TFMx IR Detector Photomodules

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General Information

Introduction

Infrared remote controls have become a standard part of home entertainment equipment. Nearly all functions of sat receivers, TV sets, VCRs, hi-fi audio receivers and compact disk players are remote-controlled.

Without exception, the signals have been transmitted up until now with an optical carrier in the near infrared with a wavelength between 840 nm and 960 nm. Infrared headphones, interpreter transmission systems in conference rooms, optical computer links and optoelectronic keys also work in this wavelength range.

Remote control receivers must be extremely sensitive and should not react to interference from other infrared emitters. The systems must also not disturb each other.

Generally, interference between remote control systems can be avoided by addressing the different units with a special code. The aim is to integrate the control of different units into one.

For the developer of remote control systems, it is an essential task to avoid interference by omni-present optical and electromagnetic radiation sources. Therefore, certain specifications must be made for the receiver photomodule and with regards to their properties in the application.

The system developer has a substantial influence on the performance of the system by choosing a suitable transmission code. The procedure in evaluating all incoming signals (either disturbing or useful ones) contributes significantly to the optimization of the system.

This application note gives some necessary background information for the system developer to optimize the operation of photomodules. The physical boundary conditions which can have an influence on the performance of the receiver photomodules are also described.

The IR remote control photomodules within this design guide are complete front ends, including photo pin diode, AGC amplifier, bandpass and demodulator.

TEMIC offers the safety of a perfected product. The components are based on the many years' experience of Europe's number one producer of infrared receivers.

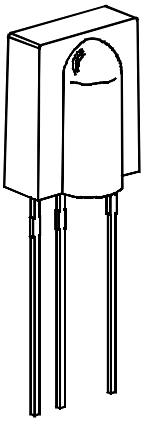
Typical applications

- TV sets
- Video recorders
- Sat receivers
- Slide projectors
- Hi-fi components
- Data communication

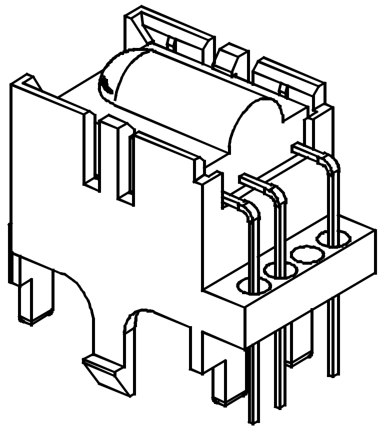
Special features

- Compact outline
- Available for carrier frequencies of 27 kHz up to 62 kHz
- No external components necessary
- Output microcomputer-compatible
- High sensitivity for large transmitting range (120 ft/ 35 m)
- Maximum interference safety against optical and electrical disturbances
- High quality level ISO 9001
- Automated large-volume production

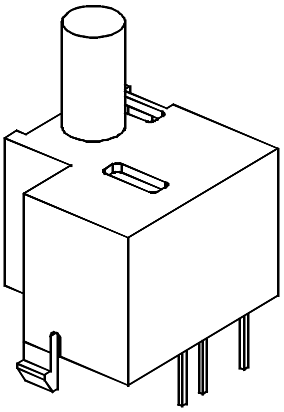
Available Types and Packages



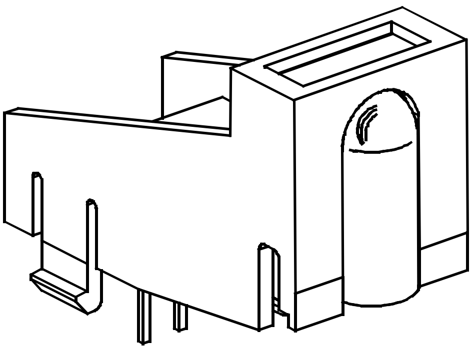
TFMS – standard side view



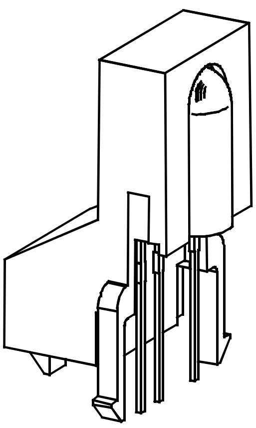
TFMT – standard top view



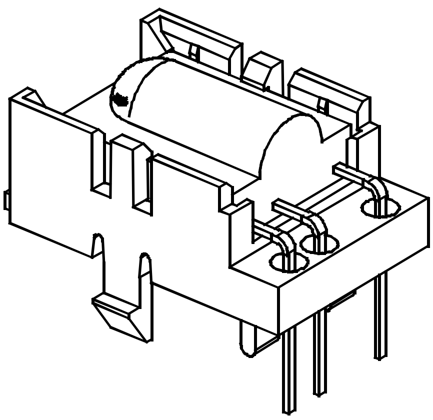
TFMY – top view with transparent holder and light guide



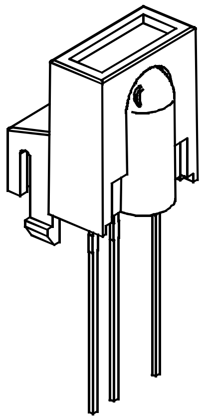
TFMW



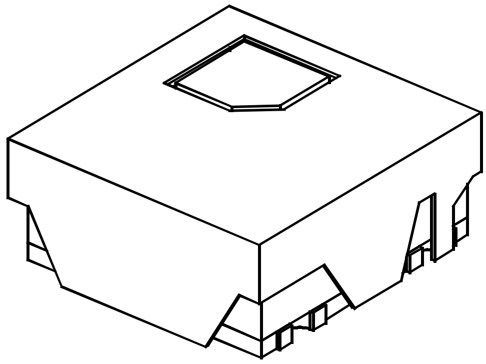
TFMX – side view with holder



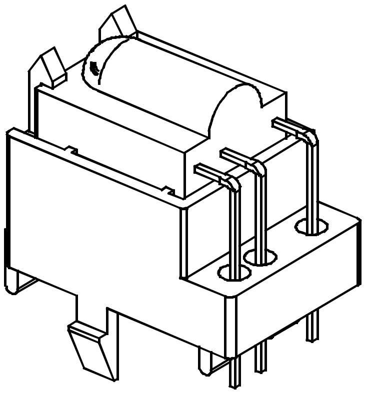
TFMU – top view with very flat holder



TFMK – side view with holder



TFMM – SMD case



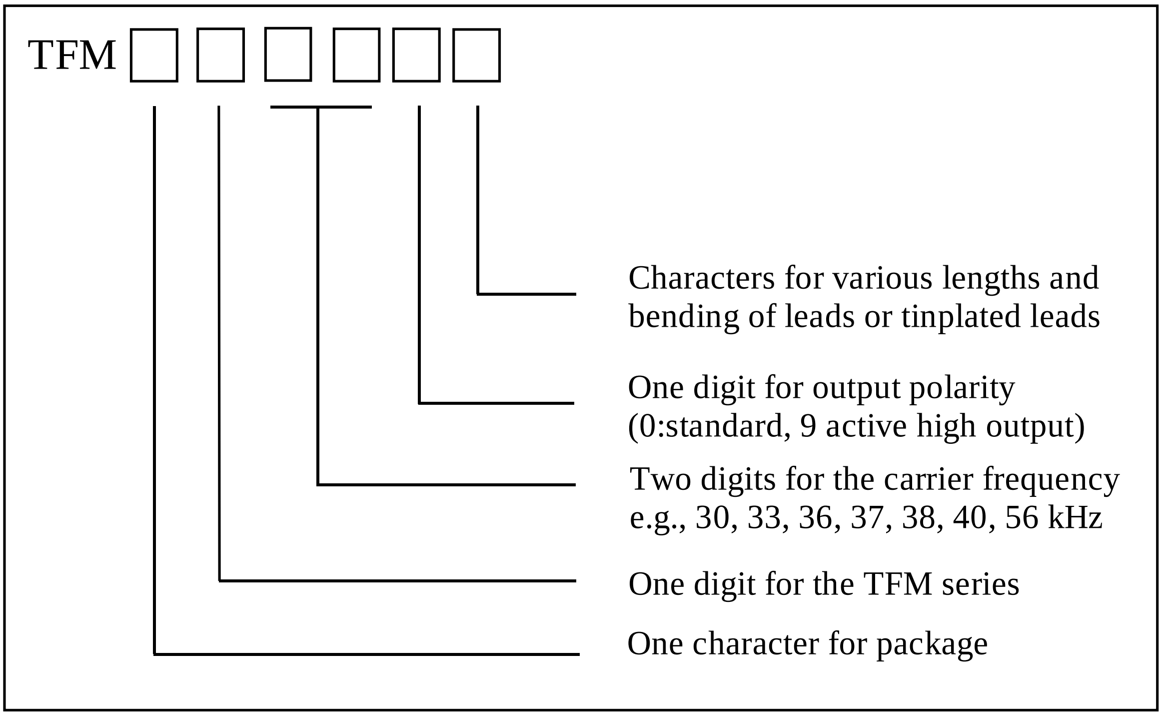
TFMC – top view with flat holder

TFM Type Series	Typical Application	Application Examples
TFM.1..0	Short bursts and high duty cycles	Continuous data transmission; RECS 80 code
TFM.1..0T	Short bursts and low duty cycles	RECS 80 code
TFM.2..0	Long bursts and low duty cycles	
TFM.5..0	Standard type suitable for most transmission codes	RC 5 code; NEC code
TFM.7..0	Standard type suitable for most transmission codes Reduced sensitivity (small PIN diode)	RC 5 code; NEC code

For more details on the features and limitations of the type series please see later in the text.

TEMIC Type Designation Code

The key to understanding the type name is shown in the following graph.



Last character:	A, B, C, D, E, F, G, H, I, ...	= Different mechanical dimensions of the lead (see pages 27-34)
	SN	= Tin-plated lead
	T	= TFM series for low duty cycle and short bursts
Example:	TFMS5360SN	= Standard receiver with 36 kHz center frequency, active low output, side view package and with tin-plated leads

Free-Space Data Transmission in the Near Infrared

Data transmission in free space places a high interference immunity on the photomodules. The receiver unit (waiting to receive signals) is loaded with different optical and electromagnetic disturbances, omni-present in the ambient or generated by the electrical appliance itself. All optical sources with an emission spectrum in the receiving bandwidth (830 nm - 1100 nm) of the detector can be considered as disturbing sources. Possible sources for electrical interferences are all modulated power signals in the operating frequency range as found especially in deflecting currents in TV sets with their harmonics. Another potential source for disturbances are energy-saving fluorescent lamps.

Optical Sources of Interference

In the visible, remote control receivers are totally insensitive because they are equipped with an optical cut-off filter at a wavelength of e.g., 830 nm. Therefore, only radiation with longer wavelengths are detected. Special measures in the design and technology of TEMIC devices ensure that sensitivity above 950 nm drops as sharply as possible.

The silicon photo detector receives in this way a limited spectrum originating from the common broad band "white" light sources which are emitted in the visible and infrared, respectively. For the assessment of visible radiation, mostly the quantity illuminance (measured in Lux = Lumen/ m^2) instead of the quantity irradiance (measured in Watt/ m^2) is used. However, the quantity illuminance is absolutely unsuitable for the description of infrared radiation because the part of radiation with wavelengths longer than 780 nm is generally not assessed. This will be described later more detailed.

Generally, the question of the photo current generated in a remote control receiver by a defined illumination arises. This can not be answered without knowing the spectral distribution of the source.

Various Radiation Sources in Filtered Silicon Detector Diodes

The spectral distribution of a radiant source is very varied and is dependent on the mechanism of radiation generation. The spectral emission curve of a thermal radiator such as e.g. an incandescent (tungsten) lamp is very broadband and is described very well by Planck's radiation law.

The spectral emission of fluorescent lamps is rather complicated. In the infrared only, little radiation is emitted. The spectral emission is a combination of the relative broadband emission of the luminescent phosphor, the emitted mercury lines and the lines emitted from the gas filling the tubes. For assessment of the disturbing influences of these sources, consideration has to be given to the various time constants (milliseconds) of the activated luminescent materials. Direct emission on the other hand is modulated to the current, passing through the lamp with all high frequency parts on it. Therefore, one part of the emitted spectrum is to be considered as a low-frequency source while the other must be regarded as a broadband disturbing source with high frequency parts.

In the main, the sun can be seen as a thermal radiator which is influenced by atmospheric absorption.

Silicon photo diodes with integrated cut-off filters are used in IR data transmission systems such as the remote control appliance. The spectral responsitivity of the diode in the received band is near 100% quantum efficiency. For the lower wavelength cut-off, the edge is at about 820 nm to 900 nm depending on the wavelength of the emitters. The long wavelength cut-off and wavelength dependent decrease of the sensitivity at longer wavelengths is given by the spectral absorption of the silicon and the thickness of the active volume (in pin diodes the wafer thickness). The response to different light sources can be numerically calculated with this kind of detector model. For the calculation, a thermal radiator with a temperature of 5900 K was chosen as an equivalent to the solar spectrum (see figure 1) for direct and global radiation under AM2 conditions.

This radiator is compared with a standard illuminant A radiator (T = 2856 K) which is approximately equivalent to a common tungsten incandescent lamp. In figure 2, the spectral density of the emission of both sources are shown as a function of the wavelength normalized to equal photometrically weighted outputs. Additionally, the sensitivity of the human eye V(λ) and of a filtered silicon detector (similar to TEMIC BPV23NF) is shown. It can easily be seen that the radiation from the sun-equivalent source contains much less radiation than the tungsten lamp in the sensitive wavelength range of the silicon detector diode.

These facts can also be numerically evaluated with regard to the expected photo current of the detector diode resulting in the data given in table 1. The irradiance and illuminance necessary to generate a photo current I_{ra} = 100 µA are listed for the filtered silicon detector diode with an effective area of 8 mm^2.

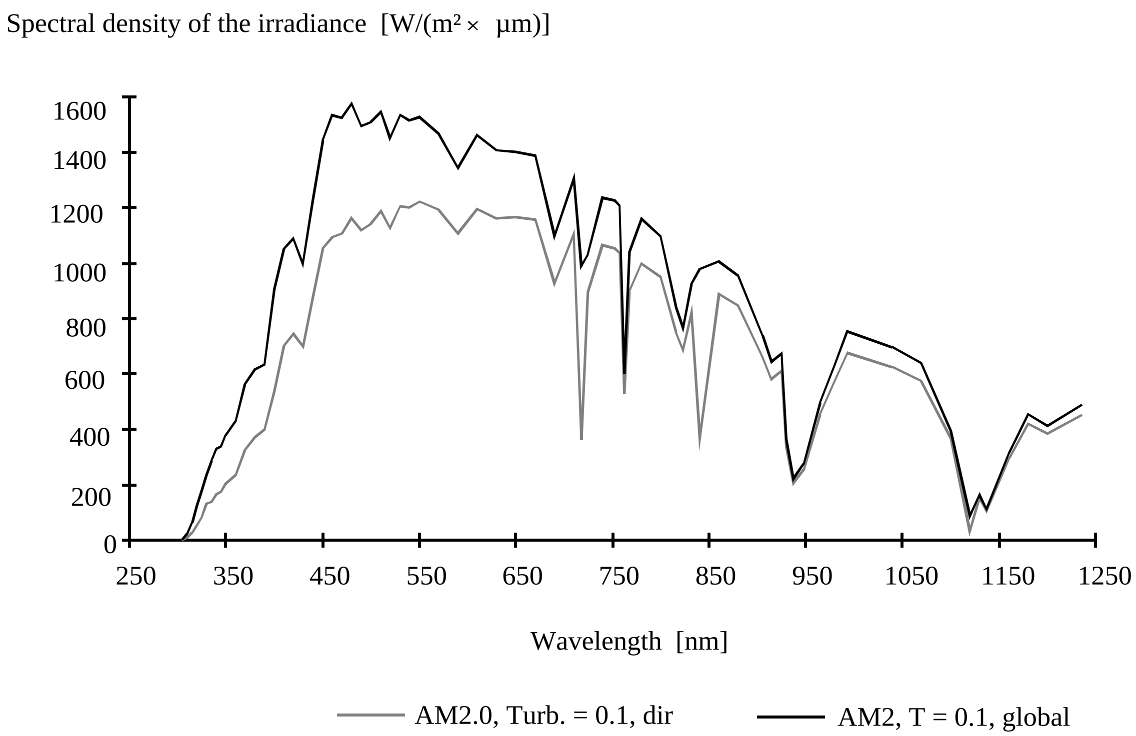


Figure 1. Spectral distribution of solar spectrum

Of course an irradiance could be assigned to the thermal radiation. However, this is not very effective in our consideration because it cannot describe a result in terms of e.g. a photo current (the total irradiance is the integrated quantity over the wavelength from zero to infinity). The illuminance resulting from the radiation of an infrared emitter is per definition zero. The result is of significance in that drastically different illuminances of radiation sources are necessary for the generation of equal photo currents. The efficiency of the sunlight as a disturbing source (photometrically weighted, same illuminance) is a factor of 6 smaller than that of an incandescent lamp. In this calculation, the atmospheric absorption of water is not taken into account (see figure 1 – AM2 is equivalent to the solar irradiance on late afternoon. Vertical axis: Spectral density of the irradiance as a function of the wavelength.). This additional damping is increased with decreased azimuth. This should be considered when calculating the photo currents of detectors in the ambient as e.g. remote control detectors in cars. An equivalent mathematical correct weighting of the real sunlight (see figure 2) is mathematically no problem but it makes no sense because its spectral distribution changes during the day and is dependent on weather conditions.

Weighting is carried out by the human eye [function V/(λ)] and by a filtered silicon detector. The amplitudes are normalized to give, photometrically weighted, the same illuminance. The human eye will see both sources as equal 'brightness'.

Table 1. Filtered silicon detector diode (area A = 8 mm^2, sensitivity equivalent to figure 2)

Source	**Wave-length**	**Irradi-ance**	**Illumi-nance**
IRED	950 nm	18 W/ m^2	-
Thermal radiator	T = 5900 K equivalent to sun	–	14700 Lux
Thermal radiator	T = 2856 K standard illuminant A	–	2500 Lux

The necessary irradiation or illumination to generate a photo current of I_{ra} is 100 µA.

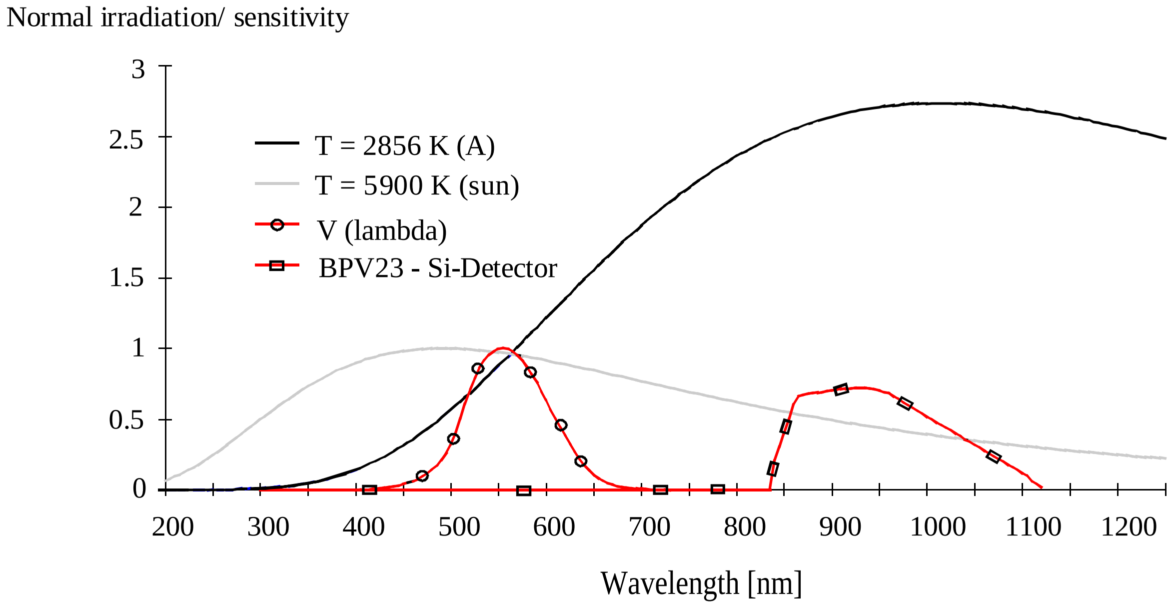


Figure 2. Blackbody radiation with various color temperatures

Application Hints

In this sub-chapter, recommendations for the design of a front panel for, e.g., a TV or a VCR device is given.

Usually, the front panels of home devices are black and the optical window in front of the IR receiver should also be black. That means that a plastic material is needed which is transmissive for the infrared signals but not transparent for visible light. The diagram in Figure 3 shows an example of the spectral transmittance of such a plastic material (Bayer Makrolon color 45/601).

The cut-off wavelength should be between 700 and 850 nm in order to appear black and in order not to absorb signal energy.

There is a loss of power in every front panel of about 8% due to reflection (4% at each side). On the one hand, the thickness of the panel should kept small, as there is an additional loss of energy in the plastic material. On the other hand, the thickness of the plastic or the color mixture should not be too small in order to avoid that one can see inside the device. In contrast to other products which have a metal can shielding, the TEMIC TFM receiver has an advantageous black package which prevents that it is visible behind the front panel.

The relation between the necessary thickness and the optical transmittance is given by:

$\tau(\lambda) = (1 - \rho) \times e^{[-\alpha(\lambda)\times d]}$

$\tau(\lambda)$ =	Spectral transmittance
ρ =	Constant factor for reflection loss (about 0.08)
e =	2.718282
$\alpha(\lambda)$ =	Coefficient of plastic material (about 0.03 mm^{-1} at 950 nm in the example above)
d =	Thickness of front panel

There are several plastic materials with such a spectral behavior. Some examples of Polycarbonate are given here:

Makrolon 2805; color #: 45-601 (blue - black); supplier: Bayer

Makrolon 2805: color #: 45-401 (green - black); supplier: Bayer

Lexan 21125, 21051, 21127; supplier: General Electric

Supplier's addresses: see appendix

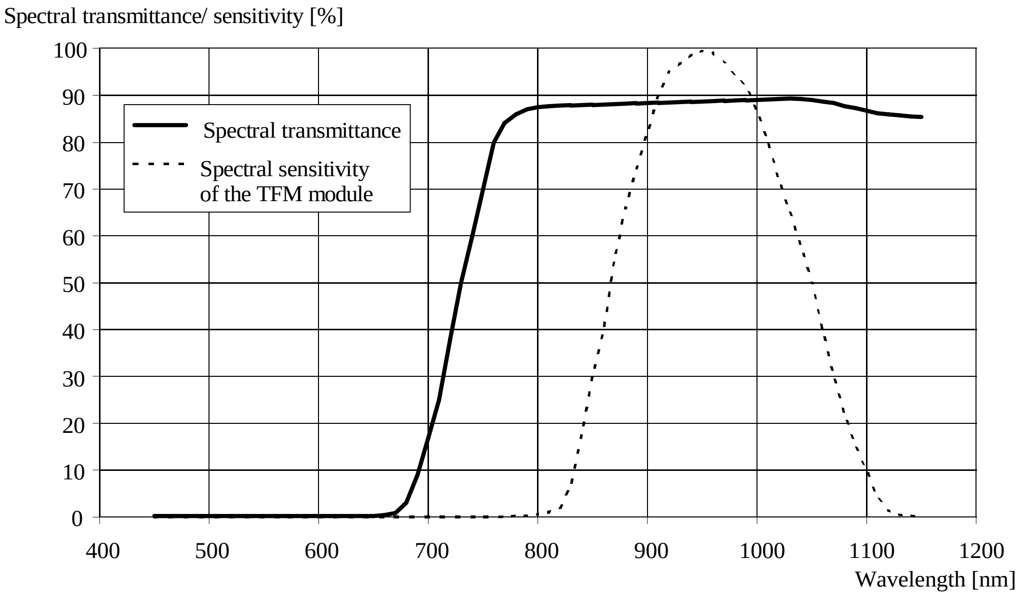


Figure 3. Spectral transmittance and spectral sensitivity of TFM modules

Transmission Range

The transmission range in free-space transmission systems is defined by a series of different parameters. Fundamental data are the properties of the transmitter and receiver units. Additionally, the ambient can influence the transmission characteristics by disturbing optical or, when arising, electromagnetic radiation.

A critical point is the comparability of calculations and measurements of the transmission range. Calculating transmission ranges in the simplest case assumes a square-law relationship between distance d and irradiance E_e. With a given intensity I_e, the result is

$$E_e = I_e / d^2$$

With known responsitivity of the receiver photomodule and known intensity of the transmitter, the transmission range can be read from figure 4 where the relationship is implemented. As a typical threshold of the receiver sensitivity for safe operation, a value of 0.3 mW/m^2 is taken for the necessary irradiance in figure 4. This is equivalent to the typical specified value of the TFMS5..0 series.

The maximum sensitivity threshold is specified at 0.5 mW/cm^2. The typical intensity values of selected emitters are listed in table 2.

Operating e.g. a TSIP5201 emitter at 1.5 A pulsed-forward current gives an intensity of 650 mW/ sr. These data result (in combination with the TEMIC receiver photomodules) in a theoretical transmission range of 43.1 m (see figure 4).

The interdependence between transmission range and irradiance at the location of the receiver is shown in figure 5. The necessary irradiance for safe reception using the receiver photomodules of the TFMS series is also shown.

In practice, it is difficult to realize the quadratic relationship between irradiance and transmission distance.

In general, a smaller decrease in sensitivity is observed due to reflection of walls and floors. This means that the example calculated here is the worst case and in reality better transmission ranges are attained.

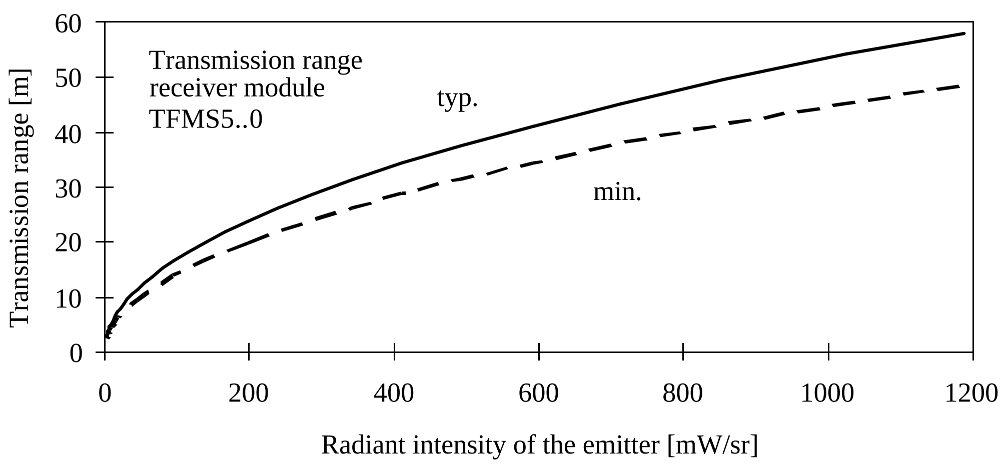


Figure 4. Maximum transmission range 8 in free space
with receiver photomodules TFMS5..0 as a function of the radiant intensity of the emitter

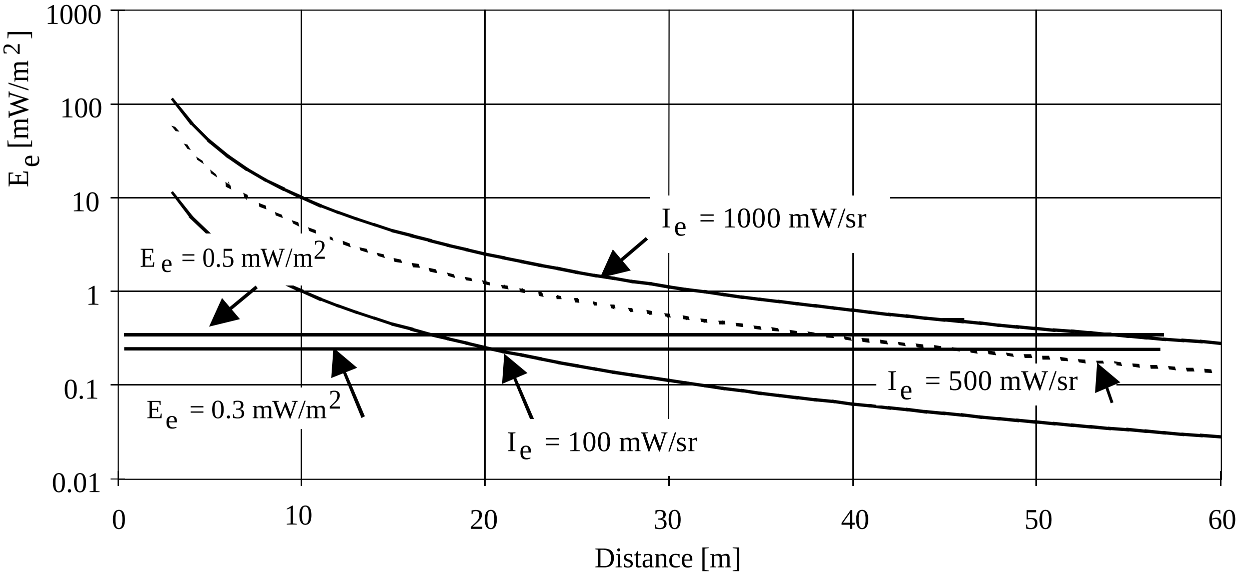


Figure 5. Irradiance E_e as a function of the distance
(parameters are the radiant intensities of the emitters)

Table 2. Emitters for remote control appliances

Emitter	Technology	Wavelength [nm]	Radiant Flux I_f = 100 mA	Radiant Intensity I_f = 100 mA	Radiant Intensity I_f = 1.5 mA	Emission Angle
			mW Typ.	mW/ sr Typ.	mW/ sr Typ.	
TSIP4401	GaAlAs	950	22	25	300	± 20°
TSIP5201	GaAlAs	950	25	50	650	± 20°
TSIP7601	GaAlAs	950	25	20	260	± 30°
TSUS4300	GaAs	950	13	18	160	± 20°
TSUS4400	GaAs	950	13	15	140	± 16°
TSUS5202	GaAs	950	15	30	280	± 15°
TSUS5402	GaAs	950	15	30	190	± 22°

The levels for indoor optical powers can be estimated by using other approximations. In this case, it is assumed that the whole inner surface of a room is irradiated with the emission of the source. To irradiate the whole surface of a square room (e.g. area = 30 m^2, height = 2.5 m) with an overall irradiance of E_e = 0.5 mW/ m^2, an emitted radiant flux of 60 mW is necessary (surface = 120 m^2, 100% efficiency). With 80% reflection loss, about 300 mW emitted radiation will be sufficient for safe reception in the whole room. 300 mW is a value which can be achieved with an emitter TSIP5201 operating at a peak forward current of 1.5 A. Under these conditions, no direct path between emitter and receiver is supposed, but radiation after at least one reflection will reach the detector (direct reception will obey the square law, see table 2).

Comparison of remote control systems is often performed in long corridors. Such measurements cannot be transferred at all from one corridor to the other because of different reflectivity properties of walls etc. In a corridor, the function of the irradiance does not obey the square of the distance law. The behavior in a corridor can be described by the function:

$$E_e = I_e \times \left(\frac{a}{d^2} + \frac{b}{d} + \frac{c}{\sqrt{d}} \right)$$

The values of a, b and c must be individually determined for each corridor.

The corridor, for example, where the system measurements are performed at TEMIC, is described in a range from 1 m to 70 m by the parameters

$$a = 0.93,\ b = 0.074,\ c = -0.0072.$$

This relationship is exactly valid for the given emitter only. By changing the emission angle or wavelength, the reflectivity of the corridor also changes and with it the values of the coefficients.

The Languages of Data Transmission Systems

In most remote control transmission systems, only small data rates are transmitted to control the functions of home entertainment equipment. A vital pre-requisite is the safety of transmission where an incorrect interpretation of the transmitted code is not permissible. Unintelligible signals must be ignored. Usually, commands are repeated until the remote controlled device reacts as desired. The operator can directly observe the result of pressing a key by visual feedback.

The commands can be transmitted by variation of the coding of the optical carrier. Some methods of modulation have been established. Nowadays, only the digital transmission of words is used where the word length can vary which means one word can include a different number of bits.

The three commonly used representations of a bit in remote control systems are described in the following paragraphs.

The transmission of a bit using two frequencies (FSK, **F**requency **S**hift **K**eying) as shown in figure 6a is accepted as a very safe method It is, however, more expensive and consumes more power than other methods and is therefore rarely used.

The other two codings (see figure 6b and 6c) offer the possibility of two operating modes either as modulated on a sub-carrier or as a pulse transmission. In the applications, only the bi-phase modulation is found modulated on a carrier while the pulse-distance modulation is used in a carrier and a pulse-modulated mode, the so-called flash mode, respectively.

The TFM receiver photomodule series is developed and optimized for the use in carrier frequency transmission. Special types for different operating frequencies are available in the range from 20 kHz to 60 kHz. Standard types are available for the frequencies 30 kHz, 33 kHz, 36 kHz, 38 kHz, 40 kHz and 56 kHz. Other frequencies in this range can be realized on request.

Flash-mode signals and the FSK cannot be received with the photomodules of the TFM series.

The words to be transmitted consist of a defined number of bits. Word lengths and coding method are defined in the transmission standards. Several transmission standards are now accepted worldwide. Some of them are described in the following paragraphs.

In European equipment, the most commonly used standards are the RC 5 code and the RECS 80 code. Another typical transmission language is the NEC code (Far East).

The RC 5 Code

In the RC 5 standard, a bi-phase coding is applied (see figure 7). The carrier frequency is fixed at 36 kHz. Similar transmission standards are used in the frequency range between 30 kHz and 56 kHz.

The transmission of a word begins with two start bits, followed by a toggle bit. The toggle bit changes its value at each key operation. With this change, an interruption of the transmission link can be distinguished from a multiple key pressing. The five address bits address the device to be controlled. The command bits contain the information to be transmitted.

Each bit in a data word consists of a burst of 32 pulses with a repetition rate of 36 kHz. The equivalent times are shown on the pulse diagrams.

To use the RC 5 code, TEMIC recommends the TFMx5360 series.

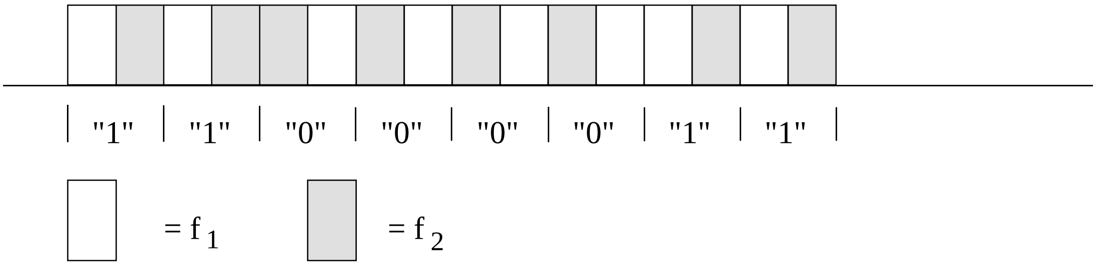


Figure 6a. Coding of a bit with two frequencies
(frequency shift keying; the sequence of the transmitted frequencies determines "0" or "1")

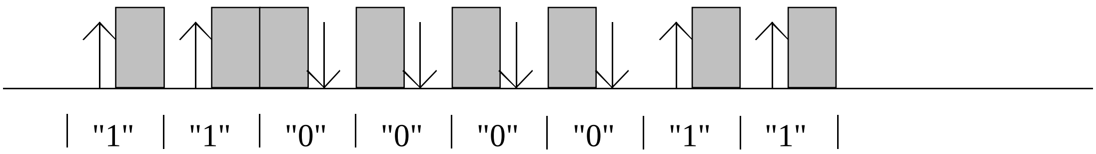


Figure 6b. Bi-phase coding
(a rising edge within a time window is equivalent to a "1", a falling edge represents a "0")

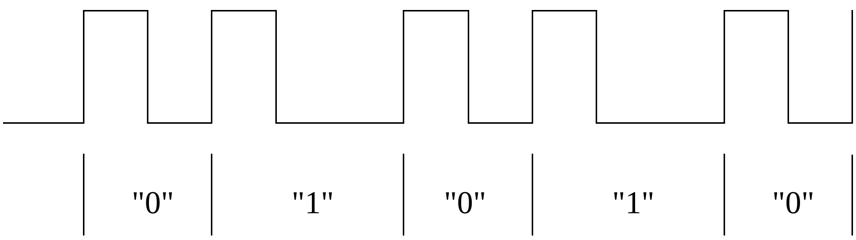


Figure 6c. Pulse-distance modulation
(the distances between the rising edges define the bit as "0" or "1", a short distance between two pulses means "0", a long distance between two pulses means "1")

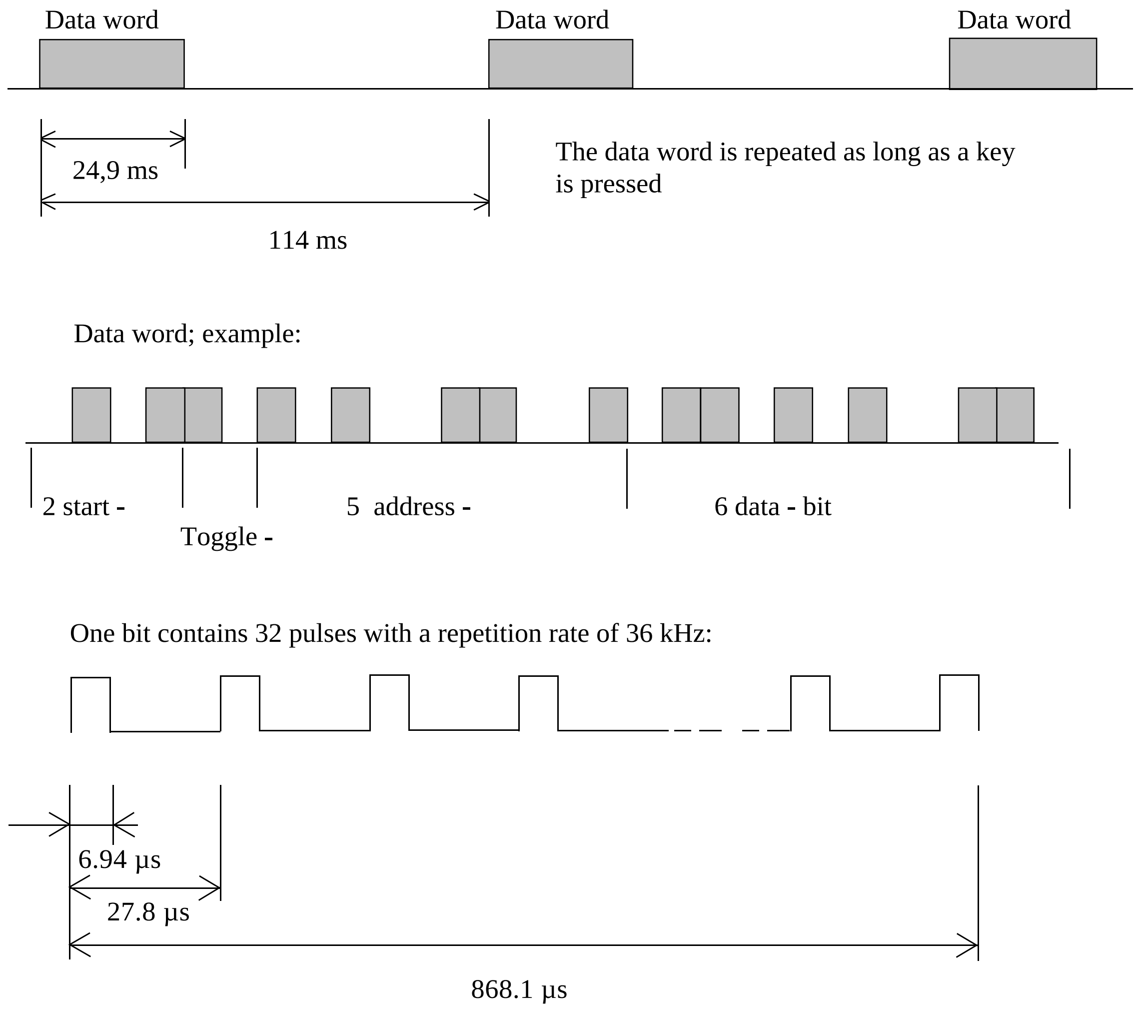


Figure 7. RC 5 transmission code

The RECS 80 Code

The data word in the RECS 80 code is, with a length of 70 ms, nearly three times as long as that in the RC 5 code. As mentioned above, the RECS 80 code operates with a digital pulse distance modulation. As in the RC 5 code, toggle, address and command bits are used. Sometimes a flash mode is found in combination with the RECS 80 code where single pulses of infrared radiation are transmitted instead of bursts. A carrier frequency of 400 kHz is also used instead of the common carrier in the range between 30kHz and 56 kHz. The IR receiver series TFMx1..0 or TFMx1..0T are optimized for the RECS 80 code with these carrier frequencies.

The TFM photomodule is not suited for receiving flash mode or 400-kHz signals.

However, a combination of a TEMIC pin photo diode (e.g. BPV23NF) with the integrated circuit U2506B is recommended for transmission in the 400-kHz band.

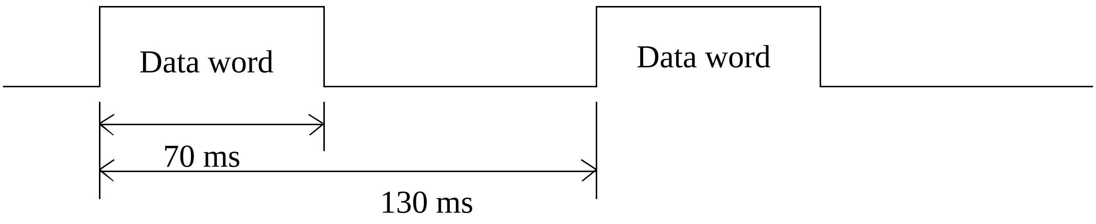


Figure 8a. RECS 80 pulse-distance modulation
(the single bits are pulse-distance coded; see figures 6c and 8b)

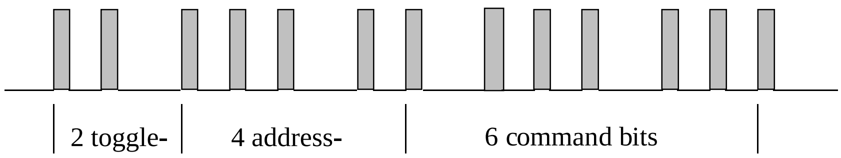


Figure 8b. Pulse-distance modulation
(example of a data word, the pulse distance for a "1" is about 7.5 ms, for a "0" about 5 ms)

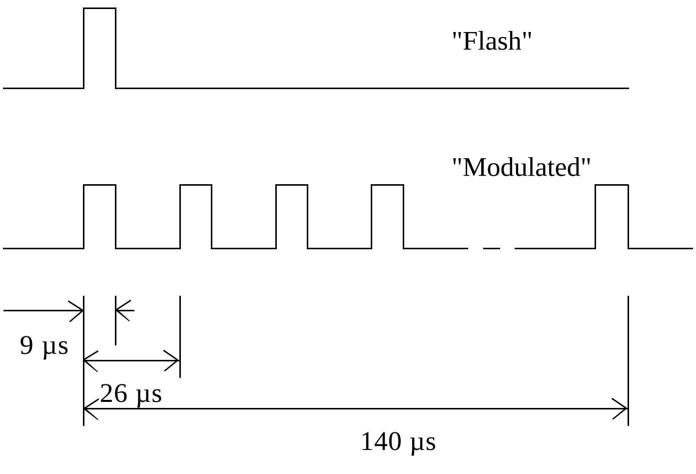


Figure 8c. Pulse-distance modulation

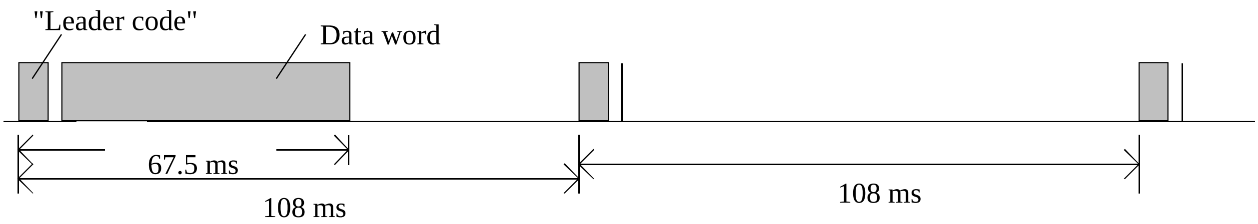


Figure 9a. NEC transmission code
(the leader code followed by a single bit is transmitted as long as a key is pressed)

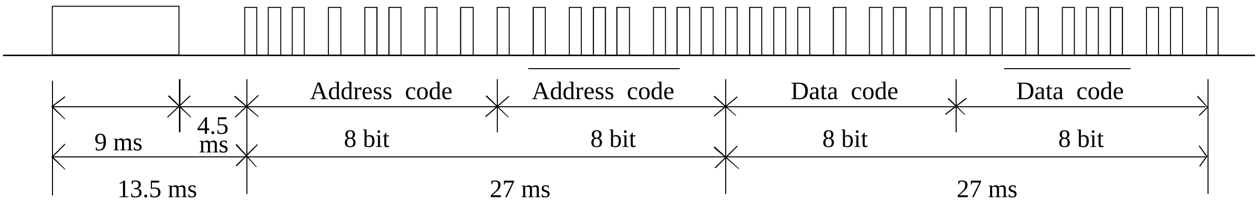


Figure 9b. NEC transmission code
(data word from figure 8a)

The NEC Code

The NEC code also works with bursts of defined carrier frequency. Therefore, receiver photomodules of the TFMS5..0 series operate optimally in this system.

The NEC code starts the transmission using a so-called leader code, a burst of a length of 9 ms, followed by the data word after a pause of 4.5 ms. This leader code is responsible for leveling the internal control loops in the receiver modules of the TFM series.

As long as a key is pressed, only the leader code is repeatedly transmitted, followed by a single bit. A specialty of this code is the property of constant word length in connection with a pulse-distance modulation. Both address and command bit are transmitted twice, first as the normal byte followed by the inverted byte. This is shown in figure 9. The burst defining a bit contains 22 pulses each of a length of 8.77 µs with a period of 26.3 µs. A "0" is represented by a pulse distance of 1.125 ms, the "1" with 2.25 ms, respectively. 8 address bits are used to identify the device to be controlled. A further 8 bits are used for the transmission of the command. As mentioned above, the words are always followed, without a pause, by the inverted words e.g. the transmission of the address "00110111" and the command "00011010" is performed by sending the word:
"00110111'11001000'00011010'11100101".

Description of the Detector Photomodules TFM Series

Functional Description

The integrated circuits of the receiver photomodules TFM are produced using TEMIC bipolar technology.

By the design, the following features are defined:

- High immunity against modulated and unmodulated ambient light, also against **C**urrent **W**ave (CW) sources
- Programmable output polarity (standard is "active low")
- Minimum of external circuitry
- Low power consumption
- Timing and output levels are microcomputer-compatible

The function of the receiver photomodules TFMx5..0, TFMx7..0 and TFMx1..0T can be described using the block diagram in figure 10a. Figure 10b explains the function of the TFMx1..0 and TFMx2..0 series. Many parts of the block diagrams in figures 10a and 10b are similar. The incident infrared radiation bursts generate an equivalent photo current. The DC part is separated in the bias block and the AC part is passed to a transimpedance amplifier followed by an automatic gain control amplifier and an integrated bandpass filter.

The final evaluation is performed by a comparator with a Schmitt Trigger stage.

The output polarity, standard "active low", can be changed to "active high" by an internal bond connection which can be set during production. With this feature, the designer is free to choose the right polarity for his application.

The blocks "short burst control" and "long-time control" are responsible for the dynamic control of the working points and the threshold levels to suppress the influences of the ambient light and other disturbing radiation sources. The short burst control is responsible for the fast reaction and controls the reference signal at the comparator to have the best noise suppression during the transmission of a data word. The long-time control has to suppress the disturbing influence of CW signals.

Input stage: The input stage provides the necessary bias voltage for the detector diode, where a 2.4×2.4 mm^2 pin diode is used. The block "bias" (figures 10a and b) additionally separates DC- and low-frequency parts from the useful signal of the photo current. The low frequency including DC current work on a low-impedance load in the block "bias". The AC signals are fed to the transimpedance amplifier.

The block "bias" reacts to the photodiode as a variable frequency-dependent load resistance similar to on LC resonant circuit with a low equivalent resistance for low-frequency signals and a high resistance of some 100 kΩ at the operating frequency. The currents at the operating frequency are converted by the transimpedance amplifier (low input impedance <10 kΩ) to a voltage at the input of the AGC amplifier.

AGC Amplifier (AGC = Automatic Gain Control): The AGC amplifier generates most of the voltage gain of the whole circuitry whereby the amplification is controlled by the output of the long-time control circuit. It supports the interference suppression of the comparator stage. The internal capacitive coupling results in a high-pass behavior. The cut-off frequency of this high pass is about 20 kHz.

Bandpass filter: The bandpass filter is tuned to the carrier frequency of the transmission system during the production process. Due to its selectivity it improves the signal-to-noise ratio of the signal. Figure of merit and amplification of the filter in the TFMx5..0 series are both approximately ten. The figure of merit in the TFMx1..0 series is seven.

Signal evaluation: The TFMx5..0, TFMx7..0 and the TFMx1..0T series have a single comparator level which is controlled by the **A**utomatic **T**hreshold **C**ontrol (ATC) or the short-burst control and the long-time control (figure 9a). The level V_T sets the sensitivity level of the evaluation. The TFMx1..0 and TFMx2..0 series use two comparators (figure 10b). One has a constant threshold at the lowest level V_T and the other is controlled by the ATC. At low signals, the comparator with the constant threshold level is used for evaluation. With large signals, the threshold of the second comparator is evaluated. Its level is shifted by the ATC to the half value of the actual signal level. This technique prevents the punch-through of small interference voltages to the output (e.g., disturbing bursts during a data telegram).

The integrator (INT) is triggered depending on the above mentioned comparison. It controls the output via the Schmitt Trigger (ST). The integrator additionally prevents the feed-through of short disturbances to the output.

The internal pull-up resistor of R = 100 kΩ on the output transistor can be used as a single load and can, according to the application, replace the external load resistor. An external resistor can operate in parallel. The output current is internally limited to about 10 mA.

Short-time control: The comparator stage is as sensitive as possible in the quiescent mode. The short-time control reduces the sensitivity at the comparator stage shortly after the first signal arrives to that level, where the signal recognition can be expected with safety. With this method, disturbances can be efficiently prevented from being detected as a falsely transmitted signal during the transmission of an information block. This reduction of sensitivity is performed by increasing the potential at the inverting input of the signal comparator. The RC combination represents the time constant (t < 15 ms) of the short-time control which is fitted well to the common transmission codes.

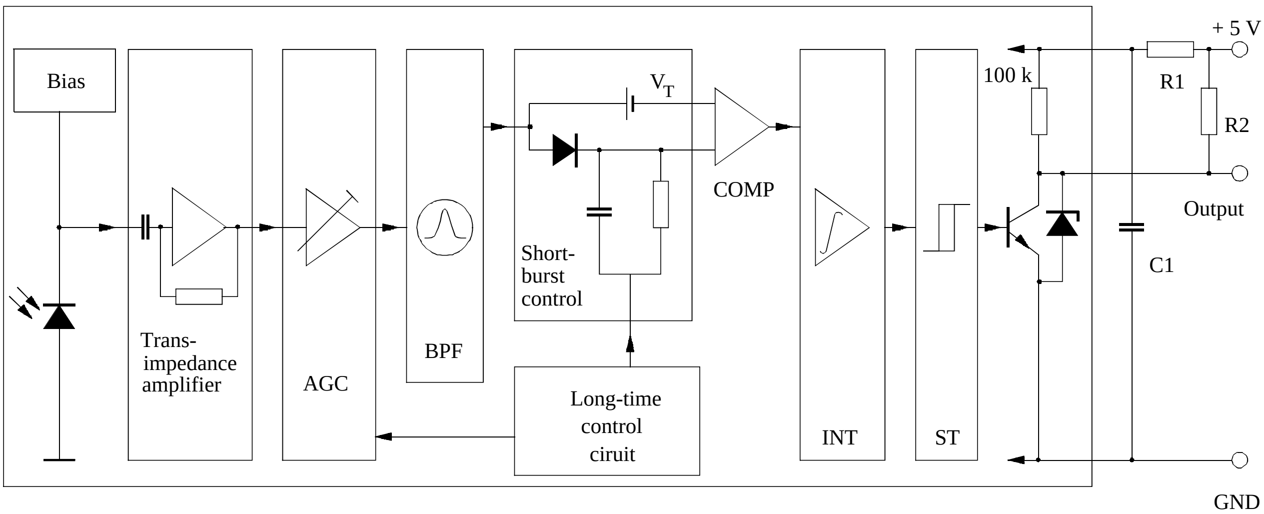


Figure 10a. Block diagram of the receiver photomodules TFMx5..0, TFMx1..0T and TFMx7..0

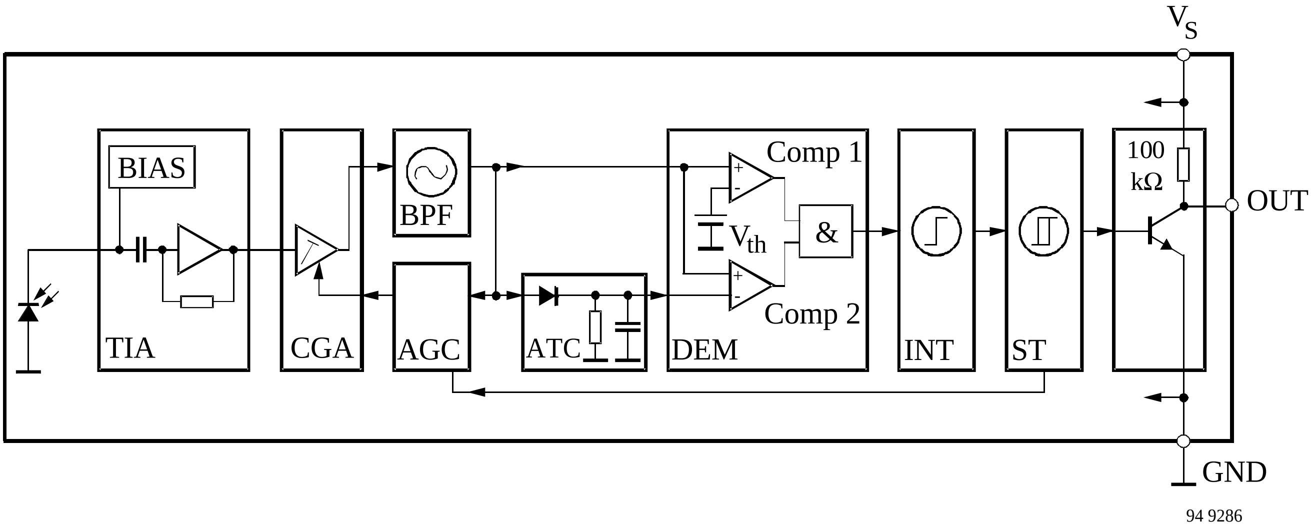


Figure 10b. Block diagram of the receiver photomodules TFMx1..0 and TFMx2..0

Long-time control: This circuit ensures that the receiver photomodule is immune to disturbances. It adapts to the existing noise or disturbance level by changing the sensitivity at the comparator input and the gain of the AGC amplifier. The reduction of the sensitivity is also effected, as with the short-time control, by increasing the potential at the inverting comparator input. The time constant of the long-time control is chosen to be suitably large to avoid a considerable sensitivity decrease during the transmission.

All continuous disturbing signals (CW sources) are extremely well suppressed by the long time control and the AGC stage. Apart from the ATC which is described above, special techniques can be implemented in order to suppress shorter disturbances. In the TFMx1..0T, TFMx2..0 and TFMx5..0 series, an integrated mono-flop function inside the long time control block ensures that short disturbances are weighted stronger for shifting the AGC level. In the TFMx1..0 series, also short disturbance signals are weighted stronger than the (useful) longer bursts because the AGC is affected mainly during the load time of the integrator in this circuit.

As the duty cycle of the data transmission is very low, the long-time control does not reduce the sensitivity while it is receiving a data telegram. The exact duty cycle limitations for each TFM series are given in the following chapter.

Behavior Under Operational Conditions

To assure optimal operation of the receiver photomodule TFMS5..0 under all thinkable application conditions, it is necessary to evaluate the behavior of this device at different boundary conditions. In the next chapter, the influence of different parameters in the application is evaluated. Emphasis is placed on the differences of the TFMx families. These data will help to optimize the appliance of the receiver photomodules.

Properties and Applications

Different Telegram Conditions

Influence of the short-time control: The short-time control raises the threshold for the signal evaluation to an optimized working point to assure the best signal-to-noise ratio for the received signal. Between the single bursts of the transmission telegram, the threshold slides back towards the initial value with a time constant of t = 15 ms until the next burst again adjusts the threshold level.

In the quiescent mode, i.e. no signal on the receiver photomodule, the circuit is controlled to its most sensitive working point. This working point is determined by the magnitude of the input noise which should not cause any signal at the output. However, due to the statistical distribution of the input noise, single pulses occasionally occurring at the output cannot be avoided. This should not present any problem for the signal processor following the photomodule as long as the likelihood of noise-generated pulses is small.

As mentioned before, in the quiescent mode the threshold is very low. Starting with the first burst of a transmission telegram, the short-time control is activated. Therefore, the switching-on time for the output signal generated by the first burst is about $2/f_{rfg}$ (f_{rfg} = rated frequency) shorter than the following bursts. This behavior should be considered in the evaluation software of the processor or should be eliminated by a leader code as in the NEC transmission code.

During the transmission, the control loops are set to those working points which guarantee the best signal-to-noise ratio. When using transmission codes with burst intervals of t_{rep} > 15 ms within the telegram, the threshold runs down during the pauses to the noise-controlled level. This mode of operation should be avoided because it is impossible to adjust the noise-optimized working point. The likelihood of noise or background radiation-generated output signals will increase. If this cannot be avoided, the signal processor software must tolerate or compensate such errors to prevent extended reaction times and adulterated transmissions.

Influence of the long-time control: The long-time control adapts the threshold level to the external disturbance sources e.g. RF- and optical CW signals. The long-time control circuit can distinguish between useful signals and disturbances as long as the transmission maintains the duty cycle condition of each type (see next chapter).

The conditions must be observed also when transmitting larger amounts of data as in special TV applications where long transmission blocks are used for service adjustments of the equipment. In this so-called factory mode, the duty cycle is increased to a maximum tolerable value and a sensitivity loss is acceptable.

When this limit is exceeded, the sensitivity of the receiver photomodule decreases continuously. For CW signals, the module is then totally insensitive because by design, CW signals are per definition disturbances. The dependence of resulting sensitivity on the applied duty cycle is shown in the data sheet.

Influence of the Integrator

The integrator stage needs a minimum burst length until the output is switched. Therefore, the integrator can suppress disturbances such as short bursts or spikes. An optimum function in the application of the receiver photomodules is achieved by using burst lengths representing one bit not shorter than the special integration time of the series. The gap between two bursts must also exceed a minimum time period (recovery time of the integrator). The various timing requirements for the TFM series are given in the next chapter.

Features and Restrictions of the Various Components in the TFM Series

To enable the remote control system to function correctly, the most suitable type of the TFM series has to be chosen regarding the criteria of the transmission code (duty cycle, burst length, gap length) and its decoding method. The duty cycle is defined in the example given in figure 11 and is as given at the bottom of this page.

Table 3. Timing requirements for the various TFM series

	Maximum Duty Cycle	**Minimum Burst Length**	**Minimum Gap Length**	**Timing Tolerance of Output Pulses**
TFMx1..0	$N/ (14.2 + 1.1 \times N)$	$6/ f_O$	$10/ f_O$	$-3/ f_O + 6/ f_O$
TFMx1..0T	$1/ [6 \times (1 + 0.25\ ms/ \{N/ f_O\})]$	150 µs	250 µs	–100 µs + 160 µs
TFMx2..0	$1/ [4 \times (1 + 0.67\ ms/ \{N/ f_O\})]$	$17\ f_O$	$17\ f_O$	$-5/ f_O + 8/ f_O$
TFMx5..0	$1/ [6 \times (1 + 0.25\ ms/ \{N/ f_O\})]$	400 µs	400 µs	+/ – 160 µs
TFMx7..0	$1/ [6 \times (1 + 0.25\ ms/ \{N/ f_O\})]$	400 µs	400 µs	+/ – 160 µs

f_O = Carrier frequency of transmission, N = Number of periods in a burst

Table 4. Time requirements example
(typical transmission code with 22 periods in a burst at 38 kHz)

	Maximum Duty Cycle	**Minimum Burst Length**	**Minimum Gap Length**	**Timing Tolerance of Output Pulses**
TFMx1380	0.57	160 µs	260 µs	–80 µs + 160 µs
TFMx1380T	0.12	160 µs	250 µs	–100 µs + 160 µs
TFMx2380	0.12	450 µs	450 µs	–130 µs + 210 µs
TFMx5380	0.35	400 µs	400 µs	+/ – 160 µs
TFMx7380	0.35	400 µs	400 µs	+/ – 160 µs

Duty cycle =

$$\frac{(T2 - T1) + (T4 - T3) + (T6 - T5) + (T8 - T7)}{t_{rep}}$$

If a data transmission language uses different burst lengths (N), the calculation can be done with an average burst length. As the long time control reacts very slowly, examinations of the duty cycle should be carried during a long interval time (about 150 ms). The duty cycle may be higher than the limit which is mentioned here for a short amount of time without loss of sensitivity (< 100 ms). However, if the application is carried out for longer than the duty-cycle boundary value, the sensitivity decreases slightly.

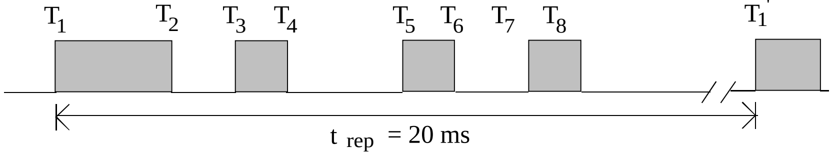


Figure 11. Duty cycle of a common transmission telegram

Working Conditions

Measurement Procedure and Test Circuit

In the block diagram (figure 10a), two resistors (R1, R2) and one capacitor are given as additional external components in the application circuit. These external components are optional and depend on the quality of the power supply conditions and the demands of the circuit that follows. R2 is the optional load resistor which can operate if necessary in parallel to the internal 100 kΩ load. The minimum resistance of R2 is 10 kΩ. In the specification, the filter combination R1/ C1 with C1 = 4.7 µF and R1 = 330 Ω is recommended to suppress disturbances on the power line. The parts can be omitted when no disturbances are expected.

The influence of the power line disturbances on the function of the device can be taken from the presentation of the threshold sensitivity vs. the amplitude of the disturbance (at center operating frequency) on the power line (see the enclosed data sheet). In the application, the R1/ C1 combination should be optimized, also regarding the commercial point of view and, if possible, omitted. In test circuits, this combination always should be implemented to obtain true measurements.

The definition of the sensitivity of a digitally switching receiver front end is a problem. When increasing the irradiance from zero on the receiver photomodule at a certain level, the output starts to react statistically to the input signal. The pulse lengths at the output are not a mirror of the envelope of the input signal. With increased signal strength, the likelihood of correct recognition is increased and the pulse lengths are a reproduction of the input envelope.

To obtain defined conditions for the measurement, an error tolerance is fixed for the delay and pulse length deviations of the output signal.

Table 5. Time windows for signal evaluation

	Delay of Leading Edge	**Timing Tolerance with Output Pulse Width**
TFMx1380	$4/f_o < t_d < 10/f_o$	$-3/f_o + 6/f_o$
TFMx1380T	100 µs < t_d < 300 µs	-100 µs + 160 µs
TFMx2380	$11/f_o < t_d < 19/f_o$	$-5/f_o + 8/f_o$
TFMx5380	100 µs < t_d < 400 µs	+/ – 160 µs
TFMx7380	100 µs < t_d < 400 µs	+/ – 160 µs

Definition: The threshold sensitivity is that irradiance, at which the measured values of delay and output pulse length all are inside the tolerated band.

Sensitivity in Dark Ambient

A remark is necessary before the definition and the measurement of this parameter are described: When comparing different transmission systems, the measured sensitivity in a dark ambient is the parameter mostly measured first although this condition is hardly present in the real application. The typical application of entertainment electronics is in a light ambient, e.g., a television receiver is rarely operated in total darkness because the light from the screen will illuminate the ambient. Therefore, the TFM series is optimized for operation in a disturbed and light ambient.

The sensitivity threshold in dark ambient is measured using the definition in the chapter “Measurement Procedure and Test Circuit“. The sensitivity is discussed from an optical point of view in the chapter "Sensitivity“.

The output pulse length in response to an input burst is drawn the data sheet. The phenomenon described in the chapter "Measurement Procedure and Test Circuit", the dependence of the output pulse length on the input signal, can be demonstrated here. At an irradiance at about

0.1 mW/ m^2, short pulses arrive at the output. With the irradiation increased to 0.3 mW/ m^2, the output signal length typically reaches the length of the input burst length. This length has not changed more than that inside the small tolerance field defined already up to an irradiation of 100 W/ m^2. This means, an overdriving or dynamic of nearly six orders of magnitude is allowed. A TV remote control with a built-in TFM works typically in a distance range from half an inch (direct contact, distance given by front plate) to more than 120 feet.

Disturbing Optical Radiation

The built-in control circuits and loops adjust the sensitivity threshold to the most sensitive working point at the existing background illumination and other radiation from optical and electrical sources. These sources can be incandescent lamps, standard fluorescent lamps, and in particular energy-saving electronic fluorescent lamps. The photo current generated in the internal detector diode induces a current noise which limits the sensitivity with background unmodulated light. The light of incandescent lamps is almost unmodulated or exhibits only a small modulation depth. Gas discharge lamps are strongly modulated with the operating current and are therefore more critical sources in respect to disturbances.

Fluorescent lamps occupy a special position in the field of optical disturbers. These lamps emit infrared disturbances such as a short burst, synchronous to the double-line frequency (2×50 Hz or 2×60 Hz equivalent to a period of 10 ms or 8.33 ms, respectively) and very similar to transmission codes. Such disturbers can cause an increase in the likelihood of line frequency synchronous output signals of the module.

This must be taken into consideration in applications with very high illuminances from fluorescent lamps to avoid transmission codes with repetition rates similar to that of the line frequency (and its harmonics). Furthermore, the software evaluation of the code should suppress these kinds of disturbances.

The threshold irradiance (in other words the sensitivity) as a function of the irradiance is shown in the data sheet. In order not to generate false output pulses by the noise of the input signal, the internal threshold must be decreased resulting in decreased sensitivity. As an example, an irradiance by dc ambient light of 18 W/ m^2 enables the module to still operate with a threshold sensitivity of 2 mW/ m^2. The dc ambient light in this case causes a photo current 1000 times larger than the signal to be detected. From table 1, it can be seen that this ambient irradiance is equivalent to an illuminance with sunlight of 14700 Lux. Typical working place illumination uses illuminances of 500 - 1500 Lux.

Behavior in Electromagnetic Fields

A most unpleasant ambient with regard to electromagnetic sources is the inside of television receivers. The horizontal deflection operates at a frequency of 15625 Hz (625×25) or 15750 Hz (525×30). The harmonics with 31250 Hz or 31500 Hz are directly on or in the neighborhood of the remote control carrier frequencies. With a standard selectivity, the interference cannot be suppressed electrically at a reasonable cost. An excellent suppression of disturbances is achieved by constructive measures in the design such as e.g. the right position of the detector chip inside the package, very short wire connections, shielding of the chip and an internal shield in the package. Here, the advantages of the compact package compared to printed circuit boards could be demonstrated. At applied field strengths of 700 V/ m at the rated carrier frequency, the sensitivity is only reduced by a factor of two, equivalent to a loss of transmission range of about 30%.

The receiver photomodule exposed to optical and electrical disturbances from its ambient will show reduced sensitivity, but because of its design it will not show a malfunction. The measures taken to suppress interferences are part of a patent pending from TEMIC.

The dependence of the sensitivity as a function of applied field strength is shown in the data sheet.

Influence of Disturbed V_S

The receiver photomodule should operate with a stable supply voltage to prevent a sensitivity decrease. This decrease depends on the amplitude and the frequency of the disturbance. As mentioned above, disturbances from the harmonics of deflection currents in TV sets are in the remote control band. Because the deflection currents are high, an interaction with the power supply voltage is possible. There is also a possibility of interference with emitted RF signals, in particular with subharmonics of the operating frequency when using switchmode power supplies. In the data sheet, the relation between sensitivity and power supply disturbances is shown for 100 Hz, 10 kHz and for the rated center.

Sensitivity

As already described in the subchapter „Measurement Procedure and Test Circuit“, the sensitivity of a digital device must be described with a threshold. The criteria of this threshold is the true to form transmission of the irradiant signal. Spectral sensitivity and angular dependence are measured under the same conditions as those mentioned above and are given in the data sheet as values relative to the reference point.

Spectral sensitivity: The maximum relative spectral sensitivity of the TFMS5..0 series is at 950 nm. The decline on the long-wave length side is predetermined by the absorption properties of silicon, whereby the thickness of the absorbing layer and some other parameters influence the gradient of the decline. The short wavelength flank is determined by the filter pigmentation of the plastic package.

The receiver characteristic is made narrowband on purpose to prevent as much radiation as possible from wideband disturbances reaching the detector.

This characteristic has been optimized for the 950 nm emitter radiation (see table 2).

System losses result when emitters of 870 nm or less are incorporated. Principally, a displacement of the short wavelength flank to shorter wavelengths is possible without problem if an applier wants to work with emitters of 840 nm, 870 nm or even 660 nm. However, in these cases the ambient light compatibility suffers.

Angular dependence: A large angular opening of the detector is desired for remote control applications to enable detection of scattered radiation. The lens arrangement, referring to the same chip area gives a gain of 2, whereas the angle characteristic approximates to the $\cos^2$ law. Larger central sensitivity can be realized at a reduced angular opening, but larger angular openings lead to reductions in the stability with regard to electrical disturbances.

Typical Circuitry

Up to now, the internal circuitry, the function and the usual operation of the photomodule has been described. It is therefore advisable to give here a few tips on the standard circuits and evaluation processes.

At present, two ways for the evaluation are pursued: Either special circuits are used to evaluate the remote control recordings (see “Typical Application Circuit“) or the evaluation is left for execution by the equipment (see “Recommendations for Evaluation“).

Typical Application Circuit

Various manufactures offer circuits for decoding remote control signal. The circuitry in figure 12 incorporates the SAA3049 circuit device.

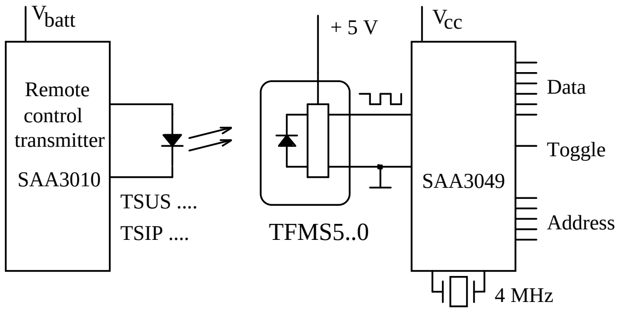


Figure 12. Typical circuit for decoding remote control signals

Recommendations for Evaluation

A transmitted telegram consists of pulses which reach the photomodule as optical signals. The output signal of the TFM presents an almost exact reproduction of the envelope of this signal. If the input signal is large enough the delay times for the rise- and decay flanks will be the same. The amplification control has reduced the sensitivity of the photomodule to a level where disturbances are not registered. In such a case, the first incoming flank causes an interrupt and the time to the following flanks is measured. This method, however, runs the danger that disturbances are accepted as signals and consequently wrong interpretations are the results. Disturbances are most likely when dealing with weak signals and should be suppressed by the software accordingly.

For example, one method used is to examine the record after an interrupt has occurred in a predetermined time window to see which type of flank of the logic signal was present (increasing or decreasing). In addition, it is possible to evaluate the pulse length with the corresponding second flank of a pulse to qualify and re-iterate the information obtained first. A filter for the input signal is effected in this manner resulting in ensured transmission over long distances.

To ease the burden on the processor during the serial acceptance of the data, a plausibility test should be performed on the signals already entered. If the test shows that the pulse sequence is non-sensical then the data word that has been entered must be rejected.

Table 6. Comparison of various manufacturers photomodules under differing ambient conditions

Type and Origin	Sensitivity in Dark Ambient/ Threshold Irradiance	Threshold Irrad. at 15 W/m^2 DC Disturbance Light	Threshold Irrad. at AC Disturbance Light (4 m W/ m^2, f = f_0)	Sensitivity Against Electrical Field Disturbance	Unexp. Output Pulses under 15 W/ m^2 Ambient DC Light
	mW/ m^2	mW/ m^2	mW/ m^2	V/ m	min.
TEMIC TFMS5360	0.33	1.6	15	1000	5
TEMIC TFMS1380	0.32	1.4	16	1000	7
A Japan	0.35	8.2	50	600	10 000
B Japan	0.3	7.4	9	260	4000
C Japan	0.36	2.5	9	320	1000
D Japan	0.64	5.5	> 999	2500	2
E Japan	0.51	5.1	> 999	5000	5
F Japan	0.62	13	> 999	380	0
G Korea	0.67	5.2	10	600	10
H Taiwan	0.4	5.2	13	120	5

Appendix

Comparison Test

Table 6 shows the results of tests carried out in TEMIC laboratories on the TFM photomodule and other manufacturers' versions. The sensitivity threshold was determined with 600 bursts, burst interval 10 ms, burst length 30 pulses with a duty cycle 1:1 at the nominal frequency. The criteria for reaching the sensitivity threshold is that 598 from 600 pulses with a time tolerance of ±160 µs must be recognized. The threshold was determined at various environmental conditions that may occur in the remote control ambient.

The ambient light suppression was tested at an irradiance of 15 W/m^2. The resulting effect is similar to that of a 1.5-kLux incandescent lamp. The source was an emitter with a wavelength of 950 nm. The compatibility with regard to electromagnetic disturbances was measured at a field strength of 100 V/m. Frequency of the disturbance was also the nominal frequency of the photomodule.

Please note: The TFM series is specified for ambient temperatures of 85°C, whereas other manufacturers only guarantee this function up to 65°C.

Summary

The TFM series for remote control systems represent a new generation of highly sensitive integrated detectors. These devices are optimal for the most widely used transmission method with either phase- or pulse-length modulation.

The most prominent property of the photomodule is the optimal transmission safety at a high sensitivity under disturbed ambient conditions. This safety and the long range guarantee the employer a secure function of his transmission system also under difficult ambient conditions. A further advantage is the compact form.

The ISO9001-controlled automatic large-volume production lines guarantee a continuously high reliability of the devices. TEMIC offers the manufacturers of modules the safety of a mature product. The devices contain the many years of experience of Europe's leader in infrared receivers.

Plastic Suppliers

U.S.

Bayer Corporation
Plastic Department
Pittsburg/PA 15205-9741
Fax: +1 412 7777 621

GE Plastic
ONE Plastic Avenue
Pittsfield/MA 01201
Fax: +1 4134 487 493

Taiwan

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P.O.Box 5535
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Fax: +88 6250 780 43

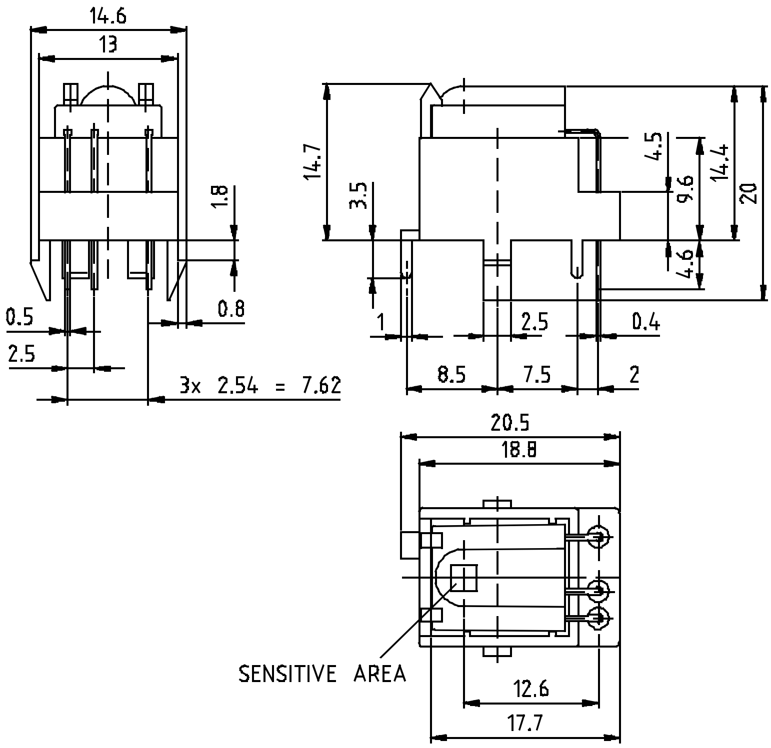
Hong Kong

Bayer Far East Service Co. Ltd.
Fax: +852 28955888

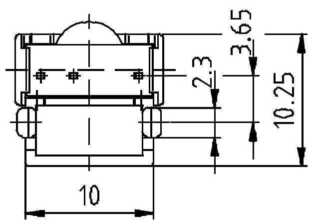
Singapore

Bayer (Singapore) Pte. Ltd
Fax: +65 2664866

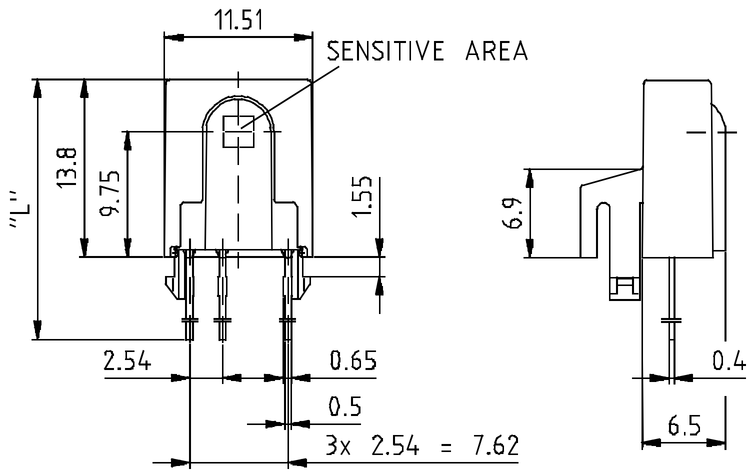
Package Dimensions



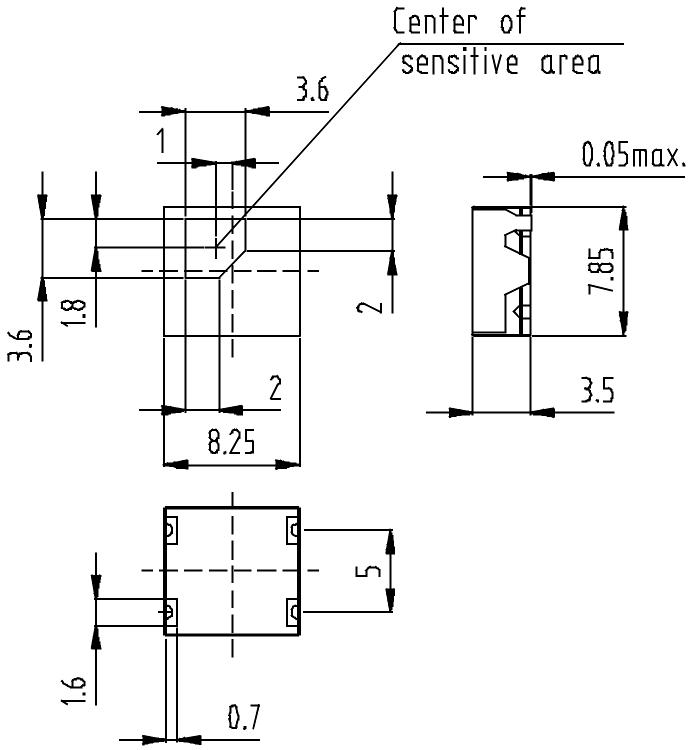
TFMC



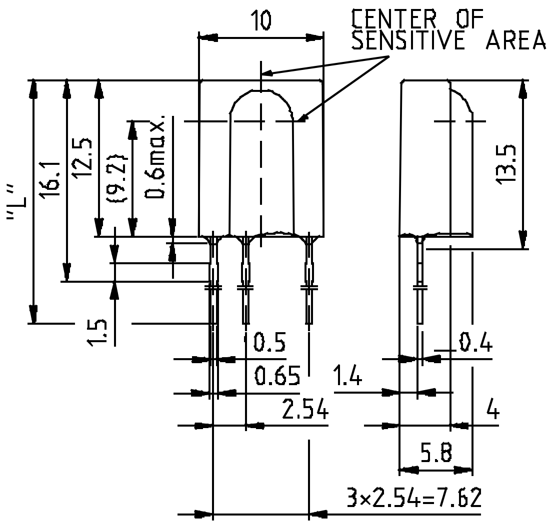
DIMENSION "L"	TYPE
17.35	TFMK ....A
18.35	TFMK ....D
31.35	TFMK ....



TFMK

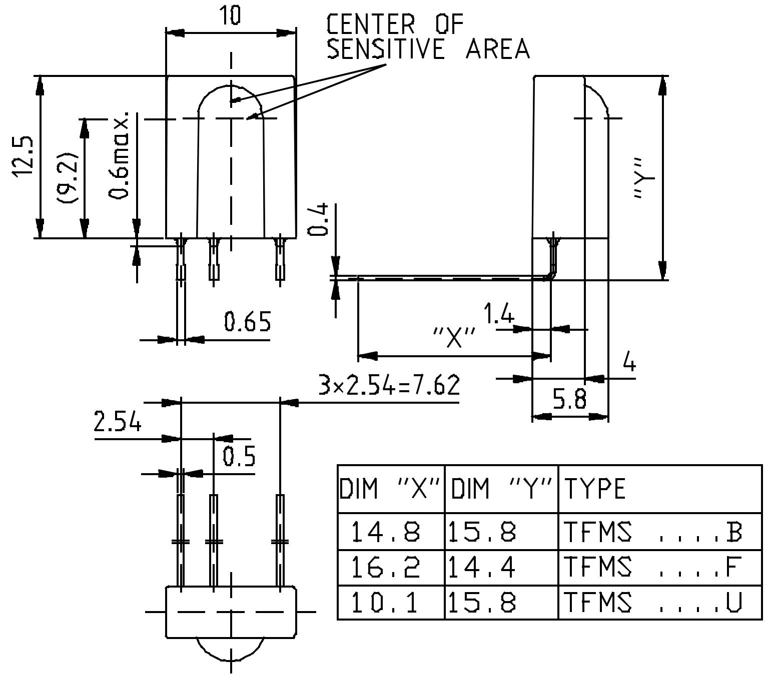


TFMM



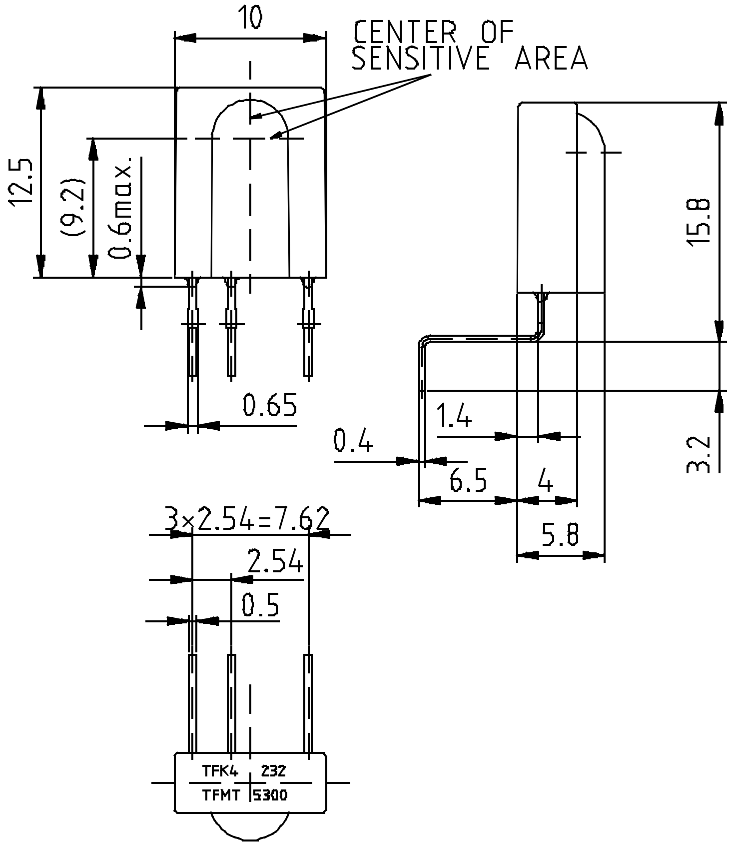
VERSION	DIM. "L"	TYPE
1	30.6	TFMS ....
2	25.9	TFMS ....G
3	17.6	TFMS ....D
4	16.6	TFMS ....A
5	21.1	TFMS ....K

TFMS (A, D, G, K)

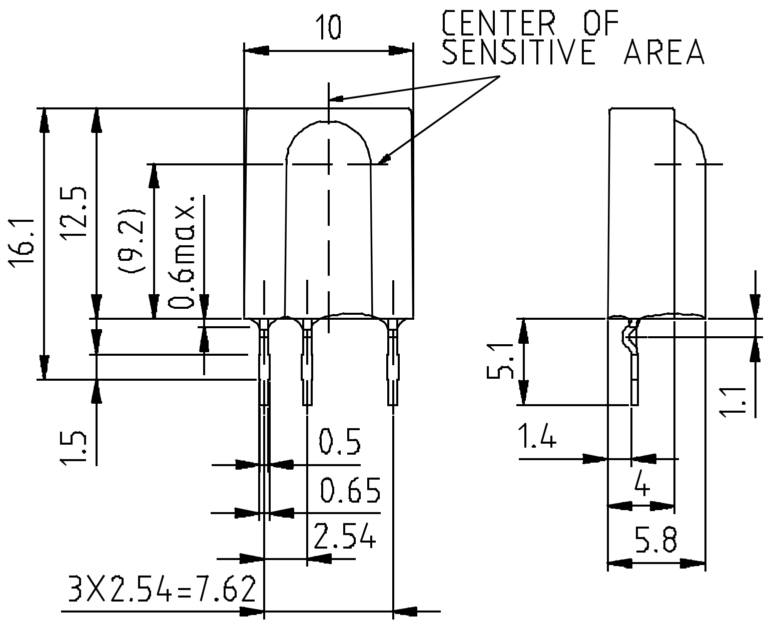


DIM "X"	DIM "Y"	TYPE
14.8	15.8	TFMS ....B
16.2	14.4	TFMS ....F
10.1	15.8	TFMS ....U

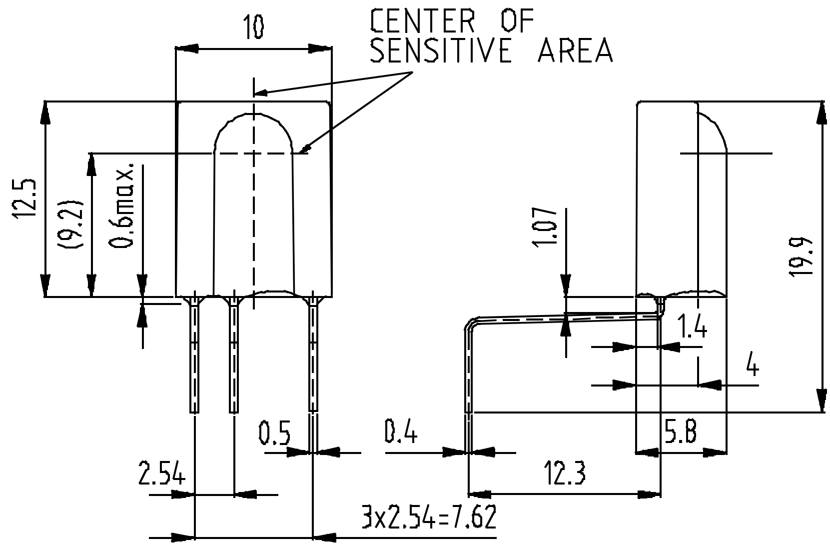
TFMS (B, F, U)



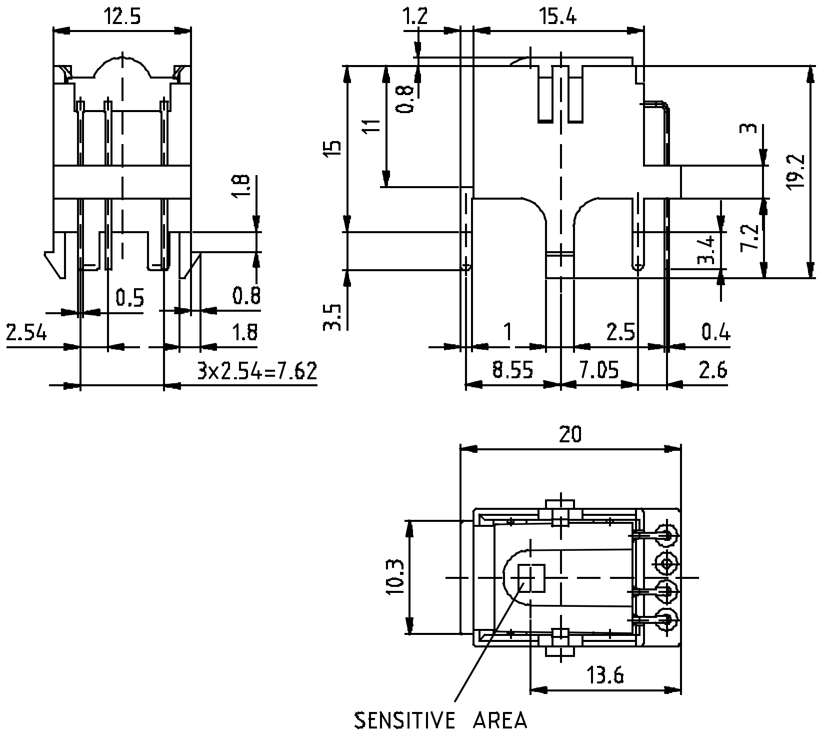
TFMS (C)


10
CENTER OF
SENSITIVE AREA
16.1
12.5
(9.2)
0.6max.
1.5
0.5
0.65
2.54
3X2.54=7.62
5.1
1.1
1.4
4
5.8

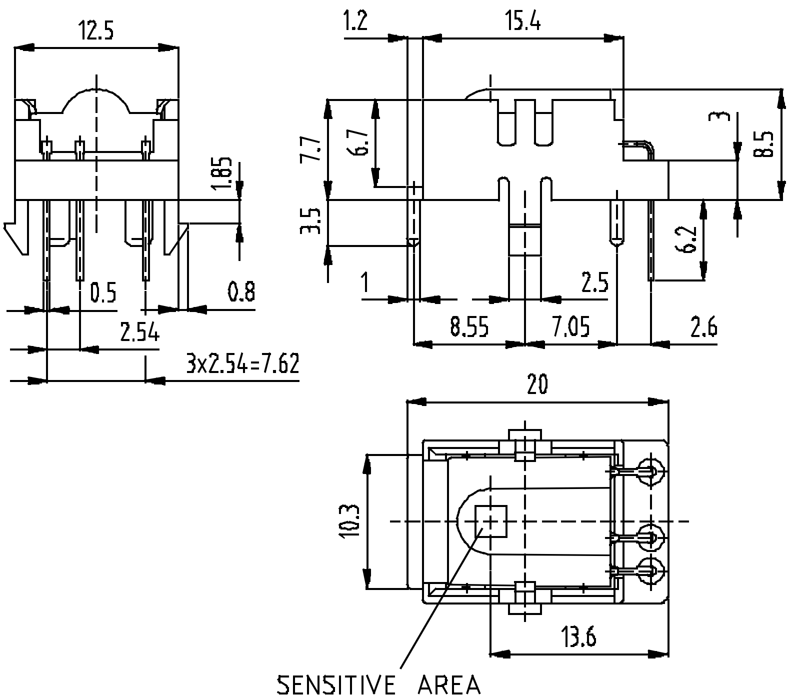
TFMS (E)


10
CENTER OF
SENSITIVE AREA
12.5
(9.2)
0.6max.
0.5
2.54
3x2.54=7.62
1.07
19.9
1.4
4
0.4
5.8
12.3

TFMS (I)


12.5
1.8
0.5
0.8
2.54
1.8
3x2.54=7.62
1.2
15.4
0.8
11
15
3
19.2
7.2
3.4
3.5
1
2.5
0.4
8.55
7.05
2.6
20
10.3
13.6
SENSITIVE AREA

TFMT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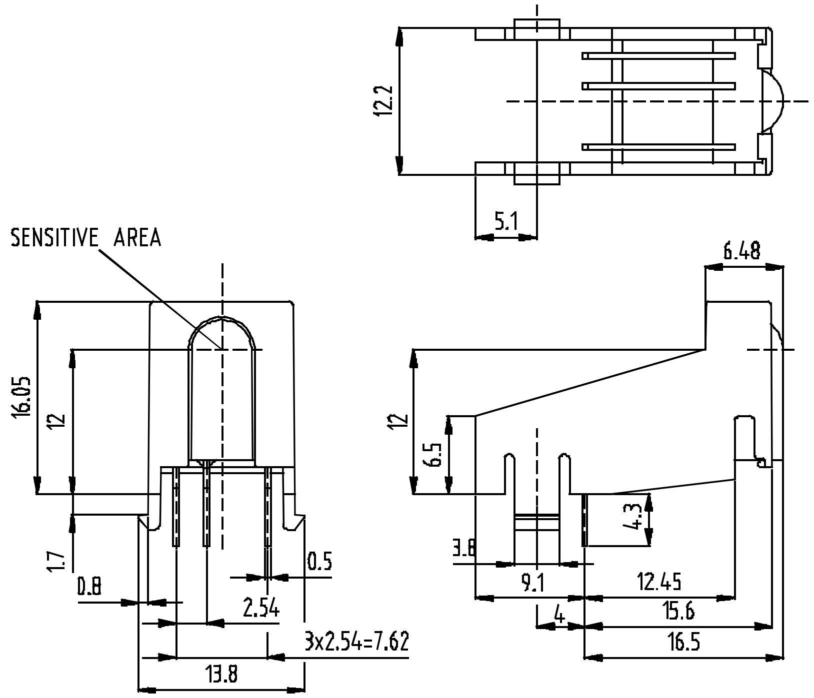
0.5
0.8
2.54
3x2.54=7.62
1.2
15.4
7.7
6.7
3
8.5
3.5
6.2
1
2.5
8.55
7.05
2.6
20
10.3
13.6
SENSITIVE AREA

TFMU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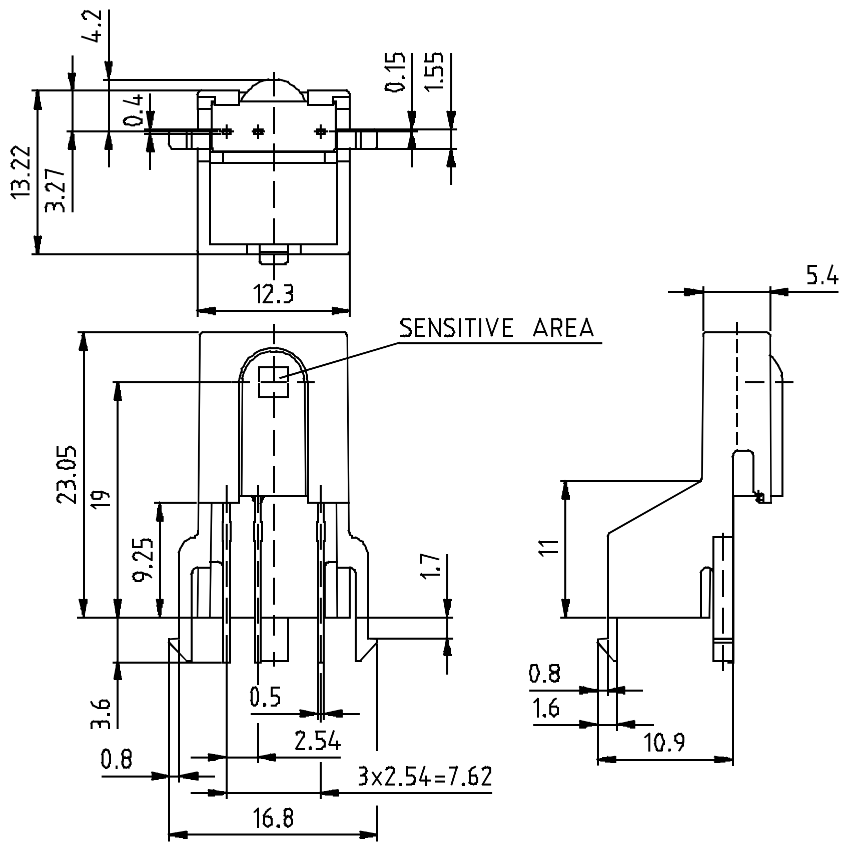
5.1
SENSITIVE AREA
6.48
16.05
12
1.7
0.8
0.5
2.54
3x2.54=7.62
13.8
12
6.5
4.3
3.8
9.1
12.45
4
15.6
16.5

TFMW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0.15
1.55
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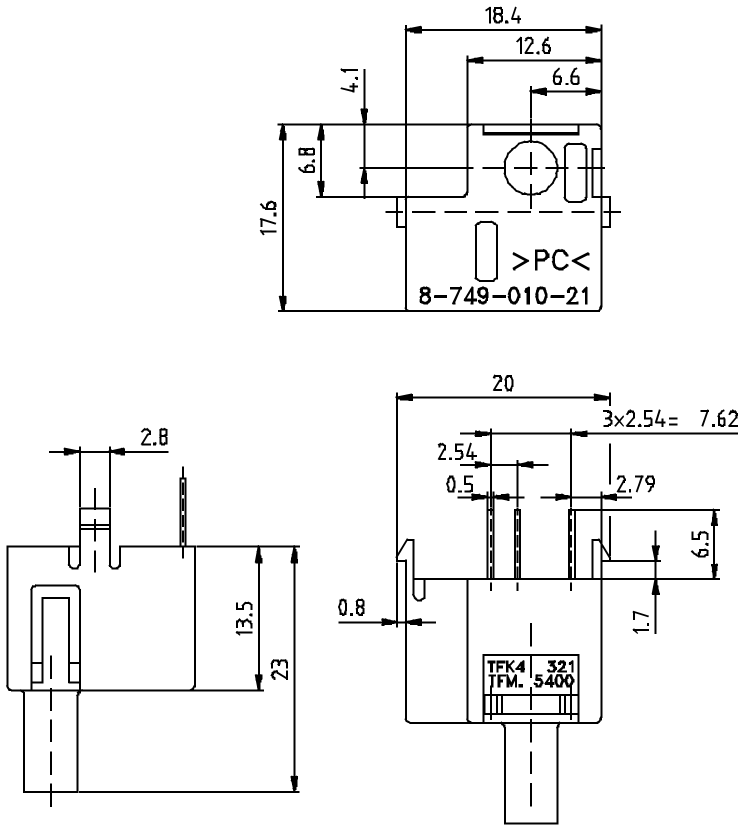
12.3
SENSITIVE AREA
5.4
23.05
19
9.25
1.7
11
0.8
1.6
10.9
0.5
3.6
2.54
0.8
3x2.54=7.62
16.8

TFMX


18.4
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17.6
>PC<
8-749-010-21
20
3×2.54= 7.62
2.54
0.5
2.79
2.8
6.5
0.8
1.7
13.5
23
TFK4 321
TFM. 5400

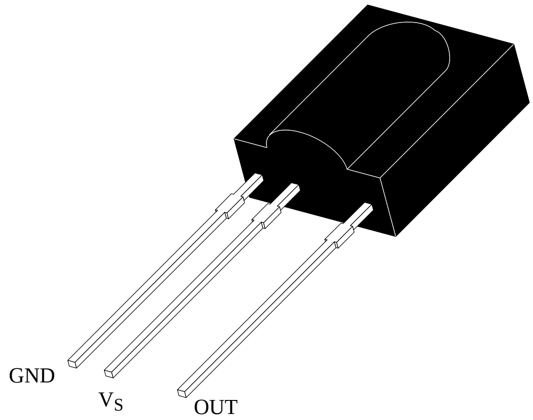
TFMY

Photo Modules for PCM Remote Control Systems

Special series with short integration time for short burst codes or enhanced data rates

Available types for different carrier frequencies

Type	f_0	Type	f_0
TFMS 1300	30 kHz	TFMS 1330	33 kHz
TFMS 1360	36 kHz	TFMS 1370	36.7 kHz
TFMS 1380	38 kHz	TFMS 1400	40 kHz
TFMS 1440	44 kHz	TFMS 1560	56 kHz



94 8691

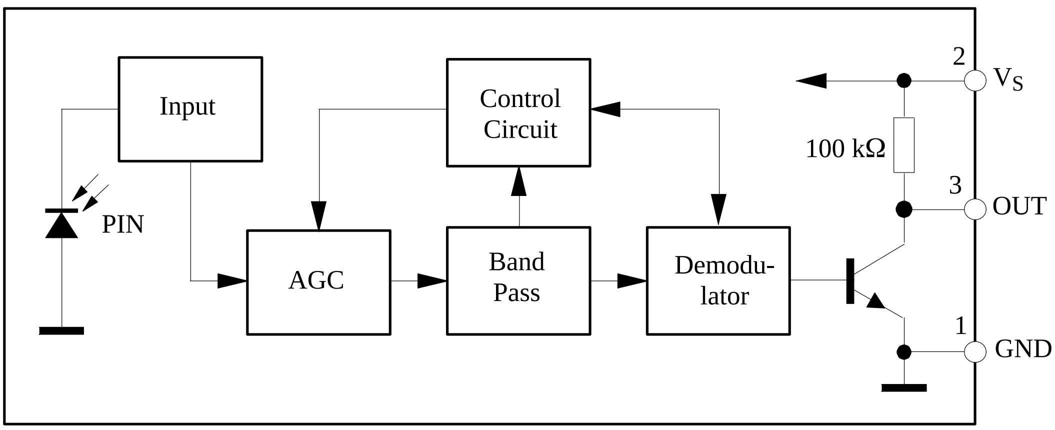
Description

The TFMS 1..0 – series are miniaturized receivers for infrared remote control systems. PIN diode and preamplifier are assembled on lead frame, the epoxy package is designed as IR filter.
The demodulated output signal can directly be decoded by a microprocessor. The main benefit is the reliable function even in disturbed ambient and the protection against uncontrolled output pulses.

Features

- Receiver module for transmission codes with short bursts (N ≧ 6 pulses per bit)
- Photo detector and preamplifier in one package
- Output active low (active high modules: TFMS 1..9)
- Internal filter for PCM frequency
- High immunity against ambient light, optimized against burst noise
- Improved shielding against electric field disturbance
- 5 Volt supply voltage
- TTL and CMOS compatibility
- Low power consumption (typical 2.5 mW)
- 2.4 kbit/s data transmission rate possible (N=6, f_o=56 kHz)

Block Diagram



94 9148

Absolute Maximum Ratings

T_{amb} = 25°C

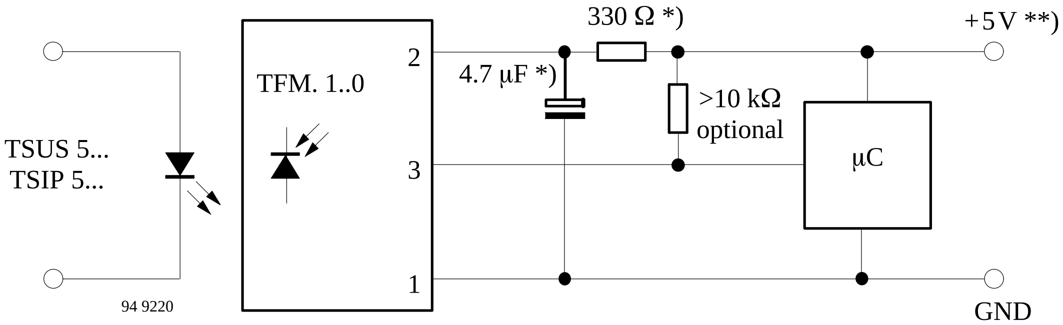
Parameter	Test Conditions	Symbol	Value	Unit
Supply Voltage	(Pin 2)	V_S	–0.3...6.0	V
Supply Current	(Pin 2)	I_S	5	mA
Output Voltage	(Pin 3)	V_O	–0.3...6.0	V
Output Current	(Pin 3)	I_O	5	mA
Junction Temperature		T_j	100	°C
Storage Temperature Range		T_{stg}	–25...+85	°C
Operating Temperature Range		T_{amb}	–25...+85	°C
Power Consumption	(T_{amb} ≦ 85 °C)	P_{tot}	50	mW
Soldering Temperature	t ≦ 10 s, 1 mm from case	T_{sd}	260	°C

Basic Characteristics

T_{amb} = 25°C

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Supply Current (Pin 2)	V_S = 5 V, E_v = 0	I_{SD}	0.4	0.5	0.8	mA
	V_S = 5 V, E_v = 40 klx, sunlight	I_{SH}		1.0		mA
Transmission Distance	E_v = 0, test signal see fig.7, IR diode TSIP5201, I_F = 0.5 A	d		32		m
Output Voltage Low (Pin 3)	I_{OSL} = 0.5 mA, E_e = 0.7 mW/m^2, f = f_o, test signal see fig.7	V_{OSL}			250	mV
Irradiance (30 – 40 kHz)	Test signal see fig.7	$E_{e\ min}$		0.4	0.6	mW/m^2
Irradiance (56 kHz)	Test signal see fig.7	$E_{e\ min}$		0.45	0.7	mW/m^2
Irradiance	Test signal see fig.7	$E_{e\ max}$	20			W/m^2
Directivity	Angle of half transmission distance	$\varphi_{1/2}$		±55		deg

Application Circuit



*) only necessary to suppress power supply disturbances
**) tolerated supply voltage range : 4.5V<V_S<5.5V

Typical Characteristics (T$_{amb}$ = 25°C unless otherwise specified)

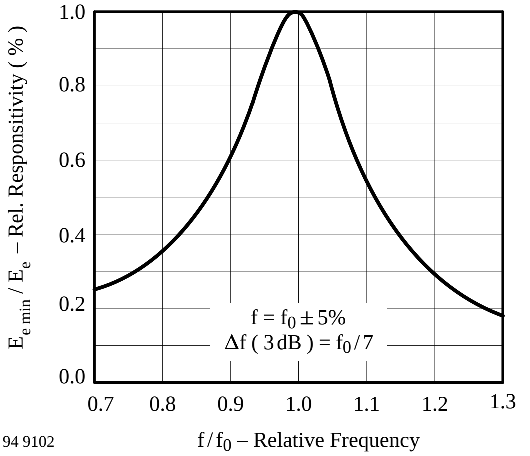


Figure 1. Frequency Dependence of Responsivity

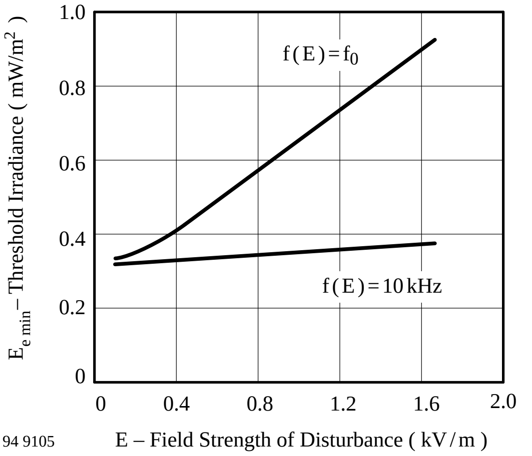


Figure 4. Sensitivity vs. Electric Field Disturbances

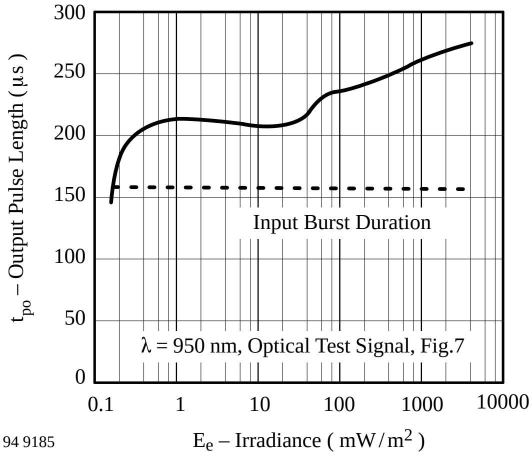


Figure 2. Sensitivity in Dark Ambient

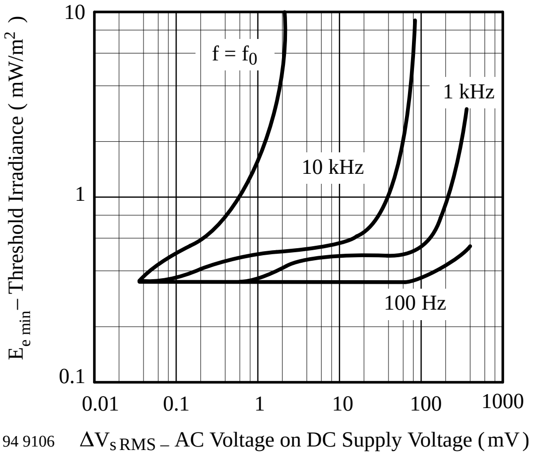


Figure 5. Sensitivity vs. Supply Voltage Disturbances

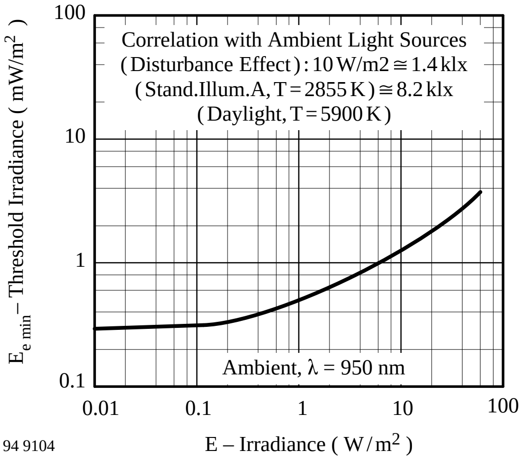


Figure 3. Sensitivity in Bright Ambient

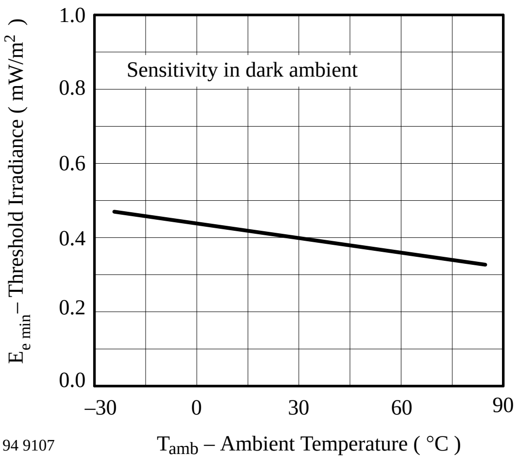


Figure 6. Sensitivity vs. Ambient Temperature

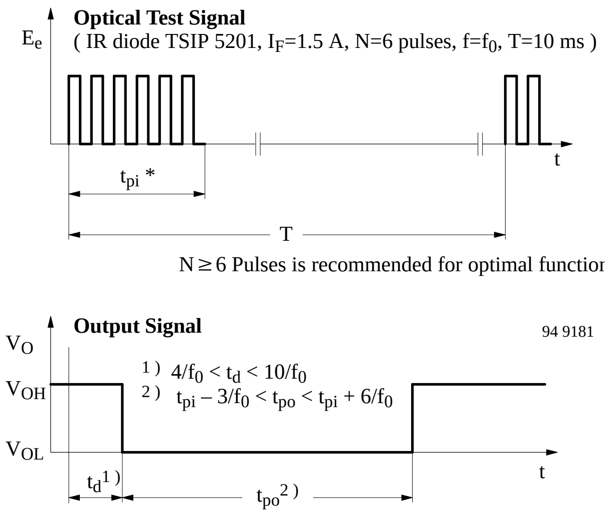


Figure 7. Output Function

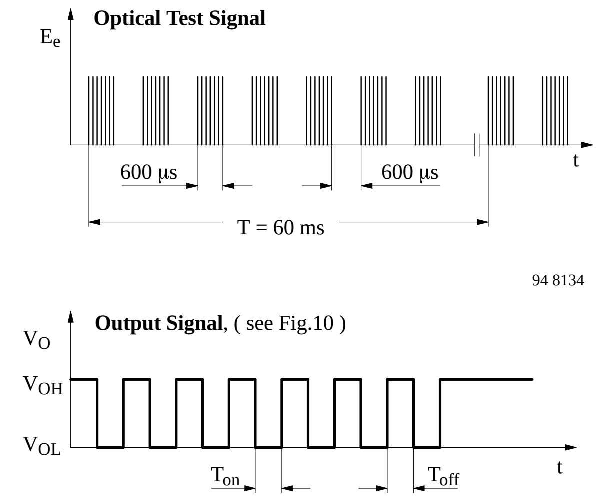


Figure 8. Output Function

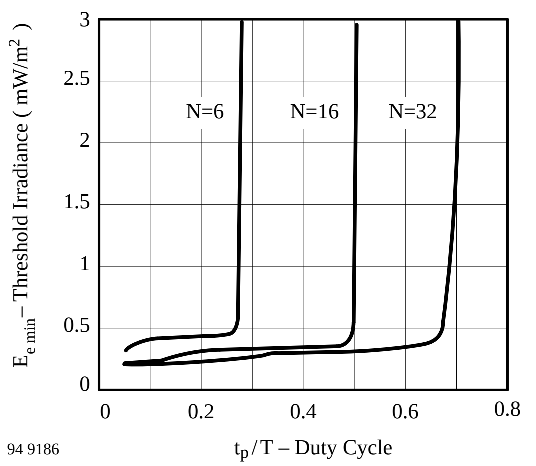


Figure 9. Sensitivity vs. Duty Cycle

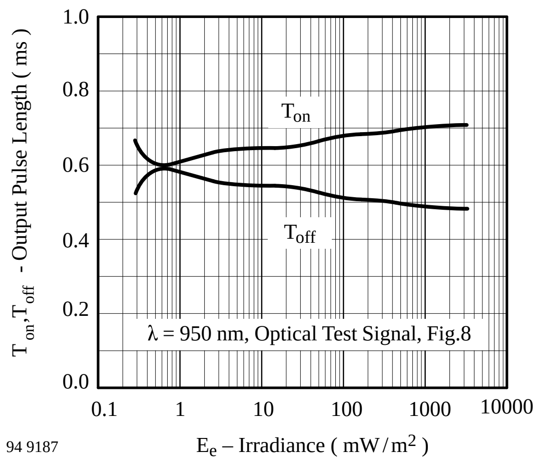


Figure 10. Output Pulse Diagram

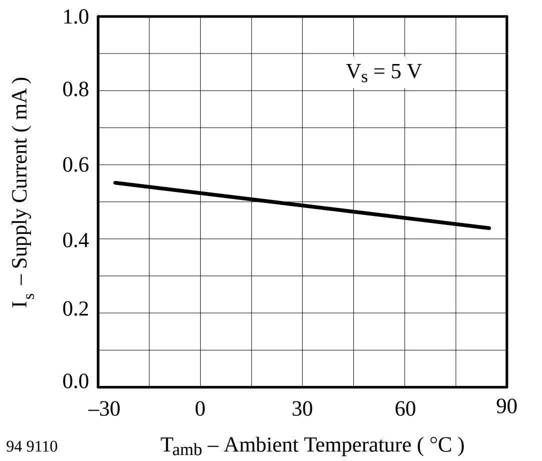


Figure 11. Supply Current vs. Ambient Temperature

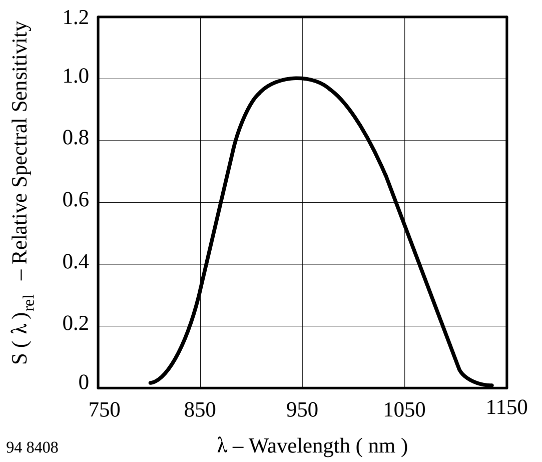


Figure 12. Spectral Response

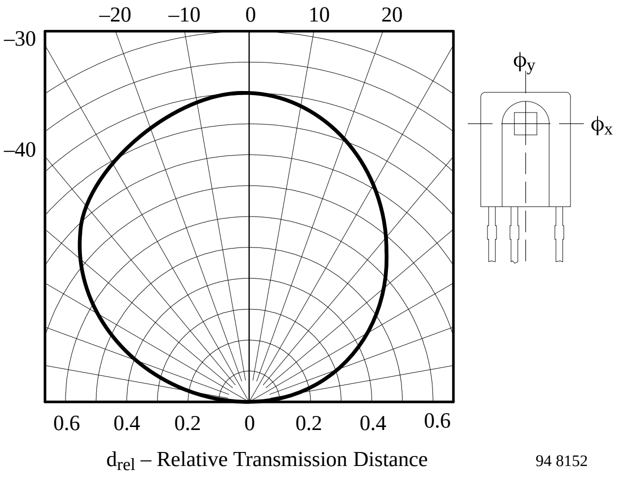


Figure 13. Vertical Directivity φ_y

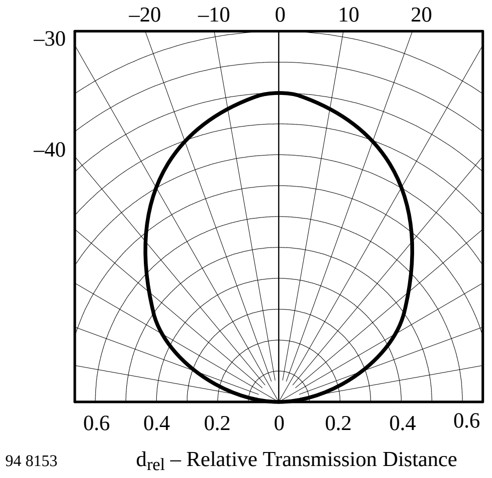
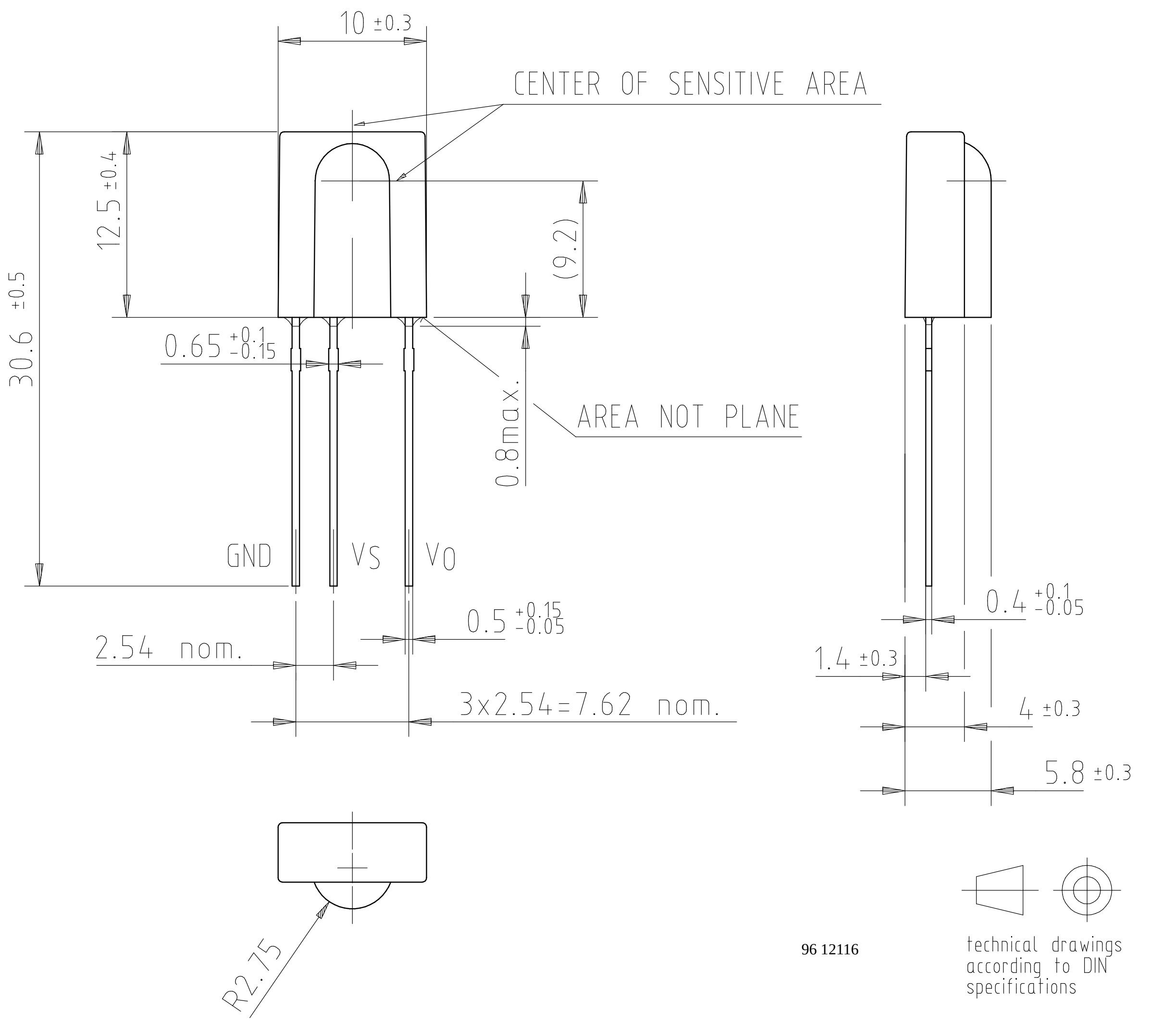


Figure 14. Horizontal Directivity φ_x

Dimensions in mm



Ozone Depleting Substances Policy Statement

It is the policy of **TEMIC TELEFUNKEN microelectronic GmbH** to

1. Meet all present and future national and international statutory requirements.
2. Regularly and continuously improve the performance of our products, processes, distribution and operating systems with respect to their impact on the health and safety of our employees and the public, as well as their impact on the environment.

It is particular concern to control or eliminate releases of those substances into the atmosphere which are known as ozone depleting substances (ODSs).

The Montreal Protocol (1987) and its London Amendments (1990) intend to severely restrict the use of ODSs and forbid their use within the next ten years. Various national and international initiatives are pressing for an earlier ban on these substances.

TEMIC TELEFUNKEN microelectronic GmbH semiconductor division has been able to use its policy of continuous improvements to eliminate the use of ODSs listed in the following documents.

1. Annex A, B and list of transitional substances of the Montreal Protocol and the London Amendments respectively
2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA
3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

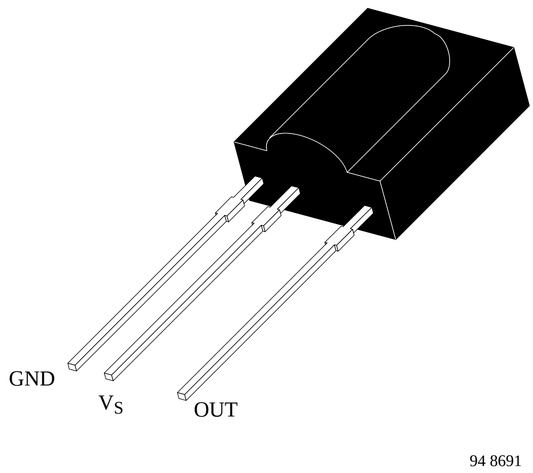
TEMIC can certify that our semiconductors are not manufactured with ozone depleting substances and do not contain such substances.

TEMIC TELEFUNKEN microelectronic GmbH, P.O.B. 3535, D-74025 Heilbronn, Germany
Telephone: 49 (0)7131 67 2831, Fax number: 49 (0)7131 67 2423

Photo Modules for PCM Remote Control Systems

Available types for different carrier frequencies

Type	f_0	Type	f_0
TFMS 5300	30 kHz	TFMS 5330	33 kHz
TFMS 5360	36 kHz	TFMS 5370	36.7 kHz
TFMS 5380	38 kHz	TFMS 5400	40 kHz
TFMS 5560	56 kHz		



Description

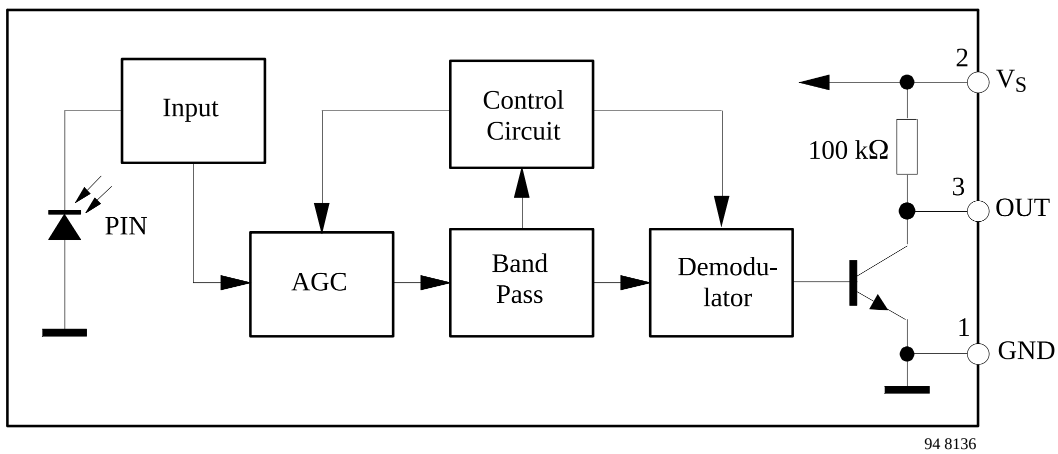
The TFMS 5..0 – series are miniaturized receivers for infrared remote control systems. PIN diode and preamplifier are assembled on lead frame, the epoxy package is designed as IR filter.

The demodulated output signal can directly be decoded by a microprocessor. The main benefit is the reliable function even in disturbed ambient and the protection against uncontrolled output pulses.

Features

- Photo detector and preamplifier in one package
- Output active low (active high modules: TFMS 5..9)
- Internal filter for PCM frequency
- High immunity against ambient light
- Improved shielding against electric field disturbance
- 5 Volt supply voltage, low power consumption
- TTL and CMOS compatibility
- Continuous transmission possible ($t_{pi}/T \leqq 0.4$)

Block Diagram



Absolute Maximum Ratings

T_{amb} = 25°C

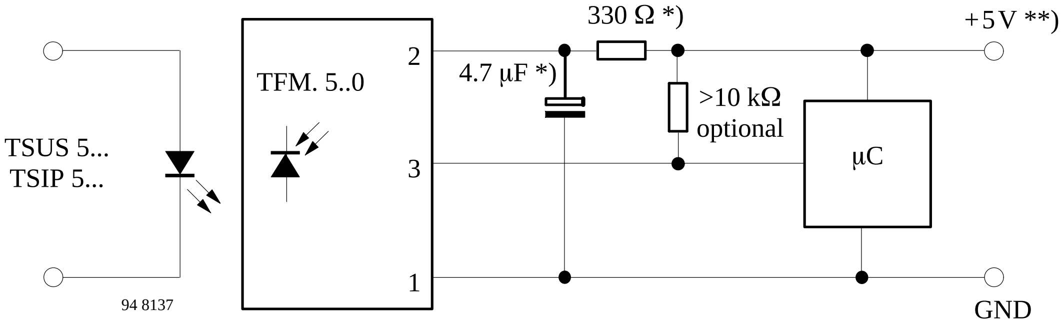
Parameter	Test Conditions	Symbol	Value	Unit
Supply Voltage	(Pin 2)	V_S	–0.3...6.0	V
Supply Current	(Pin 2)	I_S	5	mA
Output Voltage	(Pin 3)	V_O	–0.3...6.0	V
Output Current	(Pin 3)	I_O	5	mA
Junction Temperature		T_j	100	°C
Storage Temperature Range		T_{stg}	–25...+85	°C
Operating Temperature Range		T_{amb}	–25...+85	°C
Power Consumption	(T_{amb} ≦ 85 °C)	P_{tot}	50	mW
Soldering Temperature	t ≦ 10 s, 1 mm from case	T_{sd}	260	°C

Basic Characteristics

T_{amb} = 25°C

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Supply Current (Pin 2)	V_S = 5 V, E_v = 0	I_{SD}	0.4	0.5	0.8	mA
	V_S = 5 V, E_v = 40 klx, sunlight	I_{SH}		1.0		mA
Transmission Distance	E_v = 0, test signal see fig.7, IR diode TSIP5201, I_F = 1.5 A	d		35		m
Output Voltage Low (Pin 3)	I_{OSL} = 0.5 mA, E_e = 0.7 mW/m², f = f_o, t_p/T = 0.4	V_{OSL}			250	mV
Irradiance (30 – 40 kHz)	Pulse width tolerance: $t_{po}=t_{pi}\pm160\mu s$, test signal (see fig.7)	$E_{e\ min}$		0.3	0.5	mW/m²
Irradiance (56 kHz)	Pulse width tolerance: $t_{po}=t_{pi}\pm160\mu s$, test signal (see fig.7)	$E_{e\ min}$		0.4	0.7	mW/m²
Irradiance		$E_{e\ max}$	20			W/m²
Directivity	Angle of half transmission distance	$\varphi_{1/2}$		±55		deg

Application Circuit



*) only necessary to suppress power supply disturbances
**) tolerated supply voltage range : 4.5 V < V_S < 5.5 V

Typical Characteristics (T$_{amb}$ = 25°C unless otherwise specified)

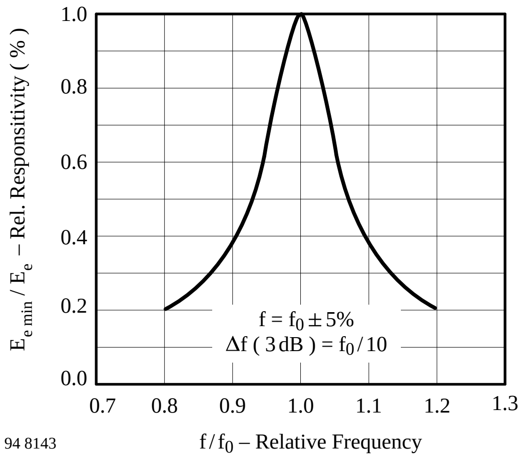


Figure 1. Frequency Dependence of Responsivity

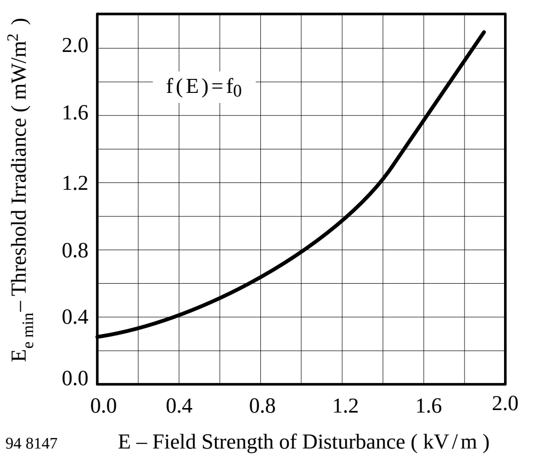


Figure 4. Sensitivity vs. Electric Field Disturbances

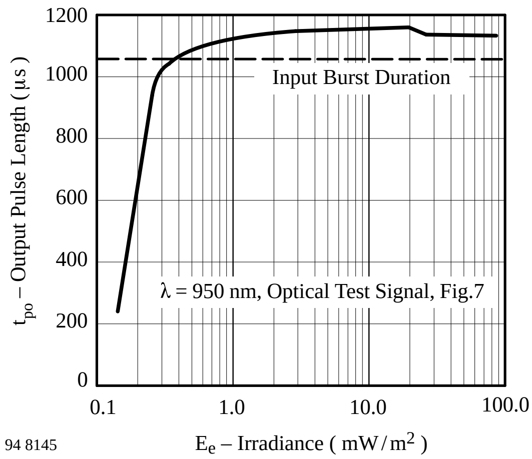


Figure 2. Sensitivity in Dark Ambient

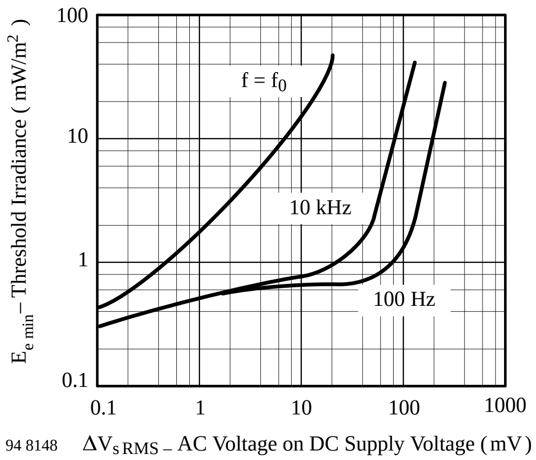


Figure 5. Sensitivity vs. Supply Voltage Disturbances

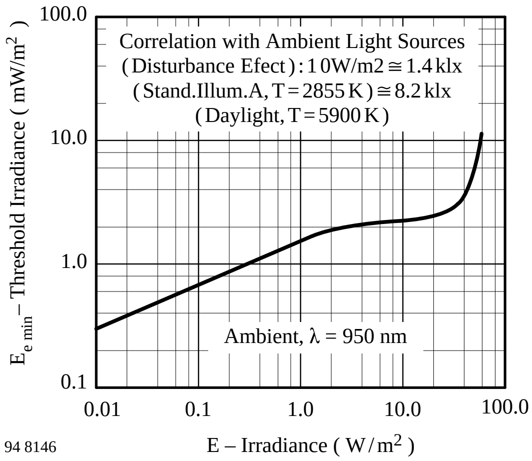


Figure 3. Sensitivity in Bright Ambient

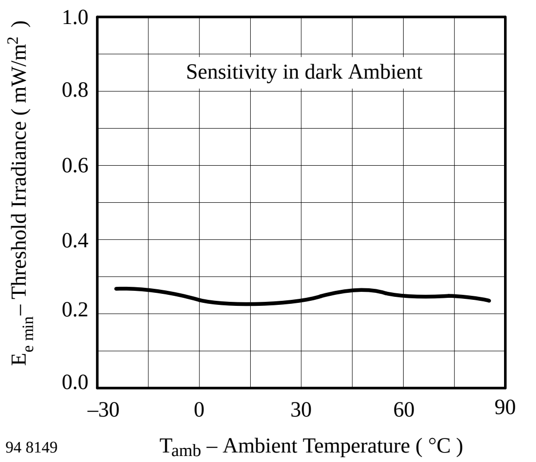


Figure 6. Sensitivity vs. Ambient Temperature

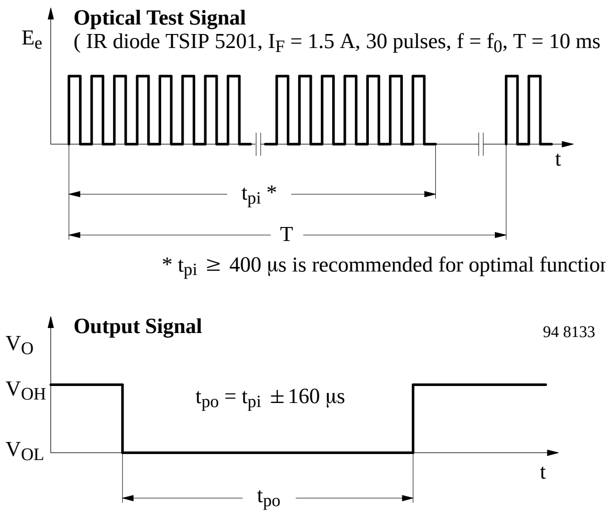


Figure 7. Output Function

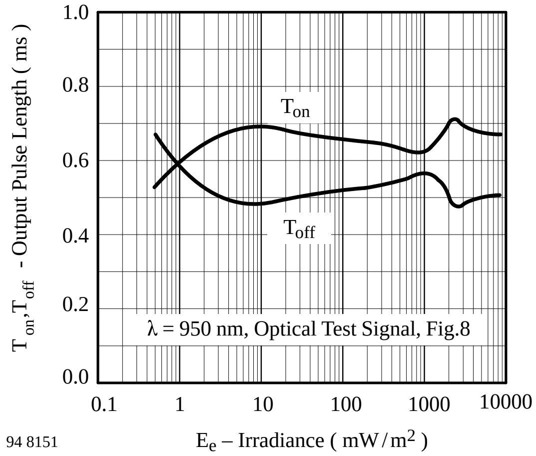


Figure 10. Output Pulse Diagram

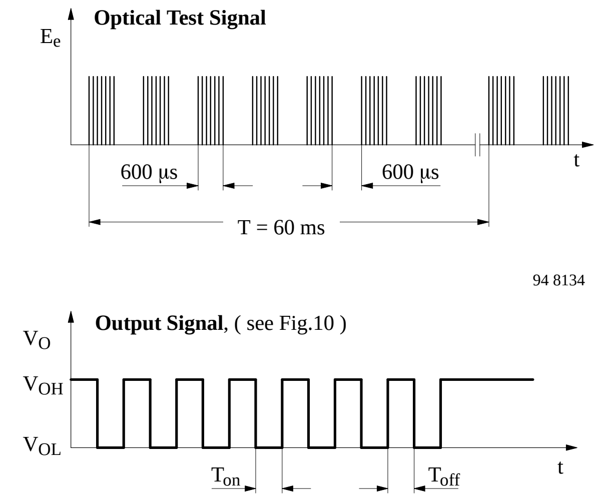


Figure 8. Output Function

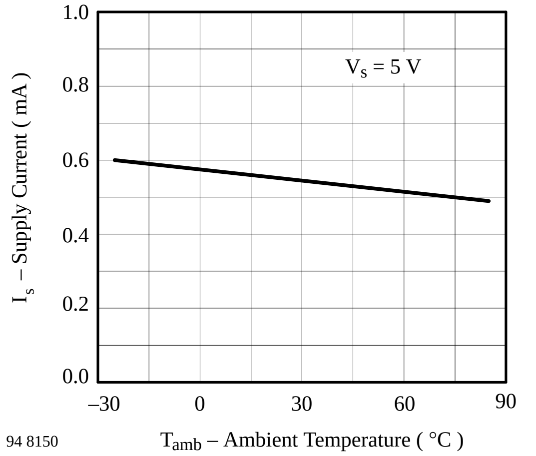


Figure 11. Supply Current vs. Ambient Temperature

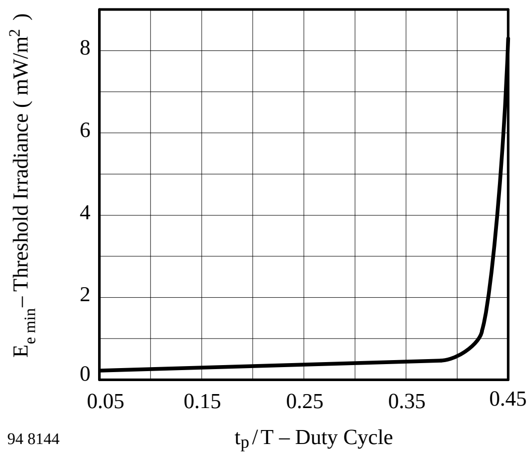


Figure 9. Sensitivity vs. Duty Cycle

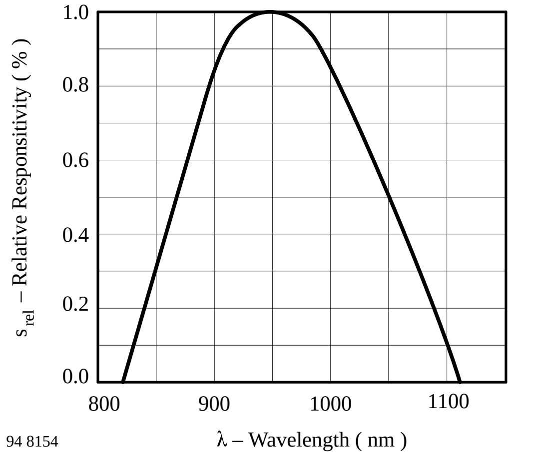


Figure 12. Spectral Response

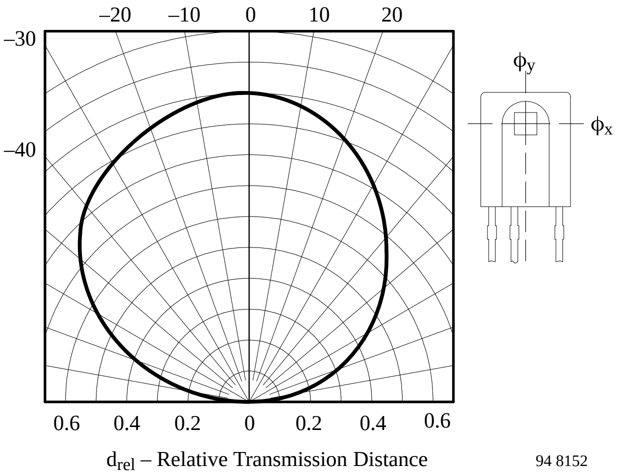


Figure 13. Vertical Directivity φ_y

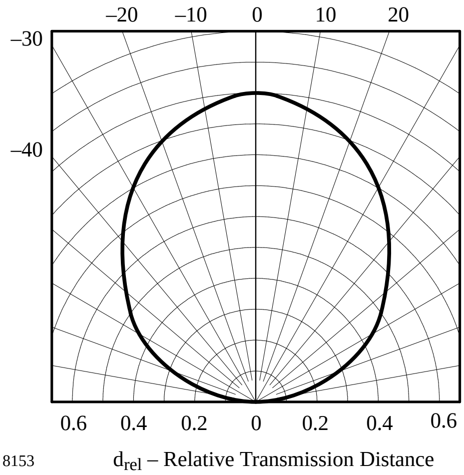
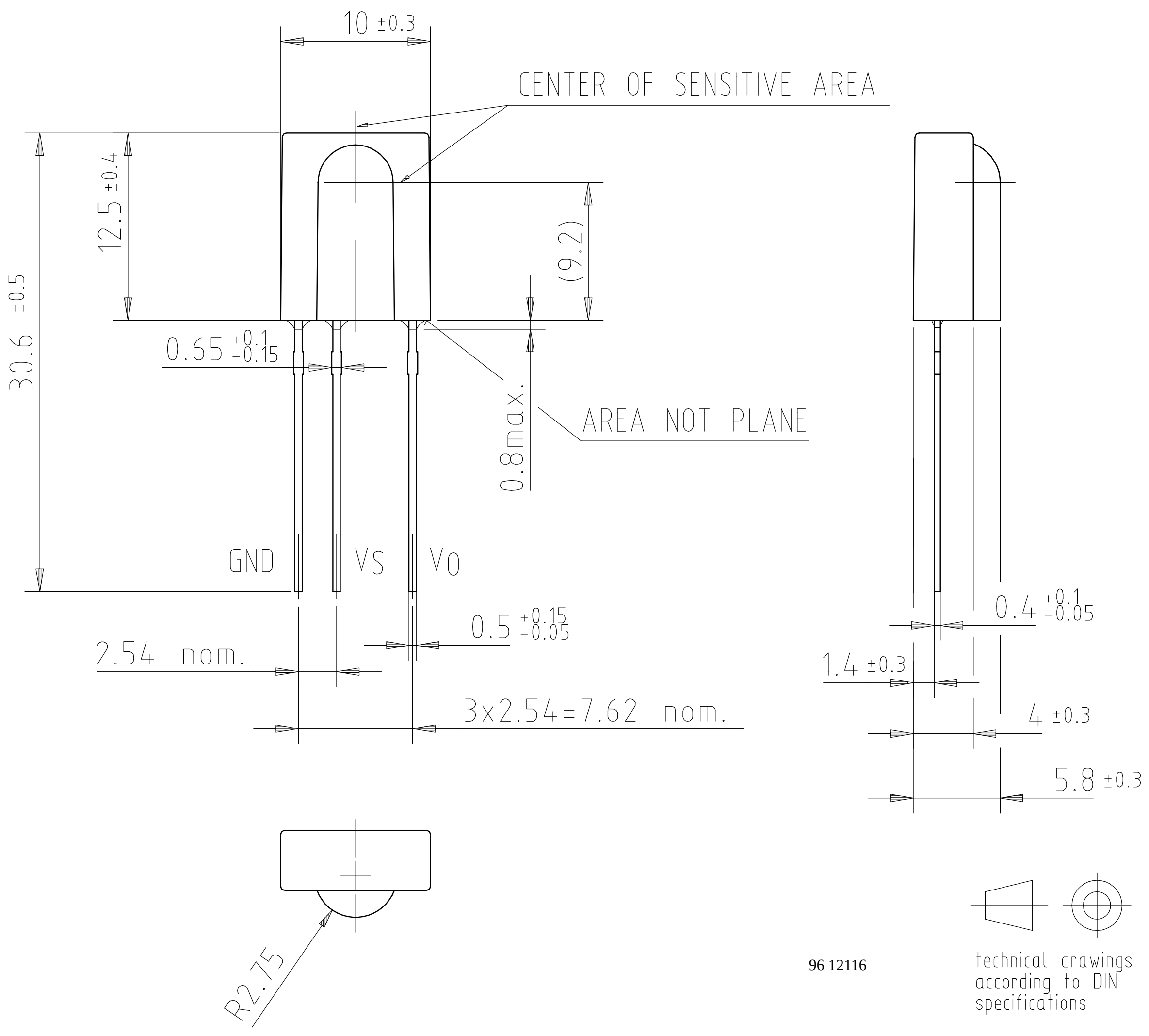


Figure 14. Horizontal Directivity φ_x

Dimensions in mm



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3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

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Telephone: 49 (0)7131 67 2831, Fax number: 49 (0)7131 67 2423