# A TV FREQUENCY SYNTHESIZER FOR 30 PROGRAMS

## INTRODUCTION

The PLL2K PLL synthesizer is a new development in the field of TV tuning systems. Based on the M3870 microcomputer and the new M206 PLL TV microprocessor interface, the PLL2K synthesizes up to 100 channels directly, stores 30 programs in non-volatile read/write memory and provides outputs for band selection and analog controls.

The main characteristics of the PLL2K are:

- Fine tuning with resolution of 62.5 kHz
- Identification of the TV signal during the search
- Possibility of automatic search of the TV signal in each channel using the AFC
- Possibility of automatic search with TV sync coincidence detector instead of AFC
- High tuning stability with 4 MHz crystal precision.

## COMPONENTS

The PLL2K system uses the following integrated circuits (see fig. 1):

### M3870 - Single chip 8 bit microcomputer

- Single supply (+ 5V)
- 2K byte ROM
- 64 byte scratchpad RAM
- 32 I/O pins TTL compatible
- Programmable timer
- External interrupt

### M206 - TV microcomputer interface

- PLL synthesizer
- NVRAM
- Buffered outputs
- Digital filter for remote control
- External prescaler, modulo 64+15/16
- NVRAM: 32 16-bit words
- 6 D/A converters
- 4 MHz crystal oscillator
- 4 buffered outputs
- Internal power-on reset circuit
- 3-wire serial bus for microcomputer interfacing

### TDA 4433 - TV signal identifier and digital interface for AFC

- Can be used in connection with the M3870 microcomputer for the channel automatic search (up/down)
- Separate output for AFC search and control
- Adjustable TV signal recognition sensitivity
- Station identification output

### M705 - 15/16 divider

- To be used in conjunction with a standard 64 prescaler
- High input sensitivity

### M709/10 - PCM remote control transmitters

M709: 40 commands, 16 addresses

M710: 64 commands, 16 addresses

- Keyboard matrix scanning: 5x8 (M709) or 8x8 (M710)
- Single-contact keyboard matrix
- Integrated antibounce and interlock
- 4-bit binary address input
- End-of-transmission code

### TDA 2320 - Remote control signal preamplifier

- High gain
- Low noise
- +5V supply

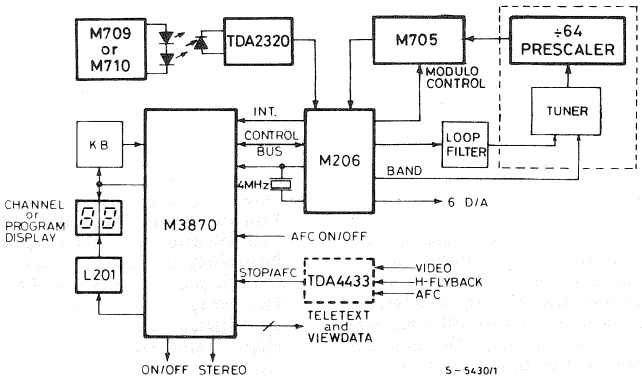
### L 201 - Darlington transistor matrix

- High sinking current
- Low saturation voltage
- Ideal for multiplexing seven segment display

Low pass filter with op amp., for example **CA3140E** or **TL 061** or **LM 324.**

The system can operate with a TDA 4420 or TDA 4421 video IF plus AFC and with other AFC circuits

*Fig. 1 - Block diagram of PLL2K system*



## DESCRIPTION OF EACH PRODUCT

Each device is described with reference to its functions. For more details, please refer to the data sheets.

## M206 PLL TV microcomputer interface

**Supply voltages:**

$V_{DD1} = V_{DD2} = +5V$; $V_{PP} = +25V$

**Technology: Double polysilicon NMOS**

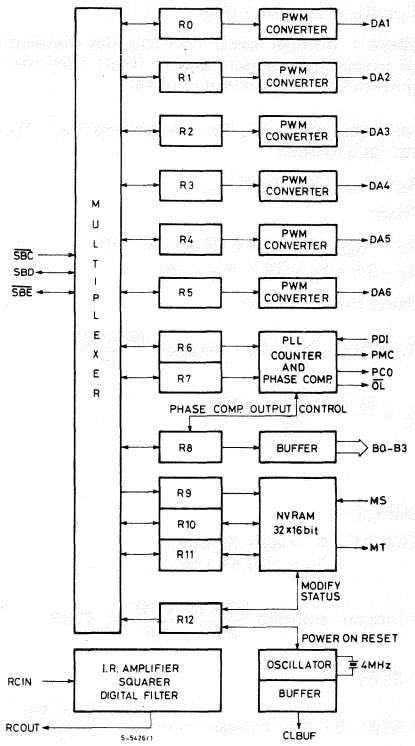
### Interface Operation

The interface operations between the microcomputer and the TV set performed by M206 are shown in the block diagram of fig. 2.
The M3870 communicates with the M206 via a three-wire serial bus: $\overline{\text{CLOCK}}$, DATA (bidirectional) and $\overline{\text{ENABLE}}$ (bidirectional). All the data transfers are controlled by the $\overline{\text{ENABLE}}$ line.
The information on the DATA line is accepted by M206 during the low level clock time. The driving of the TV analogue signals is performed by the six PWM D/A converters with a resolution of 64 steps and a frequency of 16 MHz and variable duty cycle.
The R6 and R7 registers contain the information of the division ratio of the synthesis loop. Four buffered outputs drive the TV bands. This information is contained in register 8 together with the information related to the control of the phase comparator, useful to return it to correct working, if any block occurs.
The internal NVRAM is controlled by registers R9 (address pointer) and R10, R11 (data). It is structured as 32 words of 16 bits and contains the information for 30 programs with the deviation (8 bits for the channel number and 7 bits for the deviation). Two words are reserved to contain the information of the normalized values of the D/A converters.
The register R12 contains the information of ME (modify end) of the memory and of power-on reset for the lines $V_{DD1}$ and $V_{DD2}$.

### PLL Frequency Synthesizer

The synthesis loop is shown in fig. 3. The frequency of the tuner's VCO is divided first by 64 and then by 15 or 16 by means of the fixed prescaler and of the M705 dual modulo divider. This divided frequency is then input to the programmable counter of M206, which consists of a program counter (11 bits) and swallow counter (4 bits). This swallow counter controls the dividing ratio (15 or 16) of the M705.
An internal reference frequency is generated in M206 dividing the crystal-controlled 4 MHz frequency of the clock oscillator. A phase comparator compares this fixed reference frequency and the frequency coming from the programmable counter.

*Fig. 2 - M206 block diagram*




The phase comparator output (buffered and fed to the pin 15 of M206) is integrated by a Low Pass Filter, thus providing the voltage required to control the tuner's VCO.

CALCULATING PLL COUNTER VALUES

1) F = video carrier
2) IF = 38.9 MHz
3) The frequency to be synthesized is $F_S = F + IF$
4) The reference frequency of the phase comparator is:

$$F_{ref} = \frac{4000}{4096} \text{ Hz} = 976.56 \text{ Hz}$$

5) Using (64 + 15/16) prescaler the minimum frequency step is:

$F_{ref} \cdot 64 = 62.5$ kHz

6) The dividing ratio $N_S$ is given by the ratio between the frequency to be synthesized and the reference frequency multiplied by 64.
The result has to be rounded.

$$N_S = \text{Integer rounded } \frac{F_S}{F_{ref} \cdot 64}$$

7) With the above prescaler and the counter of the M206 the ratio N is given by:

$N_S = (I_S + 1) \cdot 15 + (R_S + 1) \cdot 16$

where I (integer part) controls the division by 15 (program counter) and R (rest) controls the division by 16 (swallow counter).

Let's decrement $N_S$ by one, getting $N_C = N_S - 1$, and let's assume:

$R_S = R_C + 1 \quad I_S = I_C - 1$

Then:

$N_C = (I_C + 1) \cdot 15 + (R_C + 1) \cdot 16$

$N_C - 31 = I_C \cdot 15 + R_C \cdot 16$

Using the formulas:

$$R_C = N_C - 31 - 15 \cdot \text{Integer} \frac{N_C - 31}{15}$$

$$I_C = \frac{N - 31 - R_C \cdot 16}{15}$$

EXAMPLE:

Channel 21 $F = 471.25$ MHz

$F_S = 510.15$ MHz

$$N_S = \text{Integer rounded} \frac{510.15 \times 10^6}{62.5 \times 10^3} = 8162$$

$N_C = 8161$

$$R_C = 8161 - 31 - 15 \cdot \text{Integer rounded} \frac{8161 - 31}{15} =$$

$= 8130 - 15 \cdot 542 = 0$

$$I_C = \frac{8161 - 31 - 0}{15} = 542$$

Therefore:

$R_S = 1$

$I_S = 541$

As a matter of fact

$N_S = 542 \cdot 15 + 2 \cdot 16 = 8162$

$R_S$ and $I_S$ must be translated into binary code, and their binary values are loaded into registers R6 and R7 of the M206 as shown below:

| D6 | | | | | | D0 | |
|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | R6 (Program Counter) D6 = MSB |

| D7 | | | | | | D0 | |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | R7 (D0 = LSB Swallow Counter) (D3 = MSB Swallow Counter) (D4 = LSB Program Counter) |

**Register Loading for TV Tuning**

Every time a new dividing ratio has to be loaded, register R7 has to be loaded last because the register 7 load operation initiates the data transfer to the PLL counter.

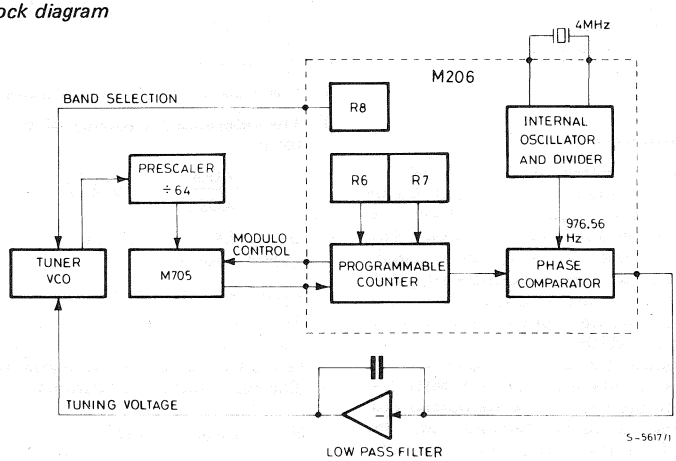
To tune the desired channel correctly, when a new dividing ratio is loaded into the registers R6 and R7, the information on the TV band which must be activated is loaded into the register 8, so that the corresponding output buffer will be switched on.

The data content of register 8 is shown below:

| D7 | | | | | | | D0 | |
|---|---|---|---|---|---|---|---|---|
| | | | | AV | UHF | III | I | Register 8 |

The correct output will be switched on by loading "0" in the corresponding bit of the register R8.

*Fig. 3 - PLL block diagram*



### Phase Comparator

The phase comparator output has a three-state push-pull configuration, with output impedance of the Low and High states farily low (typ. 200Ω). Normally this output is controlled by the internal phase comparator logic, but in some cases it may be directly controlled by the microcomputer (this may be needed when the loop does not work correctly, especially when the VCO is not oscillating or the prescaler is not operating correctly at high frequencies).
The phase comparator output control by the microcomputer is achieved loading the bits D4–D6 of the register R8 as shown in the table below.

| D6 | D5 | D4 | Phase comparator output |
|---|---|---|---|
| L | L | L | Normal PLL operation |
| H | L | L | High impedance state |
| L | H | L | Low for 1 ms, then returns automatically to normal operation |
| H | H | L | Low for 1 ms, then returns to high impedance state |
| L | L | H | High for 1 ms, then returns to normal PLL operation |
| H | L | H | High for 1 ms, then returns to high impedance state |
| L | H | H | Normal operation * |
| H | H | H | High impedance * |

* These combinations are not valid and D5 and D6 are automatically reset after 1 ms.

### Out of Lock

An out of lock signal is provided on pin 16 of the M206. This pin is held low when the phase difference between the reference frequency and the output frequency from the PLL counter exceeds 0,72° (which is equivalent to ± 2 μs).
This situation occurs normally during a change in tuning or may be caused by unwanted changes in band register or in PLL counter (provoked, for example, by spikes on supply) or by an incorrect operation of the prescaler: in this case it is better to reload the band and PLL counter registers with the right values.

### Digital Power-on Reset

Both supplies $V_{DD1}$ and $V_{DD2}$ have an integrated digital power-on reset, which lasts about 250 ms after both supplies have reached the levels necessary for the correct operation of the device.
During power-on reset the Serial Bus lines are in high impedance state, and so transfer to and from the microcomputer is inhibited. This reset condition is signalled with a low level on the out-of-lock line. The microcomputer can test this condition by reading bit 1 of the register 12: this bit is reset by any power-on-reset and the out-of-lock line is held low until this bit has been read. Reading this bit sets it high automatically. During power-on reset, the NVRAM is protected against any spurious operation.

### Remote Control Signal pre-Processing

In the M206 a section is provided which contains a preamplifier, a squarer, a digital filter and a pulse generator. The digital filter enables the pulse generator only if three successive negative pulses (4 edges) are correctly received. The distance between these pulses has to be between 25 and 27 μs.
The pulse generated by the M206 lasts about 192-256 μs and is sent to the interrupt input of the microcomputer, which will decode the signal coming from the remote control. This system allows the transmission code to be correctly filtered and received even in presence of strong light sources, and filtering the signal from noise reduces the number of interrupts of the microcomputer.

### Non Volatile Memory

The memory integrated in the M206 is organized as 32 words of 16 bits and it is word modifiable. It is a "two stacked electrode" type NVRAM fabricated with the SGS double polysilicon gate technology, which allows the integration in a single chip of the NVRAM together with all the control logic.

STORE

In order to store a new content in a memory word, first the new content must be loaded in the registers 10 and 11, and then the desired memory row address must be loaded in the register 9. After this, the store operation starts automatically; the timing sequence necessary for the correct store operation is internally generated and must be externally buffered to drive the memory (see application diagram). The store operation lasts until the new content is correctly stored in the addressed row: since this time may vary in a great range, and is not internally limited, the information if the modify end has been reached is loaded in the bit D0 of register 12 (D0 = H means that the store operation has ended). The modify operation can be aborted by the microcomputer, setting high the bit D0 of the register 12 (1s as the maximum time could be a good value)

READING

To read a memory word, the desired row address must be loaded into the register 9. After this, M206 will load the registers 10 and 11 with the content of the addressed row. Registers 10 and 11 can now be read by the microcomputer with two successive requests.

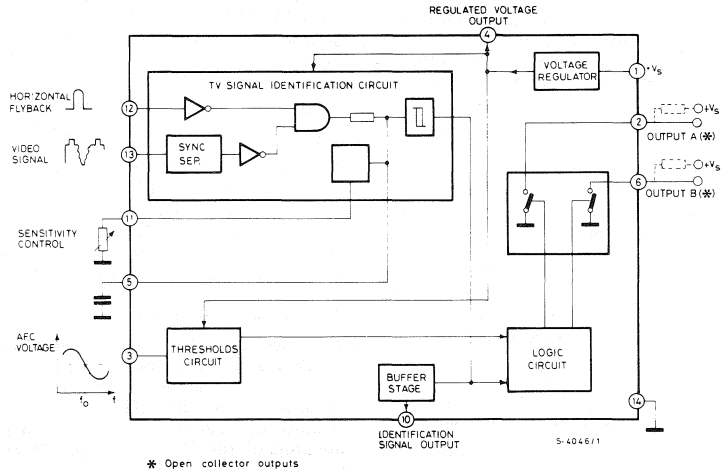
## TDA 4433 - Linear interface for TV signal identification and digital AFC interface

**Supply voltage: + 12V**

**Technology: bipolar**

This circuit essentially consists of two parts (see fig. 4): one is the TV signal detector including a TV sync separator and the other one is a threshold detector for the Digital Automatic Frequency Control.

*Fig. 4 - TDA 4433 block diagram*




* Open collector outputs

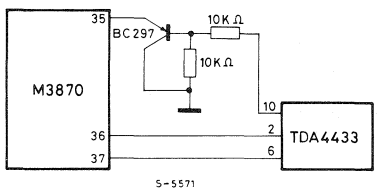
A voltage regulator is also integrated to supply the internal circuit, and is externally available. The device has a high and adjustable sensitivity.
On pin 10 an output is provided which gives an "identified" signal: this output is switched off when a station is identified.
The output pins 2 and 6 are high when no video signal is arriving at the input pin 13, or when the video signal is not recognized as a true video signal.

When a station is identified, the state of pins 2 and 6 shows the position of tuning with respect to the optimal station tuning inside the capture range of the AFC S-Curve, as shown in the table below:

| V10 | V2 | V6 | |
|---|---|---|---|
| H | H | H | No identification |
| L | H | L | $f_o - \delta f$ |
| L | L | L | $f_o$ |
| L | L | H | $f_o + \delta f$ |

The outputs of pins 2 and 6 are open drain and need external pull-up resistors. In the PLL2K, however, these pull-up resistors are integrated in the microcomputer I/O ports, so no external components are required.
In the application described in this note, the TDA 4433 is directly connected with the M3870 microcomputer as shown in fig. 5.

*Fig. 5 - Connections between TDA4433 and M3870*




## M705 - 15/16 divider

**Supply voltage: 5V**
**Technology: Si-gate CMOS**

The M705 is a 15/16 divider to be used in PLL frequency synthesis TV systems, in conjunction with a 64 prescaler and the M206 microprocessor interface.
The dividing ratio is 15 if the modulo control is high, while it is 16 if the control is low.
The device is assembled in a 8 pin plastic package.

## M709-M710 Remote control transmitters

**Supply voltage: 4.5 - 10.5V**
**Technology: Si-gate CMOS**

These devices are two PCM transmitters which are quite similar. The only functional difference concerns the number of commands that may be transmitted:

| | |
|---|---|
| M709 | 40 commands x 16 addresses |
| M710 | 64 commands x 16 addresses |

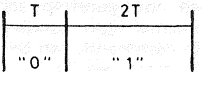
### Data Encoding

The commands are transmitted with infrared light, using a special pulse code modulation technique, pulse position modulation (PPM). Each transmitted word consists of 14 bits (1 preliminary bit, 1 start bit, 4 address bits, 6 command bits, 1 parity bit and 1 stop bit). The binary content of each bit is determined by the time interval between two pulses.

If T is the time base, the bits are coded as shown below.

odd bits

0 = T
1 = 2T



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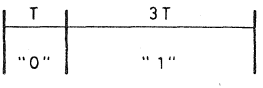
even bits

0 = T
1 = 3T



S-5552

This different code introduced for even an odd "1s" improves the noise immunity of the transmission at the receiver. In the word a parity bit is added, so that the number of "1s" transmitted must always be odd.

Preliminary pulse, start pulse and stop pulse are inserted in the transmitted word with fixed time intervals as shown in fig. 6.

So, the total word time may range from 21T to 36T.

### Transmission Mode

Both M709 and M710 may generate a transmission code with carrier (pin 1=L) or without it (pin 1=H). In the PLL2K only the carrier mode may be used. Using a 4 MHz quartz oscillator at the receiver end (M206), a reference frequency of 500 kHz ±8 kHz must be used as the clock for the transmitter.

The format of the I.R. signal is shown in fig. 7.

## APPLICATION EXAMPLE

An application for an infrared transmitter based on the M709/710 is shown in fig. 8.

*Fig. 6 - Example of a transmitted word*

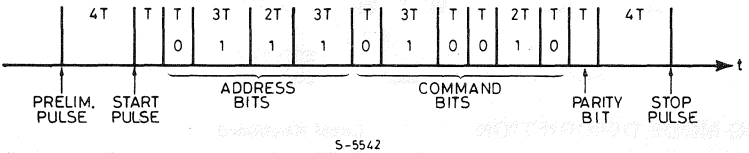


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*Fig. 7 - Format of the I.R. transmitted signal*

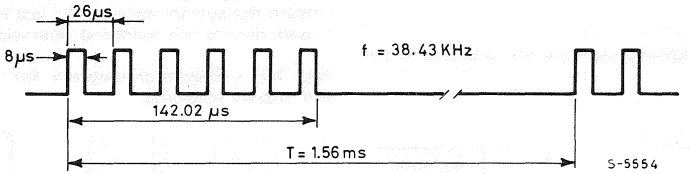

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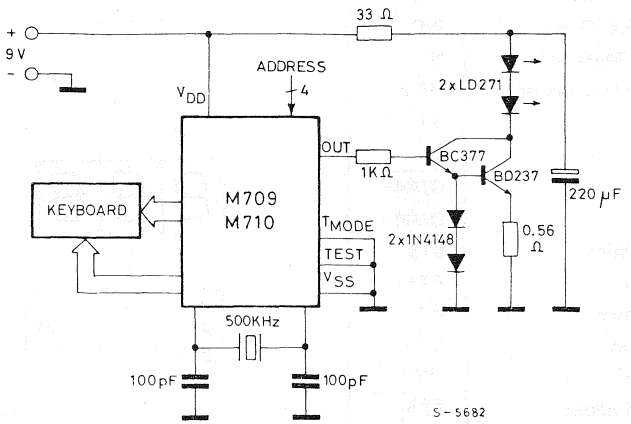
*Fig. 8 - Application for an infrared transmitter*



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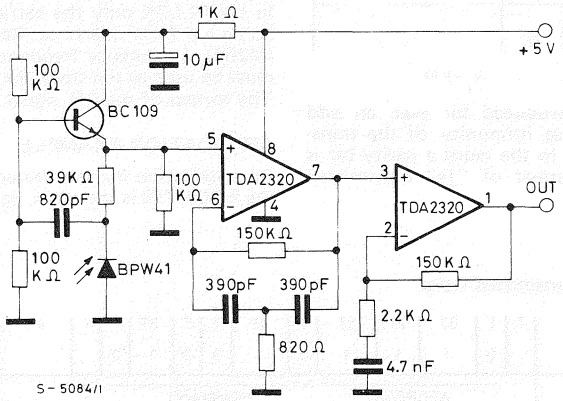
INFRARED DIODE PEAK CURRENT = 1.25A
TOTAL AVERAGE CONSUMPTION = 13mA

## TDA 2320 - Infrared preamplifier

**Supply voltage: + 5V**
**Technology: bipolar**

The design of the infrared signal preamplifier is fairly simple: a standard dual op-amp is enough for this purpose, for example the TDA 2320. The proposed configuration achieves 70 dB gain, and under normal light conditions the system, in case of single command, can be controlled in the range 0 to 20 meters (see fig. 9).

*Fig. 9 - Infrared signal preamplifier*




## OPERATING MODE DESCRIPTION

An M3870 microcomputer is the master controller of the PLL2K system.

### Commands

Both local and remote controls are available in the system.

**Local controls**

| Functions | Symbol |
|---|---|
| • Program/Channel mode * | P/C |
| • Program/Channel Up * | P/C+ |
| • Program/Channel Down * | P/C– |
| • Normalization/Mute off | N |
| • Normalized factory values | NFV |
| • Volume + | V+ |
| • Volume – | V– |
| • Analogue 4 + | D/A4+ |
| • Analogue 4 – | D/A4– |
| • Memory addressing | STS |
| • Fine tuning Up | FT+ |
| • Fine tuning Down | FT– |
| • Channel scan Up | C↗ |
| • Channel search | →T← |
| • Store analogue values | STA |

* If given in stand-by condition, these commands switch on the set (program 1 is tuned).

**Local Keyboard**

Commands are accepted after about 30 ms of continuous presence (no interruption of the contact due to bouncing). In case of double or multiple key closure the system accepts the last key that is found closed during the scanning operation (see fig. 10).

*Fig. 10 - Electrical diagram for local keyboard and display scanning*

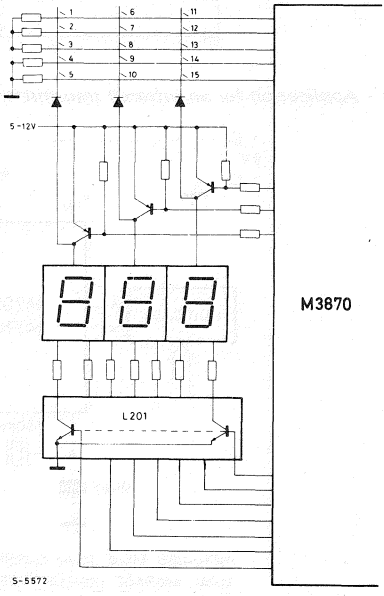


**TABLE 1 - Remote Control Commands**

| Command No. | IR code C1 | C2 | C3 | C4 | C5 | C6 | Local controls | Function |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | | End of transmission |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | | Mute on/off |
| 2 | 0 | 1 | 0 | 0 | 0 | 0 | | Mains off/Mute off/TV mode (subs. off) |
| 3 | 1 | 1 | 0 | 0 | 0 | 0 | | Reserve 1 on/off |
| 4 | 0 | 0 | 1 | 0 | 0 | 0 | | Reserve 2 on/off |
| 5 | 1 | 0 | 1 | 0 | 0 | 0 | V | Channel scan Up |
| 6 | 0 | 1 | 1 | 0 | 0 | 0 | V | Memory addressing |
| 7 | 1 | 1 | 1 | 0 | 0 | 0 | V | Store analogue values |
| 8 | 0 | 0 | 0 | 1 | 0 | 0 | | |
| 9 | 1 | 0 | 0 | 1 | 0 | 0 | V | Fine Tuning Up |
| 10 | 0 | 1 | 0 | 1 | 0 | 0 | V | Fine Tuning Down |
| 11 | 1 | 1 | 0 | 1 | 0 | 0 | V | Program/Channel Manual Up |
| 12 | 0 | 0 | 1 | 1 | 0 | 0 | V | Program/Channel Manual Down |
| 13 | 1 | 0 | 1 | 1 | 0 | 0 | V | Channel search |
| 14 | 0 | 1 | 1 | 1 | 0 | 0 | | Program mode/Mains on |
| 15 | 1 | 1 | 1 | 1 | 0 | 0 | | Channel mode |
| 16 | 0 | 0 | 0 | 0 | 1 | 0 | | 0/Mains on |
| 17 | 1 | 0 | 0 | 0 | 1 | 0 | | 1/Mains on |
| 18 | 0 | 1 | 0 | 0 | 1 | 0 | | 2/Mains on |
| 19 | 1 | 1 | 0 | 0 | 1 | 0 | | 3/Mains on |
| 20 | 0 | 0 | 1 | 0 | 1 | 0 | | 4/Mains on |
| 21 | 1 | 0 | 1 | 0 | 1 | 0 | | 5/Mains on |
| 22 | 0 | 1 | 1 | 0 | 1 | 0 | | 6/Mains on |
| 23 | 1 | 1 | 1 | 0 | 1 | 0 | | 7/Mains on |
| 24 | 0 | 0 | 0 | 1 | 1 | 0 | | 8/Mains on |
| 25 | 1 | 0 | 0 | 1 | 1 | 0 | | 9/Mains on |
| 26 | 0 | 1 | 0 | 1 | 1 | 0 | | Program 1— |
| 27 | 1 | 1 | 0 | 1 | 1 | 0 | | Program 2— |
| 28 | 0 | 0 | 1 | 1 | 1 | 0 | V | Program/Channel mode |
| 29 | 1 | 0 | 1 | 1 | 1 | 0 | V | Normalization/Mute off |
| 30 | 0 | 1 | 1 | 1 | 1 | 0 | V | Volume +/Mute off |
| 31 | 1 | 1 | 1 | 1 | 1 | 0 | V | Volume —/Mute off |
| 32 | 0 | 0 | 0 | 0 | 0 | 1 | | Analogue 2 + |
| 33 | 1 | 0 | 0 | 0 | 0 | 1 | | Analogue 2 — |
| 34 | 0 | 1 | 0 | 0 | 0 | 1 | | Analogue 3 + |
| 35 | 1 | 1 | 0 | 0 | 0 | 1 | | Analogue 3 — |
| 36 | 0 | 0 | 1 | 0 | 0 | 1 | V | Analogue 4 + |
| 37 | 1 | 0 | 1 | 0 | 0 | 1 | V | Analogue 4 — |
| 38 | 0 | 1 | 1 | 0 | 0 | 1 | | Analogue 5 + |
| 39 | 1 | 1 | 1 | 0 | 0 | 1 | | Analogue 5 — |
| 40 | 0 | 0 | 0 | 1 | 0 | 1 | | Analogue 6 + |
| 41 | 1 | 0 | 0 | 1 | 0 | 1 | | Analogue 6 — |
| 42 | 0 | 1 | 0 | 1 | 0 | 1 | V | Normalized factory values |
| 43 | 1 | 1 | 0 | 1 | 0 | 1 | | Program/Channel scan Up |
| 44 | 0 | 0 | 1 | 1 | 0 | 1 | | Program/Channel scan Down |
| 45 | 1 | 0 | 1 | 1 | 0 | 1 | | |
| 46 | 0 | 1 | 1 | 1 | 0 | 1 | | |
| 47 | 1 | 1 | 1 | 1 | 0 | 1 | | |
| 48 | 0 | 0 | 0 | 0 | 1 | 1 | | teletext/viewdata commands |
| 49 | 1 | 0 | 0 | 0 | 1 | 1 | | |
| 50 | 0 | 1 | 0 | 0 | 1 | 1 | | |
| 51 | 1 | 1 | 0 | 0 | 1 | 1 | | |
| 52 | 0 | 0 | 1 | 0 | 1 | 1 | | |
| 53 | 1 | 0 | 1 | 0 | 1 | 1 | | |
| 54 | 0 | 1 | 1 | 0 | 1 | 1 | | |
| 55 | 1 | 1 | 1 | 0 | 1 | 1 | | |
| 56 | 0 | 0 | 0 | 1 | 1 | 1 | | |
| 57 | 1 | 0 | 0 | 1 | 1 | 1 | | |
| 58 | 0 | 1 | 0 | 1 | 1 | 1 | | |
| 59 | 1 | 1 | 0 | 1 | 1 | 1 | | |
| 60 | 0 | 0 | 1 | 1 | 1 | 1 | | |
| 61 | 1 | 0 | 1 | 1 | 1 | 1 | | Teletext on } subsystem on |
| 62 | 0 | 1 | 1 | 1 | 1 | 1 | | Viewdata on } |
| 63 | 1 | 1 | 1 | 1 | 1 | 1 | | Mains on/TV mode - subsystem off |

### Remote Control Decoding

The system decodes signals transmitted by an M709 or M710 with address N° 5 and modulated transmission mode (carrier mode).
The oscillator frequency of the transmitter must be 500 kHz ±8 kHz (with clock frequency of the system = 4 MHz).
The receiver section performs the following tests on the incoming signal to achieve the necessary noise immunity:

- Check of the position of the received bits opening windows at the time bases
- Check of parity bit
- Chekc of the absence of pulses between the parity bit and the stop pulse
- Check for the word to be of 15 bits
- Check of the noise level. The receiver checks parasitic pulses outisde the time windows.

If the above test conditions are not fulfilled, the received word is rejected and not decoded. If the received signal is acknowledged as a valid word it is stored and decoded. The end of transmission will be acknowledged by receiving the end of transmission code or by means of an internal timer in the case the transmission remains interrupted for more than about 500 ms.

## Mains On

When the supply voltage is applied to the M3870 the system is set in stand-by mode. In this condition the Mains on output transistor is biased off and the analogue outputs cannot be changed. Only the Mains on command is accepted.
The set can be switched on with the commands

- Program/Channel up (11)
- Program/Channel down (12)
- Program mode (14)
- Programm/Channel mode (28)
- ON/TV mode (63)

} The set is positioned at Program 1

- 0 to 9 (16 to 25) Programs 0 to 9
- Program 1 — (26)
- Program 2 — (27)

} Switch on the set occurs only after reception of the unit digit. This digit must be entered within 8 seconds otherwise the display returns to stand-by mode

All these commands are accepted after 0.3s (local command) or if received 4 times without interruption from remote control. The end of transmission code generated internally or from remote control exits from the acceptance routine. When the command is accepted pin 8 of the M3870 (open drain) is switched on (Low) and 1.2s delay is internally generated. During this time no other command either local or remote is accepted and the Mute is inserted.

The set can also be switched on by connecting the Mains-on pin to $V_{SS}$ for at least 20 ms.
The 1.2s delay time is generated too. The set is positioned at Program 1.

In both cases the analogue values are set as in the memory of M206. The Mute is switched off and the system is operating in TV mode.

## Mains Off

The set is switched off with the command 2 received 4 times without interruption (i.e. no end of transmission). 80ms before switching the TV set off the Mute is inserted to avoid noise on the audio.
In the stand-by mode the display shows 

## Functions

### Program Mode/Channel Mode

| | | |
|---|---|---|
| P | Program mode | (14) |
| C | Channel mode | (15) |
| P/C | Program/Channel mode (toggle) | (28) |

These commands select the mode of operation of the system. The display shows the tuned program or the channel number in accordance with the selected mode of operation. If pin 22 of the M3870 is at GND the system remains in Channel mode until the Program mode command is received. If instead the pin 22 is at $V_{DD}$, the Channel mode is timed for 8 seconds. This timing restarts at each channel entry command.
After this time the system automatically reverts to the Program mode. This time can be shortened by the Program mode command or by the P/C toggle command.

### Memory Scanning

When the system returns from Channel mode to Program mode, the display shows whether the tuned station has been stored in the memory or not, comparing the actual Channel number with the information stored in the memory. If the channel is stored the display shows the corresponding Program number.
If the channel is not stored the display shows

**Program Up/Down** (P+/P—) (11, 12)

This command manually increments or decrements the program. In case of continuous command, the programs are modified every 500 ms or 5 commands from remote control. The volume is muted 80 ms before the effective program change and lasts 500 ms. When the highest or lowest Program is reached the stepping restarts from the lowest or the highest respectively.

**Channel Up/Down** (C+/C–) (11, 12)

These commands manually increment or decrement the channels. They follow the same rules of the Program +/– commands. When the highest or lowest Channel is reached the stepping restarts from the lowest or the highest respectively.
Muting is provided as in the P+/P- commands case.

**Fine tuning** +/– (FT+/FT–) (8, 9)

These commands are used for manual tuning of the set with steps of 62.5 kHz. In case of a continuous command the first step is immediately executed while further steps follow after 0.3 s waiting time, every 200 ms or 2 commands from remote control.
When the system is in Channel mode and a channel limit is transgressed during the Fine tuning operation, the display shows the new channel number.
Channel limits are considered -3.5 MHz (VHF) or -4 MHz (UHF) and +3.44 MHz (VHF) or 3.94 MHz (UHF) from the frequency stored in the M3870 ROM. The Fine tuning information can be stored in the memory. If the Fine tuning commands are given while AFC is enabled, the AFC is disabled until a new channel or program is selected.

**Direct Program Selection**

Program selection is possible only when the system is in P mode.
Programs 0 to 9 can be directly selected, while Programs 10 to 29 must be preceeded by the decade commands  or  which are timed for 8 seconds.

If no unit figure is entered within this time, the display reverts to the previously selected program. Program 0 is displayed. 

Muting is provided as in case of commands 11 and 12.

**Direct Channel Selection**

Direct channel selection is possible when the system is in C mode using double keying. Up to 100 channels can be selected (from channel 01 to channel 100, displayed and selected as channel 00). When the Channel tens is entered it is immediately displayed and one segment of the unit digit is flashing at 2Hz. The unit must be entered within 8 seconds otherwise the display will show the previously selected channel. Muting is provided during the channel change as described in the program change operation. The new channel is tuned according to the content of the ROM.

**Automatic search**

 (5) Channel scan Up

 (43) Program or Channel scan Up

 (44) Program or Channel scan Down

Channel scan: an automatic search is performed by scanning in the up direction the channel frequencies stored in the M3870 ROM. This command automatically reverts the system to Channel mode.
The end of the search is determined by the coincidence of the horizontal flyback with the video synch pulses signalled with a low level at pin 35 of the M3870. This signal can be furnished by the TDA 4433 or by a coincidence signal derived from the synch signal processor of the set. The channel are incremented at the rate of 3 steps/second.
The channels and frequency listing are slown in table 2.

Program/Channel scan Up
Program/Channel scan Down

These commands provide automatic search in Up or Down direction of the program or of the channel depending on the mode of operation.
The stop is determined by the coincidence signal at pin 35 of the M3870. Increment or decrement rate is 2 steps/second.

**Automatic Fine Tuning**

When pin 23 of the M3870 is connected to $V_{DD}$ the AFC is controlling the tuning of the station. The interface circuit TDA 4433 converts the AFC-S curve into Up or Down signals which control the counter of the loop. In this way the AFC operates continuously tracking unstable signals (i.e. VCR, TV games, etc) with steps of 62.5 kHz every 20 ms.

**Channel Search**  (13)

This command enables a search limited to the range of the preselected channel. The search starts from the actual tuning position in the Up direction with steps of 62.5 kHz. At the upper limit of the channel the search restarts from the lower limit.
The search is stopped by an Up/Down transition of the AFC-S-Curve converted by the TDA 4433.
If no station is found after a complete channel search, the tuning returns to the standard channel frequency. During channel search muting is provided.

**Memory Addressing**  (6)

When this command is given the system shows the letter P followed by two flashing segments. The first figure of the memory location must be selected within 8s. The unit's selection has to be selected within 8 seconds.
Program +/– commands are disabled during the routine. The store function is automatically activated at the reception of the unit figure.

**Reserve 1**  (3)

This command switches ON/OFF an open drain output of the M3870 (pin 10). At Power on reset (M3870 initialization) it is set in the OFF position.

**TABLE 2 - Channels and Frequencies listing**

The oscillator frequency of the tuner is the video carrier frequency +38.9 MHz. CATV channel frequencies, as indicated in the column CATV ON, are synthesized only if the CATV option pin is enabled (GND).

| Channel number | Video carrier (MHz) | | Band |
|---|---|---|---|
| | CATV option ON | CATV option OFF | |
| 01 | 46.25 | 46.25 | VHF I |
| 02 | 48.25 | 48.25 | |
| 03 | 55.25 | 55.25 | |
| 04 | 62.25 | 62.25 | |
| 05 | 175.25 | 175.25 | VHF III |
| 06 | 182.25 | 182.25 | |
| 07 | 189.25 | 189.25 | |
| 08 | 196.25 | 196.25 | |
| 09 | 203.25 | 203.25 | |
| 10 | 210.25 | 210.25 | |
| 11 | 217.25 | 217.25 | |
| 12 | 224.25 | 224.25 | |
| 13 | 53.75 | 53.75 | VHF I |
| 14 | 62.25 | 62.25 | |
| 15 | 82.25 | 82.25 | |
| 16 | 175.25 | 175.25 | VHF III |
| 17 | 183.75 | 183.75 | |
| 18 | 192.25 | 192.25 | |
| 19 | 201.25 | 201.25 | |
| 20 | 210.25 | 210.25 | |
| 21 | 471.25 | 471.25 | UHF |
| 22 | 479.25 | 479.25 | |
| • | • | • | |
| • | • | • | |
| • | • | • | |
| 73 | 887.25 | 887.25 | |
| 74 | 69.25 | 46.25 | VHF I |
| 75 | 76.25 | 46.25 | |
| 76 | 83.25 | 46.25 | |
| 77 | 90.25 | 46.25 | |
| 78 | 97.25 | 46.25 | |
| 79 | 59.25 | 46.25 | |
| 80 | 93.25 | 46.25 | |
| 81 | 105.25 | 46.25 | |
| 82 | 112.25 | 46.25 | VHF III |
| 83 | 119.25 | 46.25 | |
| 84 | 126.25 | 46.25 | |
| 85 | 133.25 | 46.25 | |
| 86 | 140.25 | 46.25 | |
| 87 | 147.25 | 46.25 | |
| 88 | 154.25 | 46.25 | |
| 89 | 161.25 | 46.25 | |
| 90 | 168.25 | 46.25 | |
| 91 | 231.25 | 46.25 | |
| 92 | 238.25 | 46.25 | |
| • | • | • | |
| • | • | • | |
| • | • | • | |
| 99 | 287.25 | 46.25 | |
| 00 | 294.25 | 46.25 | |

**Reserve 2** | R2 | (4)

This command switches ON/OFF an output of the M3870 (pin 9). At Power on reset (initialization of M3870) it is set in the OFF position.

**AV**

When program 0/AV is selected, pin 22 of M206 is switched low.

**Analogue Controls**

In the case of a continuous remote control command for varying the analogue information, the duty cycle is changed at the rate of the transmitted signal (approximately every 102 ms). In case of local controls they are varied at about the same rate. Underflow and overflow protection is provided.

At Mains on the controls are set at the level stored in the memory.
It is possible to recall the normalized factory values by the command | NFV | (42).

The volume is set at 21/64 (pulse = H). All other D/A are set at 32/64.
The values of the customer's normalized position can be stored in the memory with command | STA | (7).

The D/A 1 (volume) and 4 are stored with 1 bit resolution (6 bit), while the least significant bit of D/A 2, 3, 5 and 6 is missed.
The stored analogue values are recalled with the command Normalization (29).
The mute can be turned on and off with the command (1). It can also be turned off with the commands Volume +/– and Normalization.

## Teletext/Viewdata Data Bus outputs

The Teletext and the Viewdata modes of operation are selected by the commands 61 and 62 respectively. When one of these commands is issued the Data bus is enabled and all successive commands concerning the operation of the teletext or viewdata modes will be converted ad repeated with the appropriate code requested by the decoders (I-Bus see fig. 11).
When the system is in teletext or viewdata modes the program and channel change commands are blocked. If a command is continuously received, the Data bus is disabled after the first signal has been released. It is enabled again after the reception or the internal generation of the "end of transmission code".
When the teletext or viewdata modes are selected the subsystem pin output is switched Low. It is reset High with the commands 2 (TV off) and 63 (TV mode/TV on).
For more details concerning I-Bus code, both in Teletext/Viewdata and in TV modes, see Tables 3a/b.

*Fig. 11 – I-Bus configuration*

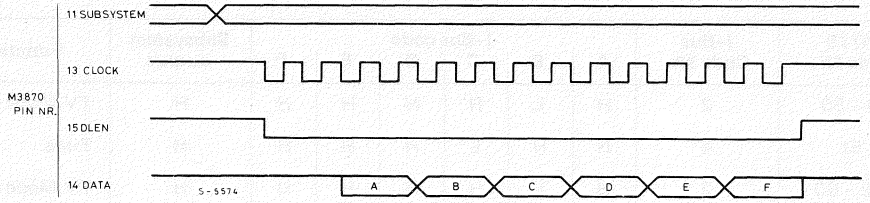



**TABLE 3a – Teletext/Viewdata Modes List of Commands (I-Bus)**

| M710 Code Nr. | I-Bus Code Nr. | I-Bus Code A | B | C | D | E | F | Sub-system output | Function Teletext | Function Viewdata | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–1 | – | – | – | – | – | – | – | L | – | – | – |
| 2 | 2 | H | L | H | H | H | H | H | Off | Off | TV Mode |
| 3–15 | – | – | – | – | – | – | – | L | – | – | – |
| 16 | 16 | H | H | H | H | L | H | L | 0 | 0 | – |
| 17 | 17 | L | H | H | H | L | H | L | 1 | 1 | – |
| 18 | 18 | H | L | H | H | L | H | L | 2 | 2 | – |
| 19 | 19 | L | L | H | H | L | H | L | 3 | 3 | – |
| 20 | 20 | H | H | L | H | L | H | L | 4 | 4 | – |
| 21 | 21 | L | H | L | H | L | H | L | 5 | 5 | – |
| 22 | 22 | H | L | L | H | L | H | L | 6 | 6 | – |
| 23 | 23 | L | L | L | H | L | H | L | 7 | 7 | – |
| 24 | 24 | H | H | H | L | L | H | L | 8 | 8 | – |
| 25 | 25 | L | H | H | L | L | H | L | 9 | 9 | – |
| 26–50 | – | – | – | – | – | – | – | L | – | – | – |
| 51 | 4* | H | H | L | H | H | H | L | Status | – | – |
| 52 | 5 | L | H | L | H | H | H | L | Timed page | Ring off | – |
| 53 | 11 | L | L | H | L | H | H | L | Reveal | Reveal | – |
| 54 | 15 | L | L | L | L | H | H | L | Teletext Reset | Viewdata Reset | – |
| 55 | 26 | H | L | H | L | L | H | L | Small charact. | Small charact. | – |
| 56 | 27 | L | L | H | L | L | H | L | Large top/Bott. | Large top/Bott. | – |
| 57 | 28 | H | H | L | L | L | H | L | Hold | Dial | – |
| 58 | 29 | L | H | L | L | L | H | L | Display cancel | Disp. canc. (4s) | – |
| 59 | 30 | H | L | L | L | L | H | L | Mix | – | – |
| 60 | 31 | L | L | L | L | L | H | L | Normal display | – | – |
| 61 | 56** | H | H | H | L | L | L | L | Teletext mode | – | – |
| | 15** | L | L | L | L | H | H | L | | | |
| 62 | 57** | L | H | H | L | L | L | L | – | Viewdata mode | – |
| | 15** | L | L | L | L | H | H | L | | | |
| 63 | 63** | L | L | L | L | L | L | H | Off | Off | TV Mode |
| | 2** | H | L | H | H | H | H | H | | | |

* When the set is in TV mode and this command is issued, the I-Bus code 4 is generated without changing the subsystem output (it remains H).
This command activates the function "time display" in TV mode.

** These two commands are automatically repeated each time the originating command has been received.
When the set is in TV mode and no Teletext command is received, the I-Bus code 2 is continuously sent on the Bus.

TABLE 3b - TV Mode List of Commands (I-Bus)

| M710 Code Nr. | I-Bus Code Nr. | I-Bus code A | B | C | D | E | F | Subsystem output | Function |
|---|---|---|---|---|---|---|---|---|---|
| 0 - 50 | 2 | H | L | H | H | H | H | H | TV Mode |
| 51 | 4 | H | H | L | H | H | H | H | Time |
| 52 - 60 | 2 | H | L | H | H | H | H | H | TV Mode |
| 61 | 56* | H | H | H | L | L | L | L | Teletext |
| | 15* | L | L | L | L | H | H | L | Mode |
| 62 | 57* | L | H | H | L | L | L | L | Viewdata |
| | 15* | L | L | L | L | H | H | L | Mode |
| 63 | 63* | L | L | L | L | L | L | H | TV Mode |
| | 2* | H | L | H | H | H | H | H | |

* These two commands are automatically repeated each time the originating command has been received.

The I-Bus command 2 is continously repeated on the Data Bus also when no remote control command is received.

## APPLICATION NOTES

A complete electrical diagram of PLL2K is shown in fig. 12. The system can operate also without AFC, as shown in fig. 13.

### M206 Supply voltages

#### +5V

$V_{DD1}$ and $V_{DD2}$ lines must be supplied with stabilized +5V. If, during stand-by operation, lower current sinking is desired on the +5V supply line, $V_{DD1}$ and $V_{DD2}$ lines must be connected to separate supply lines ($V_{DD1}$, of course, must be connected to the stand-by line which supplies M3870 too). If this current saving is not required, $V_{DD1}$ and $V_{DD2}$ may be connected to the same supply line.

#### +25V

The memory supply voltage line must be carefully designed: voltage on pin 24 and 25 must never exceed 26V during operation for a good reliability of the device. To avoid incorrect read and store operations, this supply must never drop below 24V. Thus, this supply must be accurately stabilized within this range. An application circuit to provide a memory supply is shown in fig. 14.

### Power-on and Mains-on

When giving power to the system by means of an on-panel switch, there are two possibilities. In the first one, the user switches only the stand-by supply and the system automatically sets in stand-by condition (pin 8 of M3870 high): by means of local keyboard or via remote control, the user can make the TV set enter normal operation (TV on).
In the second possibility, while switching on the stand-by supply, the user can temporarily force low pin 8 of M3870 (for example, by means of a slide in parallel with the power-on switch): this condition is latched by M3870 and the TV set is immediately switched on.
An electrical diagram for the TV mains-on relay driving is shown in fig. 15.

When power is supplied to the TV set, the NVRAM word corresponding to the addressed program must be read for correct tuning. To read the memory correctly, memory supply must reach at least 24V before the reading operation is performed.
When programming the M3870 software, the designer must take this into account, and must know the rise time of memory supply of the TV set in which the PLL2K shall be used. In our standard PLL2K this time has been set equal to 600 ms, so memory supply rise time must be less than this time.

*Fig. 12 - Application circuit of PLL2K*

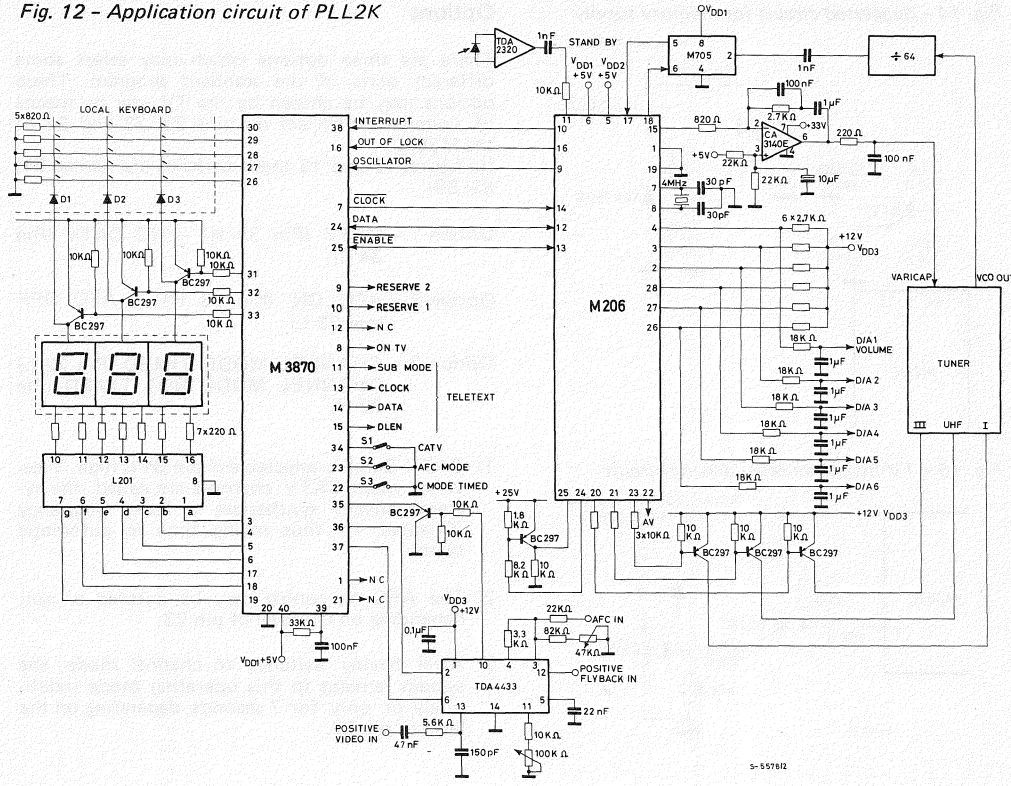



*Fig. 13 - Application circuit of PLL2K (without AFC)*

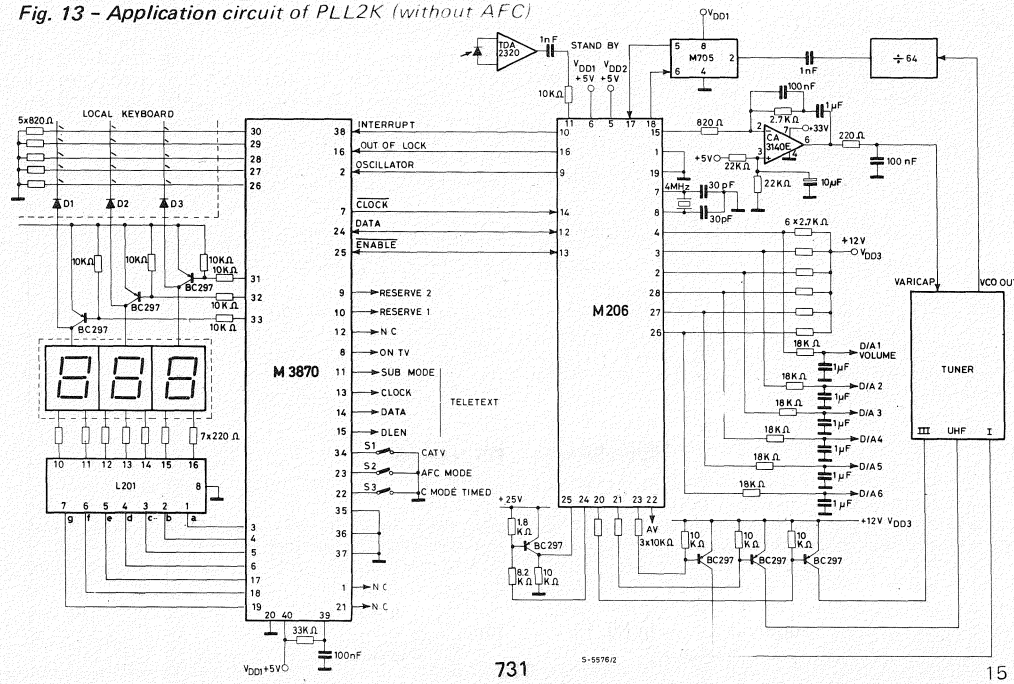


*Fig. 14 - Suggested circuit for memory supply*

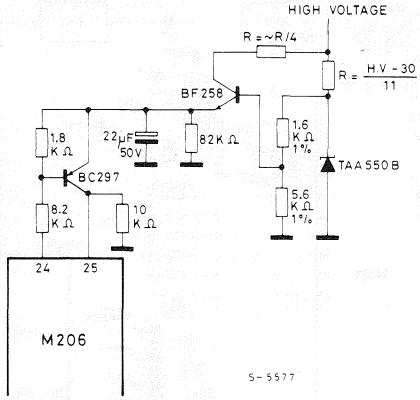
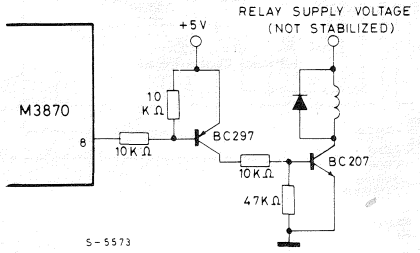



*Fig. 15 - TV mains-on relay driving circuit*




## Options

There are three options which may select some different parts of the standard program. These options may be chosen by the TV user by means of switches which act on pins 22, 23 and 34 of the M3870.
(In figures 12 and 13 these switches are named S1, S2, S3).

Option 1 – CATV (Pin 34 H) – NO CATV (Pin 34 L).

Option 2 – AFC ON (Pin 23 H) – AFC OFF (pin 23 L)

Option 3 – CHANNEL MODE TIMED (Pin 22 L) CHANNEL MODE NOT TIMED (Pin 22 H)

1) CATV Band is selectable if pin 34 is high. Vice-versa, when CATV channels are called, the systems always synthesizes a fixed frequency (Channel 1), thus saving time in automatic search

2) The AFC on tuning may be enabled or not, depending on the level of pin 23.

3) After having switched to channel mode, the system remains in this operating mode indefinitely or only for 7 seconds, depending on the level of pin 22.