage in that there is only one replacement condition (life of two separate batteries may be different).

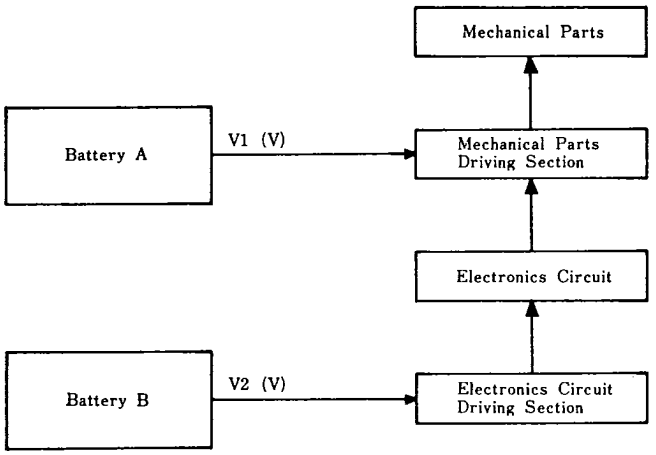

Fig. 9(a). 2 Batteries Power Source System.

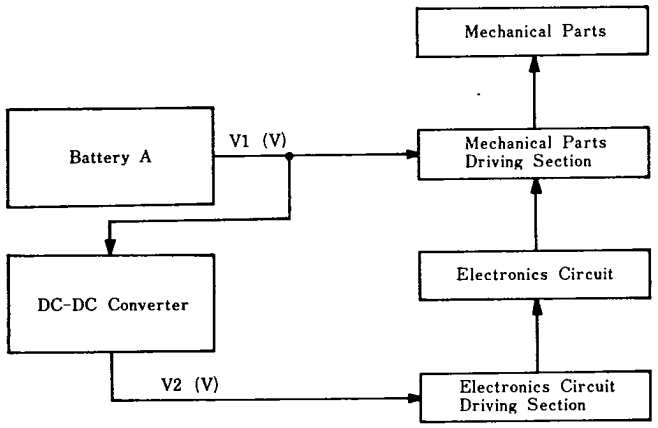

Fig. 9(b). 1 Battery Power Source System.

12-9. Use of Individual Power Supplies

Heretofore, the power for different functions in electronic equipment is supplied from a main source, see (a) in Fig. 10. However, with use of the DC-DC Converter, as shown at (b) in the same figure, the power supplies for different circuits can be distributed. This method has the merit in simplifying the design and structure of the systems, increasing the reliability and for ease in maintenance. In addition, from power supply considerations, standardization is possible, resulting in standardization at low cost.

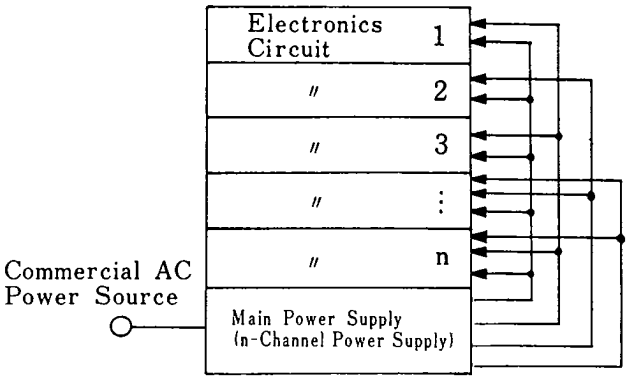

Fig. 10(a). Traditional Power Source System.

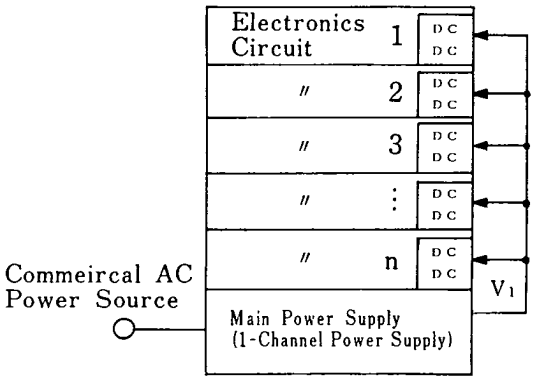

Fig. 10(b). Power Source System Useing DC-DC Converter.

12-10. Practical Applications

The general applications of the Toko DC-DC Converters have been given on previous pages. Examples of practical circuits will be shown hereafter.

(a)

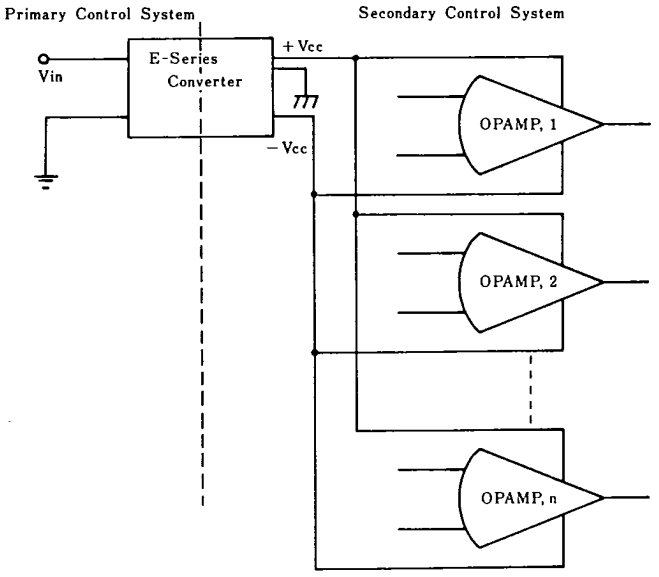

Fig. 11. Application of E-Series Converter as an Isolator.

21A

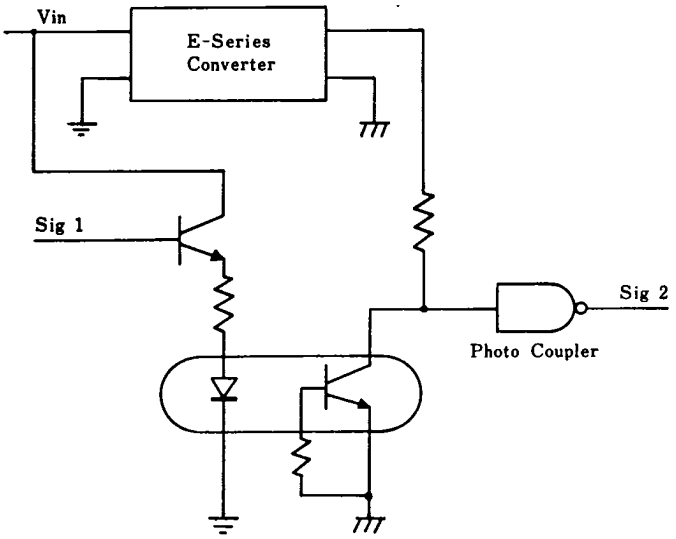

Fig. 12. Application of E-Series Converter as a Power Source of Photo-Coupler.

(c) Condition of Higher Output Stability

It is possible to obtain higher output stability than given in the catalog specifications for a given Converter unit. In this case the output voltage of the Converter should be 2V higher than required output voltage. It must be noted, however, that the usable current range will be less by the amount used in the stabilizing circuit.

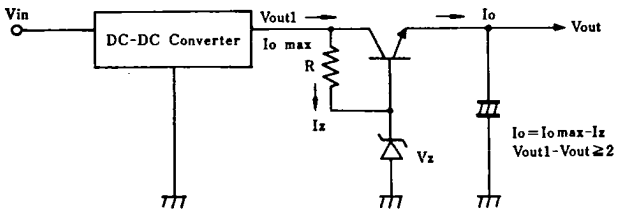

Fig. 13. DC-DC Converter with Simple Stabilizing Circuit.

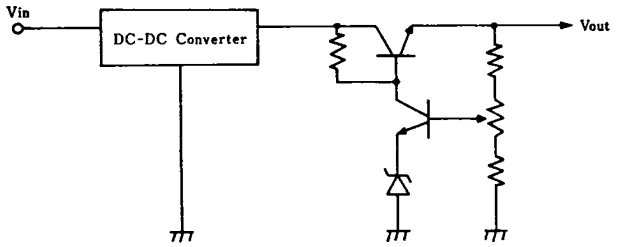

Fig. 14. DC-DC Converter with Variable output Stabilizing Circuit.

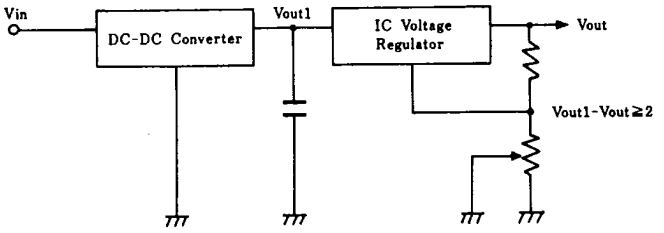

Fig. 15. DC-DC Converter with IC Regulator.

(d) Adding an Over-Current Protector Circuit

The TOKO DC-DC Converters are not provided with the over-current protect circuit. However, protection can be provided with addition of a current cut-off circuit, an example of which is shown in Fig. 16. Fig. 17 shows an example of a protector circuit with characteristics of the cut-back type. Precautions in the circuit design are higher Converter output voltage requirement and the limited output current range as mentioned in the previous section.

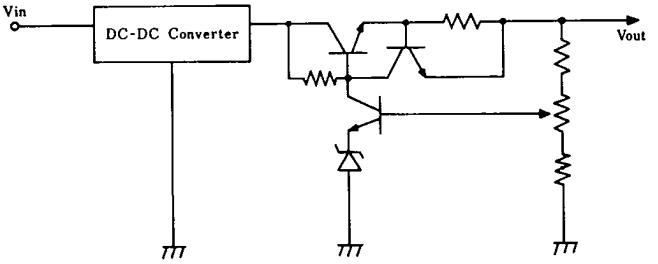

Fig. 16. DC-DC Converter with Over-Current Protector Circuit.

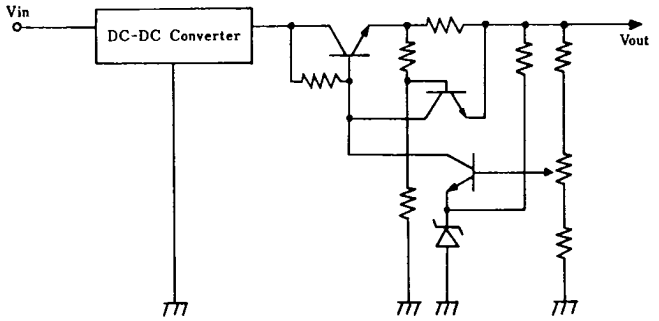

Fig. 17. Current Limiting Characteristics.

12-11. Special Usage of E-Series

Since the input and output circuits used in the E-Series are isolated, there is a choice in grounding at the output side.

(a) Double Output Voltage Application

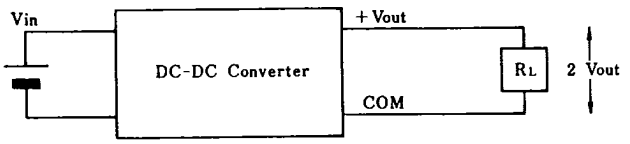

Fig. 18. Double Output Voltage Application of DC-DC Converter.

(b) Multiple Output Voltage Application

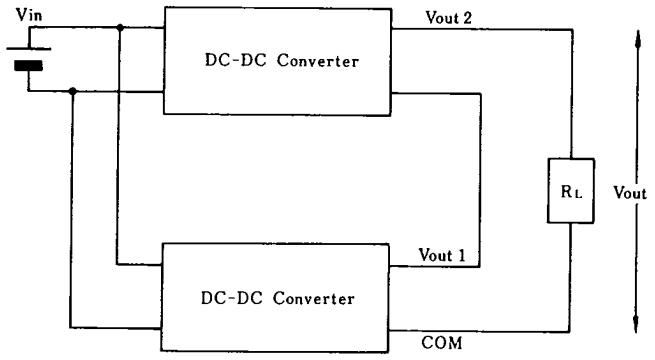

Fig. 19(a). Multiple Output Usage of DC-DC Converter.

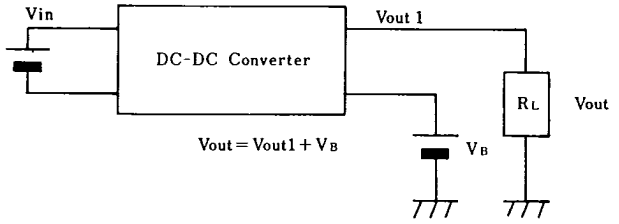

Fig. 19(b). Multiple Output Usage of DC-DC Converter.

12-12. Multi-Channel Output Application

The standard F,M,K, and E-series Converters have one or two output channels. The output may be distributed for multi-channel output operation by connecting zener diodes of suitable rating in series with the respective output, see Fig. 20. The output current will depend on the zener diode characteristics but the output voltage will be the same. Furthermore, the power loss in the diode must be accounted for.

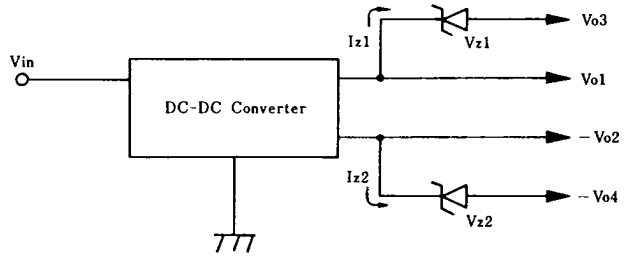

Fig. 20. Multi Channel Output Application of DC-DC Converter.

12-13. Modification for Large Power Output Control

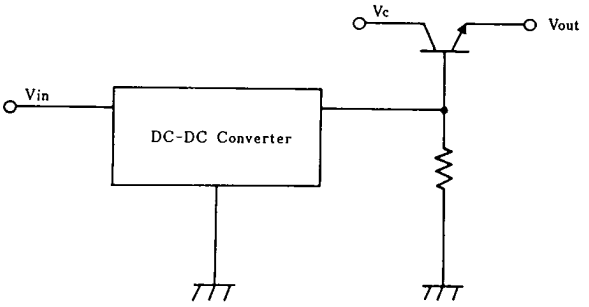

Fig. 21 (a). Modification for Large power output control.

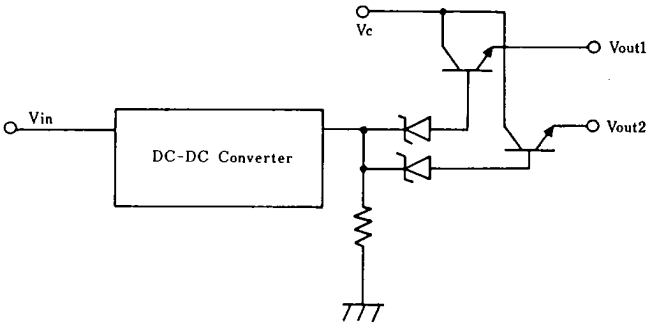

Fig. 21 (a). Modification for Large power output control.

Output power of the F,M,K, Series and E-Series standard DC-DC Converters are rated at 1W and 1.5W respectively. It is possible, however, to obtain higher outputs with use of a current amplifier transistor as shown at (a) and (b) in Fig. 21. The maximum output current will depend on the current rating of the transistor in circuit. At (a), the output voltage. Vout, will be lowered by the V_{BE} of the transistor. Again, at (b), a zener diode is connected in series with the base of the transistor. This markes it possible to set the output voltage as required, and also possibility of multi-channel operation. In the above modes of operation, the separate supply, V_c, for the transistor collector is required and it must satisfy the relation, V_c-V_{out}=2V. Again, if the Converter input voltage, V_{in}, is selected so that V_{in}-V_{out}=2V, then V_{in} may be used instead of a separate V_c.